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Researchers solve riddle of plant immune system

Researchers create ingredients to produce food by 3D printing

Abandoned cropland should produce biofuels

Advertorial

Controlling Green peach aphid in canola

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

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

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

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

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

Transform® WG
Isoclast® active

INSECTICIDE

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

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

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

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

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

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

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

Chris Brown
Technical Specialist
Corteva Agriscience

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RESEARCHERS CREATE INGREDIENTS TO PRODUCE FOOD BY 3D PRINTING

FOOD ENGINEERS IN BRAZIL AND FRANCE DEVELOPED GELS BASED ON MODIFIED STARCH FOR USE AS "INK" TO MAKE FOODS AND NOVEL MATERIALS BY ADDITIVE MANUFACTURING

It is already possible to produce food with a 3D printer, potentially delivering products that suit consumer preferences regarding taste, texture, cost, convenience, and nutrition. In the near future, it will be possible to produce food with personalised shapes, textures, flavours, and colours considered attractive and healthy for children and the elderly, for example.

A group of researchers at the University of São Paulo's Luiz de Queiroz College of Agriculture (ESALQ-USP) in Brazil, partnering with colleagues in France at Nantes Atlantic College of Veterinary Medicine, Food Science and Engineering (Oniris) and the National Institute for Research on Agriculture, Food and Environment (INRAE), have made strides toward achieving this goal. They are developing hydrogels based on modified starch for use as "ink" in 3D printing of foods.

Recent results of the project, supported by FAPESP (São Paulo Research Foundation), are published in the journal Food Research International. "In the past few years we've developed different technologies to modify starch and obtain gels with ideal characteristics for use as 'ink' to produce food by 3D printing," Pedro Esteves Duarte Augusto, a professor at ESALQ-USP and principal investigator for the project, told Agência FAPESP.

The first gels produced by the researchers were based on cassava starch. They themselves developed the method used to modify the structure and properties of the starch with ozone during a previous project also supported by FAPESP.

They produced ozone by applying an electrical discharge to oxygen, bubbled the gas in a container with a mixture of water and cassava starch in suspension, and dried the mixture by removing the water. The result was modified starch.

By varying aspects of the process such as ozone concentration, temperature, and time, they were able to obtain gels with different properties in terms of the right consistency for use in 3D printing.

"Control of the conditions enabled us to obtain weaker gels for other applications and firmer gels that are ideal for 3D printing because they retain the shape of the printed structure without flowing or losing moisture," Augusto said.

In the past two years, the researchers have developed another starch modification method. This involves dry heating of cassava and wheat starch in an oven while controlling both temperature and time.

Using the new method they were also able to obtain gels based on modified starch that displayed optimal printability, defined as the ability to make a 3D object by additive manufacturing (layer-by-layer deposition) and to maintain its structure once printed. Dry heat treatment also extended the textural possibilities of printed samples based on wheat starch hydrogels.

"We obtained good results with both methods. They're simple, cheap and easy to implement on an industrial scale," Augusto said.

Samples of gel based on cassava and wheat starch were printed at Oniris and INRAE in France via a project to develop functional starch-based gels for 3D printing funded by the Pays de la Loire regional innovation agency under a program called "Food 4 tomorrow".

Through the partnership with French scientists, ESALQ-USP researcher Bianca Chieregato Maniglia conducted postdoctoral research at Oniris and INRAE, applying the ozone and dry heating techniques to produce gels based on modified cassava and wheat starch for 3D printing of foods.

The techniques were developed with the collaboration of other researchers in ESALQ-USP's Process Engineering Research Group (Ge^2P).

"The combined experience of all the researchers involved in the project enabled us to obtain gels with better printability, resulting in foods with better shape, definition and texture, which are essential parameters for product acceptability," Maniglia said.

Novel ingredientes

The ESALQ-USP group now plans to study other methods of modification and sources for the production of 3D food printing gels. ESALQ-USP has recently purchased a 3D printer, which they will use to produce the structures developed with the new gels.

The gels based on modified cassava and wheat starch can be used to print other things apart from food, such as biomedical products including drug capsules and nutraceuticals - foods designed not only to nourish but also to confer health benefits.

"We've demonstrated the feasibility of food production by 3D printing and fabrication of tailor-made ingredients. Now we plan to extend the applications and test other raw materials," Augusto said.

Food engineers in Brazil and France developed gels based on modified starch for use as "ink" to make foods and novel materials by additive manufacturing

OUT OF THIS WORLD: U OF I RESEARCHERS MEASURE PHOTOSYNTHESIS FROM SPACE

As most of us learned in school, plants use sunlight to synthesise carbon dioxide (CO2) and water into carbohydrates in a process called photosynthesis. But nature's "factories" don't just provide us with food -- they also generate insights into how ecosystems will react to a changing climate and carbon-filled atmosphere.

Because of their ability to make valuable products from organic compounds like CO2, plants are known as "primary producers." Gross primary production (GPP), which quantifies the rate of CO2 fixation in plants through photosynthesis, is a key metric to track the health and performance of any plant-based ecosystem.

A research team with the U.S. Department of Energy's Centre for Advanced Bioenergy and Bioproducts Innovation (CABBI) at the University of Illinois Urbana-Champaign developed a product to accurately measure GPP: the SatelLite Only Photosynthesis Estimation Gross Primary Production (SLOPE GPP) product at a daily time step and field-scale spatial resolution.

The team leveraged the Blue Waters supercomputer, housed at the U of I National Centre for Supercomputing Applications (NCSA), in their research. Their paper was published in Earth System Science Data in February 2021.

"Quantifying the rate at which plants in a given area process CO2 is critical to a global understanding of carbon cycling, terrestrial land management, and water and soil health -- especially given the erratic conditions of a warming planet," said Kaiyu Guan, project leader and NCSA Blue Waters Professor.

"Measuring photosynthesis is especially pertinent to agricultural ecosystems, where plant productivity and biomass levels are directly tied to crop yield and therefore food security. Our research directly applies to not only ecosystem service, but also societal well-being," said Chongya Jiang, a research scientist on the project.

Of particular intrigue is the relevance of GPP monitoring to bioenergy agricultural ecosystems, where the crops' "factories" are specially designed to produce renewable biofuels. Quantifying CO2 fixation in these environments is instrumental to optimising field performance and contributing to the global bioeconomy. CABBI scientists, such as Sustainability Theme researcher Andy VanLoocke, suggest that this critical new data can be used to constrain model simulations for bioenergy crop yield potentials.

The technology used in this experiment is cutting-edge. As its name suggests, it is purely derived from satellite data, and therefore completely observation-based as opposed to relying on complex, uncertain modelling methods.

One example of an observation-based technology is solar-induced chlorophyll fluorescence (SIF), a weak light signal emitted by plants that has been used as a novel proxy for GPP. Inspired by their years-long ground observations of SIF, Guan's group developed an even more advanced method to improve GPP estimation: integrating a new vegetation index called "soil-adjusted near-infrared reflectance of vegetation" (SANIRv) with photosynthetically active radiation (PAR).

SLOPE is built on this novel integration. SANIRv represents the efficiency of solar radiation used by vegetation, and PAR represents the solar radiation that plants can actually use for photosynthesis. Both metrics are derived from satellite observations.

Through an analysis of 49 AmeriFlux sites, researchers found that PAR and SANIRv can be leveraged to accurately estimate GPP. In fact, the SLOPE GPP product can explain 85% of spatial and temporal variations in GPP acquired from the analysed sites -- a successful result, and the best performance ever achieved benchmarked on this gold-standard data. As both SANIRv and PAR are "satellite only," this is an achievement that researchers have long been seeking but is just now being implemented in an operational GPP product.

Existing processes to quantify GPP are inefficient for three key reasons: spatial (image-based) precision, temporal (time-based) precision, and latency (delay in data availability). The SLOPE GPP product created by Guan's team uses satellite images twice as sharp as most large-scale studies (measuring at 250 meters versus the typical >500 meters) and retrieves data on a daily cycle, eight times finer than the norm. More importantly, this new product has between one and three days latency, whereas existing datasets lag behind by months or even years. Finally, the majority of GPP products employed today are analysis- rather than observation-based -- the metrics they use to calculate GPP (e.g., soil moisture, temperature, etc.) are derived from algorithms rather than real-world conditions gleaned from satellite observations.

"Photosynthesis, or GPP, is the foundation for quantifying the field-level carbon budget. Without accurate GPP information, quantifying other carbon-related variables, such as annual soil carbon change, is much less reliable," Guan said. "The Blue Waters supercomputer made our peta-bytes computing possible. We will use this novel GPP data to significantly advance our ability to quantify agricultural carbon budget accounting, and it will serve as a primary input to constrain the modelling of soil organic carbon change for every field that requires soil carbon quantification. In addition to the SLOPE GPP data, similar methods allow us to generate GPP data at 10-meter and daily resolution to even enable sub-field precision agricultural management."

GENETIC ENGINEERING WITHOUT UNWANTED SIDE EFFECTS HELPS FIGHT PARASITES

Around a third of the world's population carries Toxoplasma gondii, a parasite that puts people with a weakened immune system at risk and can trigger malformations in the womb. The single-celled pathogen also leads to economic losses in agriculture, with toxoplasmosis increasing the risk of abortion among sheep, for example.

The parasite has a complex life cycle and infests virtually all warm-blooded creatures, including wild rodents and birds. It is introduced into livestock, and thus into humans, exclusively via cats. Only in this main host infectious stages form that are shed with the feces into the environment as encapsulated oocysts and from there enter the food chain.

"If we succeed in preventing the production of these oocysts, we can reduce the occurrence of toxoplasmosis among humans and animals," says Adrian Hehl, professor of parasitology and Vice Dean of Research and Academic Career Development at the University of Zurich's Vetsuisse Faculty. He and his research group have developed methods making an intervention of this sort possible.

Live vaccine protects cats from natural infection

In earlier research, the team already identified various genes that are responsible for the formation of oocysts. This has enabled them to develop a live vaccine for toxoplasmosis: the researchers can use the CRISPR-Cas9 gene editing scissors to switch off these essential genes and infect or inoculate cats with the modified parasites. These pathogens do not produce infectious oocysts, but still protect cats from natural infection with Toxoplasma in the wild.

Manipulation without side-effects

To make the sterile parasites, the researchers used the CRISPR-Cas9 gene editing scissors. While this enables precise modifications to the genetic material, depending on the protocol the method generally used can also have disadvantages. Errors and unintended genetic alterations can creep in. Now the research group around Hehl reports that in Toxoplasma, such unwanted side-effects can be avoided using a modified technique.

For CRISPR-Cas9 gene editing, scientists usually insert a ring-shaped piece of DNA, a so-called plasmid, into the cell. This contains all the information necessary to create the gene scissors and the elements that recognise the desired place in the genetic material. The cell thus produces all the components of the gene scissors itself. Afterwards, however, the plasmid remains in the cell and can trigger additional, unplanned genetic changes.

Gene scissors disappear without a trace

The method used by the Zurich team works differently. The researchers assemble the preprogrammed gene scissors outside the cell and then implant them directly into the parasites. After the genetic material has been manipulated, the components are very rapidly broken down completely, with only the desired edit remaining.

"Our approach isn't just quicker, cheaper and more efficient than conventional methods. It also enables the genomic sequence to be altered without leaving traces in the cell," explains Hehl.

"This means we can now manufacture experimental live vaccines without plasmids or building in resistance genes."

Genetic engineering legislation lags behind

Given these results, Hehl questions the federal government's plans to make CRISPR-Cas9 genome editing subject to the existing law on genetic engineering (and the moratorium, which has been extended to 2025): "Our method is good example of how this new technology differs from conventional approaches to genetic engineering." He says that it is now possible to inactivate a gene without leaving unwanted traces in the genetic material, in a way which is indistinguishable from naturally occurring mutations. Unlike many other controversial applications of genetic engineering, this procedure does not affect the production of food either, and thus does not constitute a direct intervention in the food chain.

Journal Reference:

Rahel R. Winiger and Adrian B. Hehl. A streamlined CRISPR/Cas9 approach for fast genome editing in Toxoplasma gondii and Besnoitia besnoiti. Journal of Biological Methods, 2020 DOI: 10.14440/jbm.2020.343

TWEAKING CAROTENOID GENES HELPS TOMATOES BRING THEIR A-GAME

COOKED, FRESH, SUN-DRIED, OR JUICED, WHICHEVER WAY YOU PREFER THEM, TOMATOES ARE ARGUABLY ONE OF THE MOST VERSATILE FRUITS ON THE PLANET -- AND YES, DESPITE MAINLY BEING USED IN SAVOURY DISHES, TOMATOES REALLY ARE A FRUIT.

The popularity of tomatoes has led to the development of more than 10,000 cultivars of various sizes, shapes, and hues. Interestingly though, there is little genetic diversity among modern tomato varieties. This lack of diversity, coupled with the fact that many traits are controlled by multiple genes, makes improving plant yield and quality a major challenge for tomato breeders.

But in a study published this week in Scientific Reports, researchers led by the University of Tsukuba explain how modern gene editing technology may be able to give tomato breeders a helping hand.

"The tomato was the first genetically modified food to be approved for human consumption,"

says senior author of the study Professor Hiroshi Ezura. "However, many early transgenic varieties contained genes derived from other species, raising safety concerns among consumers. Therefore, coupled with the fact that most transgenic varieties showed only moderate improvements in quality, tomato breeding has, for the most part, moved away from transgenics."

Unlike traditional genetic modification, modern gene editing techniques leave no trace in the genome and can introduce small changes within a native gene, mimicking natural variation.

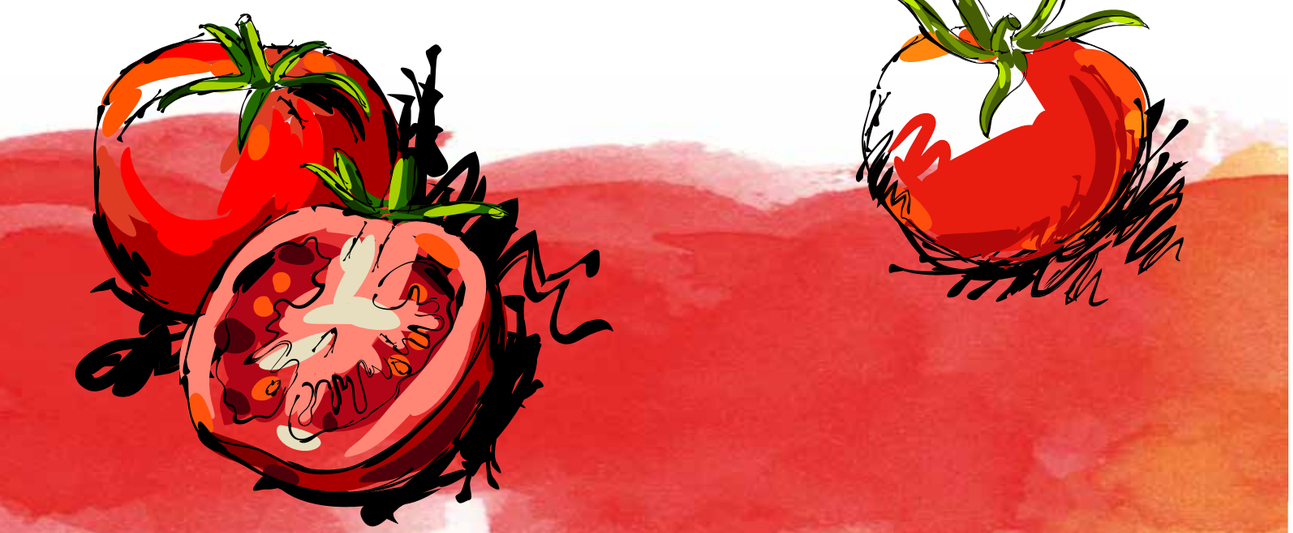
Tomatoes contain relatively high levels of carotenoids, the yellow, red, and orange pigments found in many plants. Carotenoids are precursors to vitamin A and demonstrate antioxidant and anti-cancer properties, making them hugely important to human nutrition. Several natural mutations that enhance carotenoid accumulation in tomatoes have been documented, but their introduction into commercial varieties is a complicated and time-consuming prospect.

The University of Tsukuba-led team therefore set about reproducing carotenoid accumulation mutations in tomatoes using gene editing technology.

"Single nucleotide changes in individual tomato genes had previously been achieved using Target-AID gene editing technology," explains Professor Ezura. "However, we designed a system whereby changes were simultaneously introduced into three genes associated with carotenoid accumulation."

Among 12 resulting tomato lines, 10 contained mutations in all three target genes. Further examination of two lines with the dark green fruit and purple roots of natural carotenoid accumulation mutants revealed high levels of carotenoids, particularly lycopene, in the gene-edited plants.

Professor Ezura explains, "This shows that it is possible to improve multigenic plant quality traits using gene editing technology, and opens up a whole range of options for improving the yield, shelf-life, nutrient content, and disease resistance of different crop plants, which has obvious benefits for both human health and the environment."



Journal Reference:

Johan Hunziker, Keiji Nishida, Akihiko Kondo, Sanae Kishimoto, Tohru Ariizumi, Hiroshi Ezura. Multiple gene substitution by Target-AID base-editing technology in tomato. Scientific Reports, 2020; 10 (1) DOI: 10.1038/s41598-020-77379-2

NEWLY DISCOVERED TRAIT HELPS PLANTS GROW DEEPER ROOTS IN DRY, COMPACTED SOILS

A previously unknown root trait allows some cereal plants to grow deeper roots capable of punching through dry, hard, compacted soils, according to Penn State researchers, who suggest that harnessing the inherited characteristic could lead to crops better able to deal with a changing climate.

"This discovery bodes well for American and global agriculture because the trait helps corn, wheat and barley grow deeper roots, which is important for drought tolerance, nitrogen efficiency and carbon sequestration," said Jonathan Lynch,

distinguished professor in plant science. "Breeding for this trait should be helpful in developing new crops for climate mitigation."

Called multiseriate cortical sclerenchyma by the researchers -- or MCS -- the phenotype is characterised by small cells with thick walls just beneath the surface of the roots. Roots with the MCS genotype have a greater concentration of lignin -- a complex organic polymer that is important in the formation of cell walls, especially in wood and bark, that lends rigidity.

More lignin gives the MCS roots greater tensile strength and greater root tip bending force compared to non-MCS genotypes. This added rigidity helps roots penetrate hard soil layers.

The findings of the root anatomy study, published today (Feb. 1) in Proceedings of the National Academy of Sciences, are striking. Corn genotypes with MCS had root systems with 22% greater depth and 39% greater shoot biomass in compacted soils in the field compared to lines without MCS.

Soil compaction reduces porosity, limits water infiltration, reduces aeration and restricts root growth by presenting a physical impediment, noted lead researcher Hannah Schneider, postdoctoral scholar in Lynch's research group in the College of Agricultural Sciences.

"Compacted soil layers constrain crop productivity by restricting root growth and exploration in deeper soil layers, which in turn limits access to nutrients and water," she said. "Plants with roots that are able to penetrate hard soil and forage deeper have an advantage in capturing water and nutrients -- ultimately performing better in drought or low soil fertility."

The study included both field and greenhouse components to assess root-penetration ability in compacted soils.

Scientists conducted two field experiments to study root growth -- one at the Apache Root Biology Centre in Willcox, Arizona, and the other at Penn State's Russell E. Larson Agricultural Research Centre at Rock Springs. At each location, researchers grew six corn genotypes contrasting in root lignin content. Each field experiment involved compaction and noncompaction treatments.

When the corn flowered, soils were cored near randomly selected plants to assess root growth. The roots of two plants per research plot also were dug up and evaluated, and shoot biomass was collected.

Twelve wheat genotypes and six corn genotypes also were grown in a greenhouse at the University Park campus. Large growth containers, or "mesocosms," were set up with a compacted soil layer to determine which roots penetrated the hard substrate. After more than a month's growth, root segments from each of the corn and wheat genotypes were collected, measured and tested for tensile strength and root tip bending force.

This research utilised laser ablation tomography -- known as LAT -- to visualise the anatomy of roots from plants in the study. Lynch's research group developed the unique technology in 2011 for other root-analysis applications. Researchers using LAT can measure the light spectra given off by different cells cut by the laser to differentiate between various tissues.

Genetic variation for MCS was found in each of the cereals examined by the researchers, and heritability was relatively high, they reported, suggesting that this trait can be selected in breeding programs. Of the plant lines reviewed in this study, MCS was present in 30 to 50% of modern corn, wheat and barley cultivars.

The implications of corn crops growing deeper roots to range farther for water and nutrients -- and as a consequence producing larger yields -- would be immense in regions where the populace is food-insecure, Schneider pointed out. That is especially true in the face of a changing climate that is making vast areas more drought-prone.

"We observe MCS in corn, wheat, barley and many other cereal crops, and our work suggests that many of the benefits of MCS may be analogous across different species," she said. "MCS could be an important trait for stress tolerance and increased yields in cereal crops."

Journal Reference:

Hannah M. Schneider, Christopher F. Strock, Meredith T. Hanlon, Dorien J. Vanhees, Alden C. Perkins, Ishan B. Ajmera, Jagdeep Singh Sidhu, Sacha J. Mooney, Kathleen M. Brown, Jonathan P. Lynch. Multiseriate cortical sclerenchyma enhance root penetration in compacted soils. Proceedings of the National Academy of Sciences, 2021; 118 (6): e2012087118 DOI: 10.1073/pnas.2012087118

PLANT GENOME EDITING EXPANDED WITH NEWLY ENGINEERED VARIANT OF CRISPR-CAS9

Alongside Dennis vanEngelsdorp, associate professor at the University of Maryland (UMD) in Entomology named for the fifth year in a row for his work in honey bee and pollinator health, Yiping Qi, associate professor in Plant Science, represented the College of Agriculture & Natural Resources on the Web of Science 2020 list of Highly Cited Researchers for the first time. This list includes influential scientists based on the impact of their academic publications over the course of the year. In addition to this honour, Qi is already making waves in 2021 with a new high-profile publication in Nature Plants introducing SpRY, a newly engineered variant of the famed gene editing tool CRISPR-Cas9. SpRY essentially removes the barriers of what can and can't be targeted for gene editing, making it possible for the first time to target nearly any genomic sequence in plants for potential mutation. As the preeminent innovator in the field, this discovery is the latest of Qi's in a long string of influential tools for genome editing in plants.

"It is an honour, an encouragement, and a recognition of my contribution to the science community," says Qi of his distinction as a 2020 Web of Science Highly Cited Researcher. "But we are not just making contributions to the academic literature. In my lab, we are constantly pushing new tools for improved gene editing out to scientists to make an impact."

With SpRY, Qi is especially excited for the limitless possibilities it opens up for genome editing in plants and crops. "We have largely overcome the major bottleneck in plant genome editing, which is the targeting scope restrictions associated with CRISPR-Cas9. With this new toolbox, we pretty much removed this restriction, and we can target almost anywhere in the plant genome."

The original CRISPR-Cas9 tool that kicked off the gene editing craze was tied to targeting a specific short sequence of DNA known as a PAM sequence. The short sequence is what the CRISPR systems typically use to identify where to make their molecular cuts in DNA. However, the new SpRY variant introduced by Qi can move beyond these traditional PAM sequences in ways that was never possible before.

"This unleashes the full potential of CRISPR-Cas9 genome editing for plant genetics and crop improvement," says an excited Qi.

"Researchers will now be able to edit anywhere within their favourable genes, without questioning whether the sites are editable or not. The new tools make genome editing more powerful, more accessible, and more versatile so that many of the editing outcomes which were previously hard to achieve can now be all realised."

According to Qi, this will have a major impact on translational research in the gene editing field, as well as on crop breeding as a whole. "This new CRISPR-Cas9 technology will play an important role in food security, nutrition, and safety. CRISPR tools are already widely used for introducing tailored mutations into crops for enhanced yield, nutrition, biotic and abiotic stress resistance, and more. With this new tool in the toolbox, we can speed up evolution and the agricultural revolution. I expect many plant biologists and breeders will use the toolbox in different crops. The list of potential applications of this new toolbox is endless."

Journal Reference:

Qiurong Ren, Simon Sretenovic, Shishi Liu, Xu Tang, Lan Huang, Yao He, Li Liu, Yachong Guo, Zhaohui Zhong, Guanqing Liu, Yanhao Cheng, Xuelian Zheng, Changtian Pan, Desuo Yin, Yingxiao Zhang, Wanfeng Li, Liwang Qi, Chenghao Li, Yiping Qi, Yong Zhang. PAM-less plant genome editing using a CRISPR–SpRY toolbox. Nature Plants, 2021; 7 (1): 25 DOI: 10.1038/s41477-020-00827-4

A KNOCKDOWN THAT IS SO GRANULAR

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

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

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

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

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

HOW BEAN PLANTS FEND OFF FAMISHED FOES

For a caterpillar, a green leaf can make a nice meal. But to the plant itself, it's an attack. And very hungry caterpillars can do a lot of damage as they eat their way through life.

Plants can fight back, unleashing an array of chemical defences to discourage wayward foragers -- from releasing chemicals that attract caterpillar predators to secreting compounds that make the plant taste so foul that desperate caterpillars resort to cannibalism. But scientists know little about how plants detect these attacks and marshal defences.

In a paper published Nov. 23 in the Proceedings of the National Academy of Sciences, a team led by scientists at the University of Washington and the University of California, San Diego reports that cowpeas -- a type of bean plant -- harbour receptors on the surface of their cells that can detect a compound in caterpillar saliva and initiate anti-herbivore defences.

"Despite chemical controls, crop yield losses to pests and disease generally range from 20-30% worldwide. Yet many varieties are naturally resistant or immune to specific pests," said lead author Adam Steinbrenner, a UW assistant professor of biology.

"Our findings are the first to identify an immune recognition mechanism that sounds the alarm against chewing insects."

The receptor is a protein known by the acronym INR. The team showed that, in response to both leaf wounds and the presence of a protein fragment specific to caterpillar saliva, the cowpea's INR protein boosts the production of ethylene, a hormone that plants often produce in response to munching by herbivores and other types of environmental stress. The protein fragment in caterpillar spit that elicited this response, Vu-IN, is actually a fragment of a cowpea protein, which gets broken down by the caterpillar as it dines on cowpea leaves.

Researchers have fewer methods to study cowpeas compared to other plants. So to learn more cellular details about INR's function, they popped the gene for INR into tobacco plants. These tobacco plants, when exposed to Vu-IN, increased production of ethylene as well as reactive oxygen species, another anti-herbivore defence that consists of chemically reactive forms of oxygen. In addition, the team's experiments showed that a tobacco-eating caterpillar -- the beet armyworm -- munched less on INR-harbouring tobacco plants than plants without INR.

The research shows that plants like the cowpea sound the alarm only after their cells detect specific molecules associated with herbivory. Vu-IN is a trigger for cowpea defences. Other plants likely have different molecular triggers for their own defensive systems, the researchers believe.

Understanding how plants activate their immune systems could help scientists develop more effective strategies to defend crop plants against hungry insects.

Journal Reference:

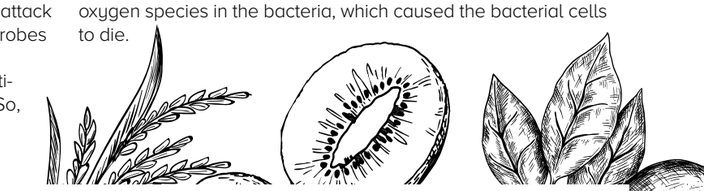
Adam D. Steinbrenner, Maria Muñoz-Amatriaín, Antonio F. Chaparro, Jessica Montserrat Aguilar-Venegas, Sassoum Lo, Satohiro Okuda, Gaetan Glauser, Julien Dongiovanni, Da Shi, Marlo Hall, Daniel Crubaugh, Nicholas Holton, Cyril Zipfel, Ruben Abagyan, Ted C. J. Turlings, Timothy J. Close, Alisa Huffaker, Eric A. Schmelz. A receptor-like protein mediates plant immune responses to herbivore-associated molecular patterns. Proceedings of the National Academy of Sciences, 2020; 202018415 DOI: 10.1073/pnas.2018415117

PLANT-INSPIRED ALKALOIDS PROTECT RICE, KIWI AND CITRUS FROM HARMFUL BACTERIA

Plants get bacterial infections, just as humans do. When food crops and trees are infected, their yield and quality can suffer. Although some compounds have been developed to protect plants, few of them work on a wide variety of crops, and bacteria are developing resistance. Now, researchers reporting in ACS' Journal of Agricultural and Food Chemistry have modified natural plant alkaloids into new compounds that kill bacteria responsible for diseases in rice, kiwi and citrus.

Currently, no effective prevention or treatment exists for some plant bacterial diseases, including rice leaf blight, kiwifruit canker and citrus canker, which result in substantial agricultural losses every year. Scientists are trying to find new compounds that attack bacteria in different ways, reducing the chances that the microbes will develop resistance. Plant compounds called tetrahydro-β-carboline (THC) alkaloids are known to have antitumor, anti-inflammatory, antifungal, antioxidant and antiviral activities. So, Pei-Yi Wang, Song Yang and colleagues wondered whether derivatives of THC alkaloids could help fight plant bacterial diseases.

The researchers used a THC alkaloid called eleagnine, which is produced by Russian olive trees and some other plants, as a scaffold. To this framework, they added different chemical groups to make a series of new compounds, two of which efficiently killed three strains of plant pathogenic bacteria in liquid cultures. The team then tested the two compounds on rice, kiwi and citrus plant twigs and leaves and found that the new alkaloids could both prevent and treat bacterial infections. The researchers determined that the compounds worked by increasing levels of reactive oxygen species in the bacteria, which caused the bacterial cells to die.



Journal Reference:

Hong-Wu Liu, Qing-Tian Ji, Gang-Gang Ren, Fang Wang, Fen Su, Pei-Yi Wang, Xiang Zhou, Zhi-Bing Wu, Zhong Li, Song Yang. Antibacterial Functions and Proposed Modes of Action of Novel 1,2,3,4-Tetrahydroπcarboline Derivatives that Possess an Attractive 1,3-Diaminopropan-2-ol Pattern against Rice Bacterial Blight, Kiwifruit Bacterial Canker, and Citrus Bacterial Canker. Journal of Agricultural and Food Chemistry, 2020; 68 (45): 12558 DOI: 10.1021/acs.jafc.0c02528

INCREASING SOIL ORGANIC CARBON TO REALISE PRODUCTIVITY AND FUTURE OFFSET GAINS

DR. UWE STROEHER, HEAD OF R&D NEUTROG, AUSTRALIA

Soil organic carbon (SOC) is an increasingly used term within discussions about the benefit SOC can have on soil, its productivity and also offsetting carbon emissions via increasing SOC with the potential of receiving carbon credits. For the agricultural industry, both these areas are relevant to increasing efficiency and sustainability which makes it worth understanding further.

SOC, as its name suggests, is the organic carbon within the soil and excludes carbon sources such as carbonates or carbon dioxide. SOC includes obvious material such as fresh residues, the carbon in soil microbes (whether dead or alive), the sugars and amino acids secreted by plant roots, the plant roots and the long-term permanent sources of carbon such as humic substances **(Figure 1).**

Some of these sources of carbon are transient, (meaning that they don't stay in the soil for extended periods of time and turn over at a very rapid rate), but they still provide a key benefit in their role as the building blocks of more stable carbon. Stable carbon are those materials that become permanent sources of SOC, i.e. humic substances and organic carbon bound to soil particles. These permanent carbon sources represent the factors which will eventually count towards carbon credits.

Increasing SOC is not a short-term project and takes a number of years simply due to the fact that while SOC can be increased via the addition of organic inputs, it is simultaneously decreased during the breakdown of the organic material through leaching and the release of carbon dioxide.

So how do we increase SOC, in light of the fact that the carbon within the soil is in continual flux?

In very basic terms, in order to increase SOC the amount of carbon entering the soil has to be greater than the amount leaving the soil. However, due to the continual turnover of carbon and the degradation of organic material it is not just a matter of adding organic material to the soil. For every tonne of organic material added approximately 80% of this will be lost over a period of 3 to 4 years in carbon dioxide alone (not including any leaching) **(Figure 2).**

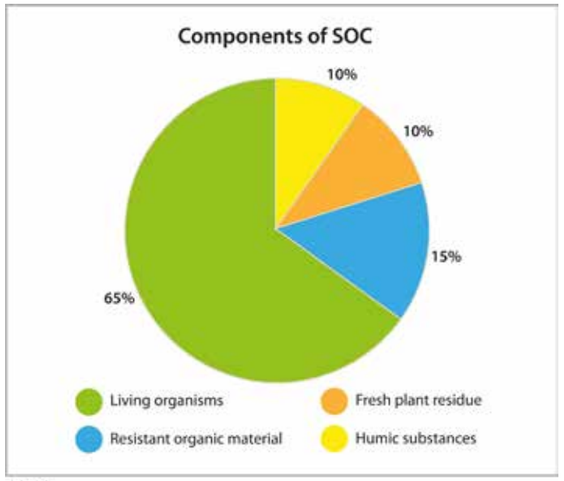


Fig.1

This is because microbes use the organic material as a source of energy to grow and multiply, and subsequently release carbon dioxide, resulting in high levels of carbon loss from the initial inputs. In essence, only about 20% of the organic material applied will end up as a more permanent source of carbon.

While this may seem like a great start to increasing the underlying SOC levels, the huge weight of bulk soil makes for some interesting calculations of how much SOC actually increases by this method. A fairly simple calculation shows that; 1 hectare of soil to a depth of 10cm weighs approximately 1200 tonnes, by adding 10 tonnes of organic matter of which 60% is carbon this will only increase the SOC by 0.36%. Again this seems like a good approach until you consider that after a few years the action of soil microbes will have whittled this down to ~0.07% of residual permanent SOC. This would indicate that there is limited practical scope to directly increase SOC by applying large amounts of low-quality organic matter. Furthermore, many of these low-grade organic inputs have their own issues (discussed later). This calculation leads to the importance of a distinction between high-quality and low-quality organic material.

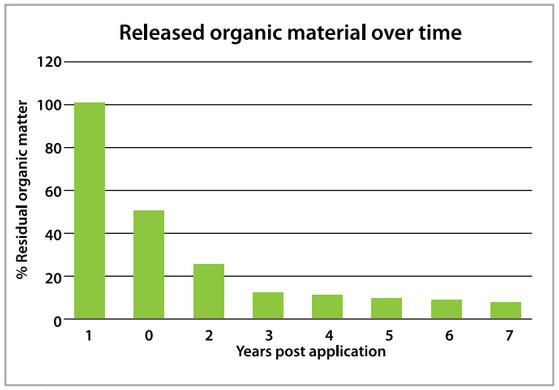


Fig.2

High quality organic material will contribute carbon to the soil at the same time as stimulating the soils biological activity. And while it may seem counter intuitive to stimulate soil microbes which will only increase and speed up the breakdown process of organic inputs, what bacteria and fungi do is convert some of the transient SOC into more permanent stable SOC.

This direct action of soil microbes is not the only way in which they influence the accumulation of SOC. The number and diversity of soil bacteria and fungi in the soil are significantly increased by the addition of organic matter. This results in increased nutrient cycling and nutrient availability for plants and microbes, also helping to protect plants from pests and disease and directly stimulating plant growth by the production of plant growth hormones.

It is the above properties of soil microbes which creates an increase in plant and root growth, allowing plants to secrete more organic compounds into the soil. This results in further microbial activity which will have a positive long-term impact on SOC. The soil microbes turn some of the root material of dead plants into stable SOC and as bacteria and fungi die their cellular structures are degraded by still other microbes.

Once the material cannot degrade any further it essentially becomes part of the permanent SOC pool and can be considered as humic substance or resistant organic matter. Until recently permeant SOC such as humic substances were considered to be of solely of plant origin, however, more recently it has been shown that a significant amount of humic substances are in fact residual microbial components **(Figure 3).**

This knowledge further supports the theory that the choice of organic material added to soil can significantly affect the rate and deposition of long-term SOC. There are several critical nutrients that need to be present for degradation to occur, the most obvious being nitrogen. Manganese is a less well-known nutrient required for degradation, but it is critical for a range of enzymes which degrade cellulose and without sufficient levels of manganese, degradation is slowed significantly.

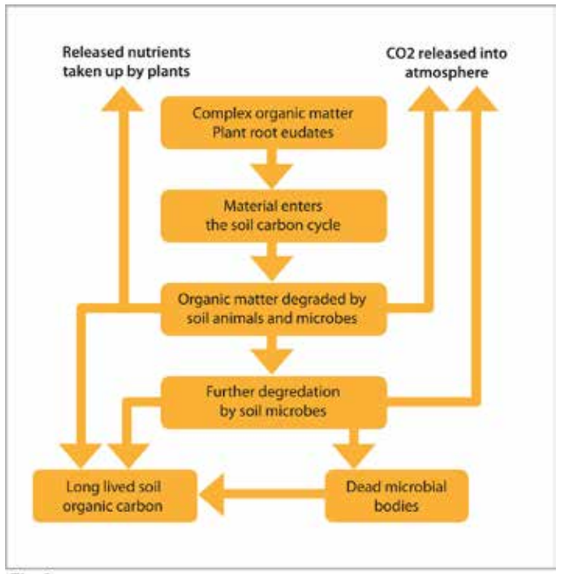


Fig.3

Organic material inputs can be assessed by their structural complexity, a factor that impacts the time it takes them to degrade. Wood wastes, stubble or straw which are an example of a structurally complex combination of carbon, oxygen and hydrogen. These materials will take a long time to degrade but should result in more humate material in the soil. Greenwaste contains elements such as nitrogen, potassium, phosphorous and some micronutrients and is less complex, therefore break down more quickly, but leave less residual humates.

The key is the combination of the organic material input, with nutrients such as those in organic based fertilisers that will expedite degradation.

A commercially viable solution is to apply a biological based fertiliser, such as Bounce Back from Neutrog Australia. Bounce Back has high enough nitrogen levels to avoid nitrogen drawdown and sufficient manganese to accelerate the breakdown of material, resulting in a quicker accumulation of permanent SOC.

The solution needs to form part of a multifaceted long-term soil improvement strategy to increase SOC levels including farming practices such as reduced tilling, leaving stubble (and not burning it) and utilising cover crops. The expectation of these practices should be that the impact will be an incremental increase in SOC over an extended period.

Increasing the SOC by just 1%, will trap approximately 20 tonnes of carbon per hectare in the top 10 cm of soil. The additional benefit of increasing the SOC is significantly improving the water holding capacity of the soil, increasing the presence of humic substances acting as soil pH buffers and retaining micronutrients which are normally leached through the soil profile. All elements that combine to improve overall production efficiencies.

AVOID REPEATING OLD MISTAKES

Since the founding of the United Nations Convention on Biological Diversity (CBD) in Rio de Janeiro in 1992, member states have regularly agreed on global strategies to bring the increasingly rapid loss of biodiversity to a halt. In 2002, the heads of state adopted the so-called 2010 biodiversity targets. Eight years later, little progress had been made and 20 new, even more ambitious goals were set for the next ten years. Last year, it became clear that this target had been missed, too. The loss of biodiversity continues unabated.

This year, new targets are being negotiated again - this time for 2030. The decisions are to be made at the Conference of the Parties (COP15) in Kunming, China. To ensure that the mistakes from previous years will not be repeated, Chinese researchers led by Prof Haigen Xu from the Nanjing Institute for Environmental Research in cooperation with Prof Henrique Pereira (iDiv, MLU) have presented an analysis of the causes of this failure, focusing primarily on implementation in the individual member states.

Their conclusion: the commitments at UN level were all too seldom transposed into national law. Four of the 20 so-called Aichi Targets are not reflected in any of the implementation plans (NBSAPs) submitted by the governments, including the phasing out of environmentally harmful subsidies. The other targets were formulated strictly enough to meet the requirements of the CBD decisions in only 22 percent of the NBSAPs. In addition, the analysis revealed insufficient financial resources and major gaps in knowledge on how to record and effectively combat biodiversity loss. Implementation of the promised goals in member states was insufficiently monitored, as effective indicators and evaluation mechanisms were lacking in some cases.

"While the CBD has now presented a first post-2020 draft that contains many improvements compared to the last decade's Strategic Plan for Biodiversity,"

says ecologist and last author Pereira, "the main problems remain: governments are not required to present a clear roadmap on how they will achieve and monitor the targets adopted under the CBD in their own countries."

The authors suggest that the CBD targets should be formulated in such a way that they can be transposed into national law as a mandatory minimum requirement. Similar to the Paris Climate Agreement or the Washington Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the CBD targets should be legally binding. Financial resources to promote biodiversity should be significantly increased and new instruments such as payments for ecosystem services and biodiversity-related taxes should be introduced. In addition, interdisciplinary research on the status, trends and drivers of biodiversity loss worldwide should be strengthened and appropriately equipped in order to develop the necessary responses. Further, the CBD should establish a mechanism to verify the compliance of member states with their targets and, if necessary, hold them accountable.

Pereira and several other colleagues at iDiv are actively contributing to biodiversity-related policy processes at various levels, for example, within the framework of the United Nations in the World Biodiversity Council IPBES and the CBD, at EU level in the negotiations of the Common Agricultural Policy (CAP) and the EU Biodiversity Strategy, as well as in national, regional and local contexts. These activities are supported by the research centre's good network of collaborators from different disciplines around the world.

Pereira is pleased about this collaboration with his Chinese co-authors as important players in nature conservation from one of the world's most influential nations. "It's inspiring to co-author such an ambitious proposal with colleagues from the host nation of COP15, where the final decisions will be made."

Journal Reference:

CREDIT: IISD/MIKE MUZURAKIS (ENB.IISD.ORG/BIODIV/POST2020/OEWG/2/24FEB.HTML)

I SEE YOU: HONEY BEES USE CONTAGIOUS AND HONEST VISUAL SIGNAL TO DETER ATTACKING HORNETS

STUDY IS THE FIRST TO DEMONSTRATE A CONTAGIOUS WARNING SIGNAL THAT RESISTS FAKE NEWS IN SOCIAL INSECTS

An Asian hornet sets its sights on a busy honey bee hive. If all goes according to plan, the hornet's attack will result in a haul of bee larvae, precious nourishment to pilfer and feed to its own hornet young.

But over time, predator-prey evolution has equipped some honey bees with a potent defence mechanism against such an attack. A signal from colony guard bees lets hornets know that their attack plans have been exposed, and also sends an alarm across the bee colony communicating that urgent reinforcements are needed due to the impending danger. This "I see you" (ISY) visual signal involves guard bees shaking their abdomens laterally and increases as the threat intensifies.

Hornets are ferocious bee predators that have invaded multiple countries around the world. Yet even the giant "murder" hornets that have generated much concern of late have come to recognise the ISY signal as a warning to back off. They are well aware that ISY can lead to a counter attack in which a mass of bees surrounds the hornet, forming a "heat ball" with a deadly mix of heat, carbon dioxide and stinging for the hornet inside.

University of California San Diego biologists studying Asian honey bees (Apis cerana) and hornets (Vespa velutina) have produced new research that deconstructs this ISY signal and shows for the first time that it is visually driven and contagious across the bee colony. The findings are described Dec. 7, 2020 in the Journal of Animal Ecology. A key point of the new study is that the bees can only succeed if they have sufficient numbers to effectively execute a heat ball.

"The beauty of the ISY signal is that hornets are only deterred if enough defending bees quickly gather to synchronously produce the signal, thereby showing the hornet that further attack is futile," said study senior author James Nieh, a professor in the Section of Ecology, Behavior and Evolution in UC San Diego's Division of Biological Sciences.

But how to gather this defence? Nieh says the ISY signal is contagious and attracts other defenders who immediately copy the signal and rush towards the signaller, even if they cannot directly see or sense the predator.

"Hornets give off smell and sound but we found that the visual of a hornet alone can elicit the signal, which was not known," said Nieh. Previous speculation held that guard bees might produce a pheromone to alert others in the colony of the impending danger. "Using just a contagious visual signal is better because guards who are too far away to smell or hear the hornet can immediately head towards the threat. In some ways, it's like a fast chain reaction," said Nieh.

Nieh says the concept links to the issue of "fake news" since animal communication often contains errors, and a false ISY alarm could rapidly spread within the colony.

One solution to the problem of false information spread is that the bees are very selective about what they consider a true threat. Using an iPad to display videos, researchers Shihao Dong, Ken Tan and Nieh found that the visual appearance and motion of the hornet alone could trigger ISY signals. Visual displays of a harmless butterfly, on the other hand, elicited no response. The second and most important safeguard against false reporting is that bees are even more choosy about what they consider to be a real ISY signal.

"We played back videos of bees performing ISY signals at different speeds, but only the correct bee image at the right speed caused other bees to respond. This helps keep the signal spread honest," said Nieh.

It is still true that a bee could occasionally "cry wolf" but Nieh thinks that evolution has limited these errors because nestmates must work together to fight these powerful predators and colonies prone to errors would suffer. Nieh and his colleagues are now testing the details of the visual cues behind ISY. They are developing animations that display related visuals that can be tested, such as whether a harmless butterfly can be depicted as threatening, or whether offshoots such as a hornet displayed without wings could be enough to trigger ISY.

Nieh believes that the findings provide a cautionary tale about fake news for all of us.

"Individuals in a honey bee colony are completely interdependent. They can't go out and make it on their own. Cooperation is paramount, especially when faced with a large, heavily armoured predator like hornets," said Nieh. "A couple of hornets can kill thousands of bees in a single day. Yet through teamwork that correctly produces synchronised, massed ISY signals, they can get the hornet to back off without harming a single bee. Maybe that's a lesson for us all."

Journal Reference:
Shihao Dong, Ken Tan, James C. Nieh. Visual contagion in prey defense signals can enhance honest defense. Journal of Animal Ecology, 2020; DOI: 10.1111/1365-2656.13390

COMMON PESTICIDES STOP BEES AND FLIES FROM GETTING A GOOD NIGHT'S SLEEP

Just like us, many insects need a decent night's sleep to function properly, but this might not be possible if they have been exposed to neonicotinoid insecticides, the most common form of insecticide used worldwide, suggests research by academics at the University of Bristol.

Two studies by scientists at Bristol's Schools of Physiology, Pharmacology and Neuroscience and Biological Sciences have shown these insecticides affect the amount of sleep taken by both bumblebees and fruit flies, which may help us understand why insect pollinators are vanishing from the wild.

Dr Kiah Tasman, Teaching Associate in the School of Physiology, Pharmacology and Neuroscience and lead author of the studies, said: "The neonicotinoids we tested had a big effect on the amount of sleep taken by both flies and bees. If an insect was exposed to a similar amount as it might experience on a farm where the pesticide had been applied, it slept less, and its daily behavioural rhythms were knocked out of synch with the normal 24-hour cycle of day and night."

The fruit fly study published today [21 January] in Scientific Reports, allowed the researchers to study the impact of the pesticides on the insect brain.

As well as finding that typical agricultural concentrations of neonicotinoids ruined the flies' ability to remember, the researchers also saw changes in the clock in the fly brain which controls its 24-hour cycle of day and night.

Dr James Hodge, Associate Professor in Neuroscience in the School of Physiology, Pharmacology and Neuroscience and senior author for the study, added:

"Being able to tell time is important for knowing when to be awake and forage, and it looked like these drugged insects were unable to sleep. We know quality sleep is important for insects, just as it is for humans, for their health and forming lasting memories."

Dr Sean Rands, Senior Lecturer in the School of Biological Sciences and co-author, explained: "Bees and flies have similar structures in their brains, and this suggests one reason why these drugs are so bad for bees is they stop the bees from sleeping properly and then being able to learn where food is in their environment.

"Neonicotinoids are currently banned in the EU, and we hope that this continues in the UK as we leave EU legislation."

Journal Reference:
Kiah Tasman, Sergio Hidalgo, Bangfu Zhu, Sean A. Rands, James J. L. Hodge. Neonicotinoids disrupt memory, circadian behaviour and sleep. Scientific Reports, 2021; 11 (1) DOI: 10.1038/s41598-021-81548-2

EARLY BREEDING REDUCED HARMFUL MUTATIONS IN SORGHUM

ITHACA, N.Y. - When humans first domesticated maize some 9,000 years ago, those early breeding efforts led to an increase in harmful mutations to the crop's genome compared to their wild relatives, which more recent modern breeding has helped to correct.

A new comparative study investigates whether the same patterns found in maize occurred in sorghum, a gluten-free grain grown for both livestock and human consumption. The researchers were surprised to find the opposite is true: Harmful mutations in sorghum landraces (early domesticated crops) actually decreased compared to their wild relatives.

The study, "Comparative Evolutionary Genetics of Deleterious Load in Sorghum and Maize," published Jan. 15 in Nature Plants. The senior author is Michael Gore, professor of molecular breeding and genetics in the College of Agriculture and Life Sciences (CALS).

The research may inform future breeding efforts in both sorghum and maize.

"We assumed that maize and sorghum would have complementary patterns of deleterious mutations, because all the work that has been done in crops up to this point has shown an increase in deleterious burden in domesticates compared to wild relatives from which crops originate," Gore said. "But sorghum does not follow this pattern and it's very surprising."
These "deleterious mutations," which potentially have a negative effect on the fitness of an organism, result from random genetic errors that occur every generation, and from ancient mutations that may be linked to beneficial genetic variants selected during crop domestication and improvement.

In the study, the researchers ran population genetics simulations to help explain why sorghum failed to follow the same pattern found in maize.

One major difference between maize and sorghum is that maize (wild and domesticated) is an "outcrosser," meaning its female flowers (ear shoots) are predominantly pollinated by other maize plants; domesticated sorghum is a "selfer," meaning the flowers of its panicles (heads) are mostly fertilised by each plant's own pollen.

It turns out that sorghum's wild relatives have more open seed heads that facilitate outcrossing. But in the process of sorghum domestication, the panicles that hold these clusters of flowers became more compact, which increased "selfing" rates.

"We posit that the alteration of panicle morphology impacted deleterious mutation patterns in sorghum," Gore said.

"The resultant increase in selfing likely contributed to the purging of deleterious mutations after domestication."

By understanding the historical patterns of harmful mutations, breeders may use that knowledge to better purge deleterious mutations from sorghum crops. "What we're learning in sorghum could also be applied to maize and vice versa," Gore said.

The image shows variation in seed head architecture of the different sorghum races, including (from left to right) bicolor, guinea, caudatum, kafir and durra.

Journal Reference:

Roberto Lozano, a postdoctoral researcher in Gore's lab, is the paper's first author. Co-authors include Ed Buckler and Jeffrey Ross-Ibarra.

NO-TILL PRACTICES IN VULNERABLE AREAS SIGNIFICANTLY REDUCE SOIL EROSION

Soil erosion is a major challenge in agricultural production. It affects soil quality and carries nutrient sediments that pollute waterways. While soil erosion is a naturally occurring process, agricultural activities such as conventional tilling exacerbate it. Farmers implementing no-till practices can significantly reduce soil erosion rates, a new University of Illinois study shows.

Completely shifting to no-till would reduce soil loss and sediment yield by more than 70%, says Sanghyun Lee, doctoral student in the Department of Agricultural and Biological Engineering at U of I and lead author on the study, published in Journal of Environmental Management.

But even a partial change in tilling practices could have significant results, he adds.

"If we focus on the most vulnerable area in terms of soil erosion, then only 40% no-till shows almost the same reduction as 100% no-till implementation," Lee says.

The study used physical data and computer modelling to estimate soil erosion in the Drummer Creek watershed, which is part of the Upper Sangamon River watershed in Central Illinois. The area's main crops are corn and soybeans, and tillage is a predominant agricultural practice.

"The rate of soil erosion is increased and accelerated by unsustainable agricultural production. One of the main reasons is conventional tillage in the field," Lee says. "Our model provides a tool to estimate the impacts of tilling on soil erosion across the watershed."

Lee and co-authors Maria Chu, Jorge Guzman, and Alejandra Botero-Acosta developed the modelling framework, coupling a hydrological model (MIKE SHE) with the Water Erosion Prediction Project (WEPP) to examine the impacts of no-till practice in the watershed. The WEPP model provided the sediment sources from the agricultural fields under different tillage practices and the hydrologic model simulated sediment transport across the watershed.

The researchers included historical data on climate, soil properties, sediment sample data, and other relevant measures, then used the coupled model to predict how different management practices affect soil erosion rates.

"Farmers may prefer tilling because wet climate conditions cause compacted soil," Lee says. "However, soil erosion removes topsoil, which contains lots of nutrients, and this may reduce yield in the long term. Soil erosion also affects water quality, both locally over time and at a distance.

"Therefore, farmers need to weigh the benefits of tilling with the consequences of soil erosion and choose the best management strategies."

The modelling framework can help identify the most vulnerable areas, so producers can implement sustainable management practices where it matters most, Lee notes.

Journal Reference:

Sanghyun Lee, Maria L. Chu, Jorge A. Guzman, Alejandra Botero-Acosta. A comprehensive modeling framework to evaluate soil erosion by water and tillage. Journal of Environmental Management, 2021; 279: 111631 DOI: 10.1016/j.jenvman.2020.111631

COULD LAB-GROWN PLANT TISSUE EASE THE ENVIRONMENTAL TOLL OF LOGGING AND AGRICULTURE?

It takes a lot to make a wooden table. Grow a tree, cut it down, transport it, mill it ... you get the point. It's a decades-long process. Luis Fernando Velásquez-García suggests a simpler solution: "If you want a table, then you should just grow a table."

Researchers in Velásquez-García's group have proposed a way to grow certain plant tissues, such as wood and fibre, in a lab. Still in it's early stages, the idea is akin in some ways to cultured meat -- an opportunity to streamline the production of biomaterials. The team demonstrated the concept by growing structures made of wood-like cells from an initial sample of cells extracted from zinnia leaves.

While that's still a long way from growing a table, the work provides a possible starting point for novel approaches to biomaterials production that ease the environmental burden of forestry and agriculture. "The way we get these materials hasn't changed in centuries and is very inefficient," says Velásquez-García. "This is a real chance to bypass all that inefficiency."

The paper will be published in the Journal of Cleaner Production. Ashley Beckwith is lead author and a PhD student in mechanical engineering. Coauthors are Beckwith's co-advisors Velásquez-García, a principal scientist in MIT's Microsystems technology Laboratories, and Jeffrey Borenstein, a biomedical engineer at the Charles Stark Draper Laboratory.

Beckwith says she's always been fascinated by plants, and inspiration for this project struck when she recently spent time on a farm. She observed a number of inefficiencies inherent to agriculture -- some can be managed, like fertiliser draining off fields, while others are completely out of the farmer's control, like weather and seasonality. Plus, only a fraction of the harvested plant is actually used for food or materials production.

"That got me thinking: Can we be more strategic about what we're getting out of our process? Can we get more yield for our inputs?" Beckwith says.

"I wanted to find a more efficient way to use land and resources so that we could let more arable areas remain wild, or to remain lower production but allow for greater biodiversity."

So, she brought plant production into the lab.

The researchers grew wood-like plant tissue indoors, without soil or sunlight. They started with a zinnia plant, extracting live cells from its leaves. The team cultured the cells in a liquid growth medium, allowing them to metabolise and proliferate. Next, they transferred the cells into a gel and "tuned" them, explains Velásquez-García. "Plant cells are similar to stem cells in the sense that they can become anything if they are induced to."

The researchers coaxed the cells to grow a rigid, wood-like structure using a mix of two plant hormones called auxin and cytokinin. By varying the levels of these hormones in the gel, they controlled the cells' production of lignin, an organic polymer that lends wood its firmness. Beckwith says she assessed the cellular composition and structure of the final product using fluorescence microscopy. "You can visually evaluate which cells are becoming lignified, and you can measure enlargement and elongation of cells." This procedure demonstrated that plant cells can be used in a controlled production process, resulting in a material optimised for a particular purpose.

Velásquez-García sees this work as an extension of his lab's focus on microfabrication and additive manufacturing techniques like 3D printing. In this case, the plant cells themselves do the printing with the aid of the gel growth medium. Unlike an unstructured liquid medium, the gel acts as a scaffold for the cells to grow in a particular shape. "The idea is not only to tailor the properties of the material, but also to tailor the shape from conception," says Velásquez-García. Thus, he envisions the possibility of one day growing a table, no two-by-fours or wood glue necessary.

The technology is far from market-ready. "The question is whether the technology can scale and be competitive on an economic or lifecycle basis," says David Stern, a plant biologist at Cornell University who was not involved with the research. He adds that scaling up this approach "would take significant financial and intellectual investment," likely from both government and private sources. Stern also points to tradeoffs in bringing pieces of forestry and agriculture into the lab. "Agriculture uses the sun's energy through photosynthesis, and -- except in irrigated lands -- natural rainfall. It does not require buildings, heat, or artificial light."

The researchers acknowledge it's still early days for these lab-grown plant tissues -- the team will keep fine-tuning the controls, like hormone levels and pH of the gel, that give rise to the final material's properties. "It is really uncharted territory," says Velásquez-García. "One pending question is: How do we translate this success to other plant species? It would be naïve to think we can do the same thing for each species. Maybe they have different control knobs."

Beckwith also anticipates challenges in growing plant tissues at large scales, such as facilitating gas exchange to the cells. The team hopes to overcome these barriers through further experimentation and eventually build production blueprints for lab-grown products, from wood to fibres.

It's a radical yet elegant vision -- "a new paradigm," according to Borenstein. "There's an opportunity here to take advances in microfabrication and additive manufacturing technologies, and apply them to solve some really significant problems in the agriculture arena."

Journal Reference:

This research was funded, in part, by the Draper Fellow Program. Written by Daniel Ackerman

Additional background: Paper: "Tunable plant-based biomaterials via in vitro cell culture using Zinnia elegans model" https://www.sciencedirect.com/science/article/pii/S0959652620356171

NEW ECO-FRIENDLY WAY TO MAKE AMMONIA COULD BE BOON FOR AGRICULTURE, HYDROGEN ECONOMY

Chemical engineers at UNSW Sydney have found a way to make 'green' ammonia from air, water and renewable electricity that does not require the high temperatures, high pressure and huge infrastructure currently needed to produce this essential compound.

And the new production method - demonstrated in a laboratory-based proof of concept - also has the potential to play a role in the global transition towards a hydrogen economy, where ammonia is increasingly seen as a solution to the problem of storing and transporting hydrogen energy.

In a paper published today in Energy and Environmental Science, the authors from UNSW and University of Sydney say that ammonia synthesis was one of the critical achievements of the 20th century. When used in fertilisers that quadrupled the output of food crops, it enabled agriculture to sustain an ever-expanding global population.

But since the beginning of the 1900s when it was first manufactured on a large scale, production of ammonia has been energy intensive - requiring temperatures higher than 400oC and pressures greater than 200atm - and all powered by fossil fuels.

Dr Emma Lovell, a co-author on the paper from UNSW's School of Chemical Engineering, says the traditional way to make ammonia - known as the Haber-Bosch process - is only cost-effective when produced on a massive scale due to the huge amounts of energy and expensive materials required.

"The current way we make ammonia via the Haber-Bosch method produces more CO2 than any other chemical-making reaction," she says.

"In fact, making ammonia consumes about 2 per cent of the world's energy and makes 1 per cent of its CO2 - which is a huge amount if you think of all the industrial processes that occur around the globe."

Dr Lovell says in addition to the big carbon footprint left by the Haber-Bosch process, having to produce millions of tonnes of ammonia in centralised locations means even more energy is required to transport it around the world, not to mention the hazards that go with storing large amounts in the one place.

She and her colleagues therefore looked at how to produce it cheaply, on a smaller scale and using renewable energy.

"The way that we did it does not rely on fossil fuel resources, nor emit CO2," Dr Lovell says.

"And once it becomes available commercially, the technology could be used to produce ammonia directly on site and on demand - farmers could even do this on location using our technology to make fertiliser - which means we negate the need for storage and transport. And we saw tragically in Beirut recently how potentially dangerous storing ammonium nitrate can be.

"So if we can make it locally to use locally, and make it as we need it, then there's a huge benefit to society as well as the health of the planet."

Journal Reference:

University of New South Wales

OUT OF THIN AIR

ARC DECRA Fellow and co-author Dr Ali (Rouhollah) Jalili says trying to convert atmospheric nitrogen (N2) directly to ammonia using electricity "has posed a significant challenge to researchers for the last decade, due to the inherent stability of N2 that makes it difficult to dissolve and dissociate".

Dr Jalili and his colleagues devised proof-of-concept lab experiments that used plasma (a form of lightning made in a tube) to convert air into an intermediary known among chemists as NOx - either NO2- (nitrite) or NO3- (nitrate). The nitrogen in these compounds is much more reactive than N2 in the air.

"Working with our University of Sydney colleagues, we designed a range of scalable plasma reactors that could generate the NOx intermediary at a significant rate and high energy efficiency," he says.

"Once we generated that intermediary in water, designing a selective catalyst and scaling the system became significantly easier. The breakthrough of our technology was in the design of the high-performance plasma reactors coupled with electrochemistry."

Professor Patrick Cullen, who led the University of Sydney team, adds: "Atmospheric plasma is increasingly finding application in green chemistry. By inducing the plasma discharges inside water bubbles, we have developed a means of overcoming the challenges of energy efficiency and process scaling, moving the technology closer to industrial adoption."

STORAGE SOLUTION

Scientia Professor Rose Amal, who is co-director of ARC Training Centre for Global Hydrogen Economy, says in addition to the advantages of being able to scale down the technology, the team's 'green' method of ammonia production could solve the problem of storage and transport of hydrogen energy.

"Hydrogen is very light, so you need a lot of space to store it, otherwise you have to compress or liquify it," says Professor Amal.

"But liquid ammonia actually stores more hydrogen than liquid hydrogen itself. And so there has been increasing interest in the use of ammonia as a potential energy vector for a carbon-free economy."

Professor Amal says ammonia could potentially be made in large quantities using the new green method ready for export.

"We can use electrons from solar farms to make ammonia and then export our sunshine as ammonia rather than hydrogen.

"And when it gets to countries like Japan and Germany, they can either split the ammonia and convert it back into hydrogen and nitrogen, or they can use it as a fuel."

The team will next turn its attention to commercialising this breakthrough, and is seeking to form a spin-out company to take its technology from laboratory-scale into the field.

COMMON WEED KILLERS FAVOUR ANTIBIOTIC RESISTANT BACTERIA, NEW STUDY SHOWS

The use of weed killers can increase the prevalence of antibiotic resistant bacteria in soil, a new study from the University of York shows.

Herbicides are one of the most widely used chemicals in agriculture and while these compounds are used to target weeds, they can cause damage to soil microbes, such as bacteria and fungi, potentially changing the ecological properties of microbial communities.

Scientists from China and the UK studied the effect of three widely used herbicides called glyphosate, glufosinate and dicamba on soil bacterial communities.

Using soil microcosms, researchers discovered that herbicides increased the relative abundance of bacterial species that carried antibiotic resistance genes. This was because mutations that improved growth in the presence of herbicides also increased bacterial tolerance to antibiotics. Herbicide exposure also led to more frequent movement of antibiotic resistance genes between bacteria.

Similar patterns were found in agricultural fields across 11 Chinese provinces where herbicide application history, and the levels of herbicide residues in soils, were linked to increased levels of antibiotic resistance genes.

Dr Ville Friman from the Department of Biology said: "Our results suggest that the use of herbicides could indirectly drive antibiotic resistance evolution in agricultural soil microbiomes, which are repeatedly exposed to herbicides during weed control.

"Interestingly, antibiotic resistance genes were favoured at herbicide concentrations that were not lethal to bacteria. This shows that already very low levels of herbicides could significantly change the genetic composition of soil bacterial populations. Such effects are currently missed by ecotoxicological risk assessments, which do not consider evolutionary consequences of prolonged chemical application at the level of microbial communities.

"While antibiotic resistance genes are not harmful per se, they will reduce the efficiency of antibiotics during clinical treatments. Keeping the frequency of resistance genes low will hence prolong the long-efficiency of antibiotics. As resistance genes can easily move between environments, agricultural fields could be globally important source for resistance genes"

The study concludes that the effects of these herbicide concentrations on microbial communities should be re-evaluated to fully understand the associated risks for the prevalence of antibiotic resistance genes.

NOVEL EFFECTOR BIOLOGY RESEARCH PROVIDES INSIGHTS INTO DEVASTATING CITRUS GREENING DISEASE

Citrus greening disease, also known as Huanglongbing (HLB), is devastating to the citrus industry, causing unprecedented amounts of damage worldwide. There is no known cure. Since the disease's introduction to the United States in the early 2000s, research efforts have increased exponentially. However, there is still a lack of information about the molecular mechanism behind the disease.

"Getting into the molecular details behind what contributes to citrus greening symptom development and disease progression is key to finding sustainable solutions to combat the pathogen,"explained plant pathologist Wenbo Ma.

"We bring the community one step closer to understanding these mechanisms with our research."
Ma and her colleagues at the University of California and the University of Florida used molecular plant pathology approaches to dissect the mechanisms of the ongoing tug-of-war between the citrus host and the bacterial pathogen that causes citrus greening disease.

"To understand how the bacterial pathogen causes citrus greening disease, we studied the function of effectors produced by the pathogen that can directly affect citrus," Ma explained.

"We demonstrated that one of the effectors promotes bacterial colonization and disease development in citrus. Our studies indicate that this likely occurs by the pathogen's manipulation of host senescence (process of aging). "

Host senescence has been shown to be manipulated by other pathogens, but this is the first indication that it plays a role in citrus greening disease progression. They hope this knowledge will help agricultural systems enhance resistance to this disease and stimulate research on the molecular plant pathology aspect of citrus greening disease.

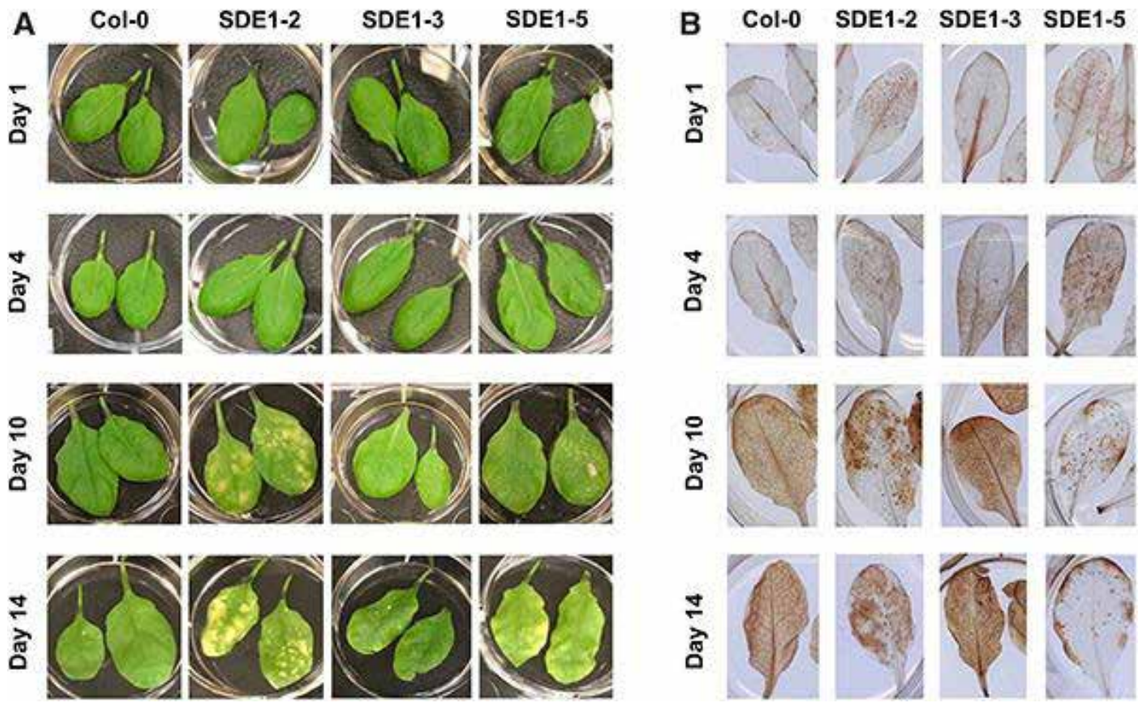


Image
Sec-delivered effector 1 (SDE1) induces reactive oxygen species (ROS) accumulation prior to yellowing symptoms in Arabidopsis thaliana leaves.

Journal Reference:
Published in the December issue of MPMI. Photo credit: Kelley J. Clark, Zhiqian Pang, Jessica Trinh, Nian Wang, and Wenbo Ma

APPLICATION OF POTASSIUM TO GRASS USED AS COVER CROP GUARANTEES HIGHER-QUALITY COTTON

By Maria Fernanda Ziegler | Agência FAPESP – The use of cover crops between cotton harvests protects the soil, conserves water, and reduces the risk of erosion. Researchers at the University of Western São Paulo (UNOESTE) and São Paulo State University (UNESP) in Brazil found that application of potassium (K) to a grass cover crop grown before cotton in sandy soil lowered production cost and resulted in cotton with a higher market value.

"The dynamics of early application of potassium to grass planted as a cover crop before cotton results in more resistant fibres and a smaller proportion of short fibres than when the conventional method of applying the nutrient to the cotton crop is used. In addition to the improvement in quality, the technique reduces production cost for the farmer because of its impact on operational dynamics. The farmer can apply potassium once instead of twice. The technique saves labor and diesel oil, as well as optimising operational logistics. In the long run, it's also expected to reduce fertiliser use," said Fábio Echer, a professor at UNOESTE and lead author of an article on the study published in Scientific Reports.

The two-year study, which was conducted on UNOESTE's experimental farm, compared the conventional method of fertilising cotton directly with two other methods, both involving early application of potassium. It also evaluated cotton growing without fertiliser and without a cover crop.

The research was funded by a master's scholarship awarded by FAPESP to Vinicius José Souza Peres. The São Paulo State Cotton Growers Association (APPA) and Fundação Agrisus also collaborated on the project.

Quantitative and qualitative analysis of fibre

In one of the treatments, the researchers applied potassium to the grass cover crop in two doses (70 kg per hectare each). They compared this with application to the cover crop of a single dose of 140 kg per hectare and split application, with half going to the cover crop and the other half to the cotton. The results in terms of fibre yield were identical to those of the conventional method. Yield and quality were both lower with no fertiliser than when the conventional method or early application was used.

"The study included a calculation of fertiliser use efficiency," Echer told Agência **FAPESP**. "We found that early application enabled the forage grass used as a cover crop to recover nutrients from the soil, in addition to the function of protecting it. This plant has a deep rhizosphere and its roots are able to find soil nutrients lost via leaching from previous crops, recycling them, and pushing them back to the surface. When the plant dries out, it releases potassium in the first rain to the crops that come next."

The main advantage of early application, however, is that it increases the commercial value of the cotton produced. The analysis of fibre quality and cotton value found that fertilising the cover crop with potassium led to a smaller proportion of short fibres, which depreciate the finished product, and also enhanced fibre fineness (micronaire), maturity and strength. "These characteristics are important. They represent higher commercial value for the production of finer cotton fabric, which is better quality and fetches a higher price on the market," Echer said.

The improvement in quality relates to the availability of potassium in the soil and plant water status. "Cotton fibre is a cell, and like all cells it needs water to expand. By conserving more water in the soil and in the plant, we can also improve fibre size," he explained.

Potassium plays a key role in the control of plant water loss. It regulates stomata functioning, carbon dioxide fixation, enzyme activation, and nutrient transport, as well as aiding stress tolerance. Soil potassium reaches plant roots mainly by diffusion, which accounts for 72%-96% of each plant's requirement.

"Extreme weather events, high temperatures, and droughts have become more frequent because of global warming, and conservationist soil management techniques such as those suggested by the study can mitigate the adverse effects of all this on production," Echer said.

"Inconsistent rainfall may limit crop viability, and because only about 8% of Brazil's cotton plantations are irrigated, the use of a cover crop is especially important. Straw mulch helps reduce soil temperature, which in turn helps conserve water."

In western São Paulo, where the experimental farm used in the study is located, the temperature can reach 70°C on cotton plantations without a cover crop (and hence with exposed soil). The use of a cover crop keeps the soil at about 28°C-30°C, conserving soil moisture.

Early application of potassium is widely used in plantations with clayey soil, Echer added, but the technique had not yet been tested on sandy soil with little organic matter, making nutrient retention harder. "Farmers were reluctant to apply fertiliser early in the case of crops planted in sandy soil," he said. "The study proves that applying potassium to the cover crop maintains yield and improves fibre quality even in sandy soil, which is more fragile, stores less water and makes potassium more susceptible to leaching."

According to the researchers, the method analysed in western São Paulo can be replicated in cotton plantations with sandy soil in Mato Grosso (the leading cotton producer in Brazil) and Bahia, as well as in other countries. "The cover crop can be different from the one we used in this study, because the climate may be different, but a precedent has been set for testing new cover species in other parts of the world," Echer said.

SCIENTISTS REVEAL STRUCTURE OF PLANTS' ENERGY GENERATORS

Researchers have revealed the first atomic structures of the respiratory apparatus that plants use to generate energy, according to a study published today in eLife.

The 3D structures of these large protein assemblies - the first described for any plant species - are a step towards being able to develop improved herbicides that target plant respiration. They could also aid the development of more effective pesticides, which target the pest's metabolism while avoiding harm to crops.

Most organisms use respiration to harvest energy from food. Plants use photosynthesis to convert sunlight into sugars, and then respiration to break down the sugars into energy. This involves tiny cell components called mitochondria and a set of five protein assemblies that arrange themselves in an 'electron transport train'.

"Knowing how plants convert energy through respiration is a crucial part of understanding how plants grow, how they adapt to changes in the environment and what strategies we can use to improve crop yields,"

explains first author Maria Maldonado, a postdoctoral fellow at the Department of Molecular and Cellular Biology, University of California, Davis (UC Davis), US. "Yet although the 3D structures of respiration components are well understood in mammals, fungi and bacteria, the technical challenges of gathering pure samples of mitochondrial complexes in plants mean these structures remain largely unknown."

The team set out to obtain 3D structures of three components in the electron transport chain - complex III, complex IV and super complex III-IV. They extracted mitochondria complexes from mung bean sprouts treated with a gentle detergent and then stabilised them before using cryo-electron microscopy to generate high-resolution structures. Based on these structures, the team then built atomic models showing how the complexes interact with other molecules, such as other proteins, ions and lipids. For each of the three complexes, they were able to determine the number and structure of subunits, and the likely molecules that bind to them and how flexible the structures are.

Their models showed that several aspects of the complexes are shared between plants, mammals, fungi and bacteria, including several components that were originally thought to exist only in plants. However, the team also found several features of the complexes that are unique to plants, including the way the supercomplex III-IV assembles. This is important, because many agricultural herbicides and pesticides are designed to interfere with the respiratory complexes, and this finding could help to make them more selective for the pests they are intended to kill.

"Our work provides high-resolution structures of plant respiratory complexes that reveal plant-specific features, allowing for the development of more selective inhibitors as herbicides and pesticides," concludes senior author James Letts, Assistant Professor at the Department of Molecular and Cellular Biology, UC Davis, US. "Further comparative analyses of these structures with the growing number of respiratory complexes will allow us to understand the fundamental principles of respiration across the tree of life."

Mung bean sprouts grown in the dark that provide the raw materials to determine the structure of plant respiratory complexes

Journal Reference:

The paper 'Atomic structures of respiratory complex III2, complex IV and supercomplex III2-IV from vascular plants' can be freely accessed online at https://doi.org/10.7554/eLife.62047. Contents, including text, figures and data, are free to reuse under a CC BY 4.0 license. Kaitlyn Abe and Maria Guadalupe Zaragoza (CC BY 4.0)

UP-FRONT HPPD USE 'KEY' TO BROADLEAF RESISTANCE MANAGEMENT

Early adopters of the Group H pre-emergent herbicide CALLISTO® have made the shift to wiser use of a HPPD inhibitor, according to Syngenta.

While other group H formulations including TALINOR® have traditionally been used as a foliar spray in Australia, research supports the use of HPPD inhibitors (Group H) in earlier growth stages of target weeds.

"The level of HPPD resistance in weeds does change over the target's lifecycle," said Syngenta Resistance Research Technical Specialist Sarah-Jane Hutchings.

"This means if you were to use the same loading of a HPPD pre versus post, we expect to see better levels of control in the pre-emergent use pattern."

CALLISTO utilises the active ingredient Mesotrione, which has benefited from decades of Syngenta research and development globally, prior to its 2020 launch here. Resistant populations of Amaranthus in northern America have been a focus for Sarah and Syngenta for some years already.

"The enzymes that metabolise Mesotrione aren't switched on until later in the plant's lifecycle when the target weed is generally two to three inches [50 to 75mm] tall," she said.

"The production of these enzymes is not switched on, or produced to a high enough level, very early in the target's lifecycle to confer resistance."

CALLISTO can be applied prior to sowing in a knifepoint-press wheel system ahead of rainfall and is compatible with grass pre-emergents including BOXER GOLD®.

Activated by rainfall, CALLISTO is primarily absorbed through the roots and translocated to the leaves.

Users have noted a tell-tale bleaching of young broadleaf weeds where they have emerged through CALLISTO treated soil. This discoloration of the plant pigments is symptomatic of interruption of photosynthesis.

"We've had some excellent feedback on CALLISTO from its first commercial year," Syngenta Technical Services Lead James Considine said.

"CALLISTO has really taken pressure off post-emergent broadleaf herbicide applications, which is huge for resistance management. We still want farmers to follow-up with that post-emergent application, but it is buying them a bit of time especially when they tend to be logistically challenged."

Since CALLISTO is a group H, James said it was important that advisors take this into account when building a suitable post-emergent strategy, utilising a 'mix and rotate strategy' along with other WeedSmart, Big 6 strategies.

"Whether you recommend farmers come back with a group B, C, F, G, I, O – or preferably a mix of two or more groups - these foliar sprays are in most cases (only) being asked to take care of the odd escape," he said.

"This strategy will help prevent weed seed set and manage weed germinations not only this year but for years to come. Syngenta is a sponsor of WeedSmart and The Big 6, and we want to see greater adoption of these strategies so farmers are dictating terms, not weeds."

"Now's the time to be talking to farmers about the weed management strategy, particularly while the results of last year's weed control measures are still fresh in their minds."

NEW HEAT METHOD KILLS PATHOGENS WITH MINIMAL DAMAGE TO PLANTS

In the strawberry nursery industry, a nursery's reputation relies on their ability to produce disease- and insect-free plants. The best way to produce clean plants is to start with clean planting stock. Many nurseries struggle with angular leaf spot of strawberry, a serious disease that can result in severe losses either by directly damaging the plant or indirectly through a violation of quarantine standards within the industry.

Angular leaf spot is caused by the bacterial pathogen Xanthomonas fragariae. Current management strategies rely primarily on the application of copper compounds after planting. Aside that these compounds are not applied until after the pathogen has had some time to establish, these products are also short-lived and can result in phytotoxicity.

Heat is another technique used to kill pathogens in plants and is typically applied prior to planting when the pathogen population is presumably at its lowest. However, heat treatments are often too harsh on plants, stunting their growth or killing them. Heat can also further spread pathogens if applied as a hot water treatment.

"One of the main problems with using heat to treat plants is that the temperature is also damaging to the tissues of most plants," explained Bill Turechek, a plant pathologist at the USDA in Florida. "This is why heat treatments are most often applied as seed treatments or on dormant woody tissues that tend to be more tolerant of the treatment."

Turechek and colleagues set out to develop a new heat-based treatment that would kill pathogens without hurting the plant. When asked what most excited them about their research and their new method, Turechek responded,

"That it works! By introducing a lower-temperature conditioning step and using steam rather than hot water, we produced plants that were better able to withstand the higher temperature treatment designed to destroy the pathogen."

The new method uniquely uses a two-step process. The first step is a conditioning heat treatment that induces production of protective proteins and other molecules in the plant. The second step involves the application of a lethal temperature that kills the pathogen while doing little damage to the plant. This method, which applies heat via aerated steam, also reduces the spread of pathogens that might not have been killed in hot water treatments and subsequently dispersed in the bath water.

A, The precision thermotherapy unit setup for the high-elevation nursery trial in 2016. The extended setup allowed treatment of 18 boxes and employed four vacuums. B, The setup used for the trials run at Escalon and Ballico in 2017. A similar setup was used for the grower-run trial in 2018.

For the strawberry industry, this new method provides a safe way to eliminate pathogens and pests and should result in reduced pesticide applications and increased fruit quality and yield.

While this method was designed to target the pathogen that causes angular leaf spot, it has been shown to be effective against fungal pathogens, some nematodes, and insect pests.

"In other words, this treatment looks to have a broad spectrum of activity against numerous microbial, insect, and mite pests," Turechek explained. This protocol should be applicable to many other commodities.

Journal Reference:

The research and the plans for building the precision thermotherapy units needed in this new method are outlined in "The Use of Aerated Steam as a Heat Treatment for Managing Angular Leaf Spot in Strawberry Nursery Production and Its Effect on Plant Yield" published in the open access PhytoFrontiers. Credit: William W. Turechek, Ole Myhrene, Janet Slovin, and Natalia A. Peres

FUNGI STRENGTHEN PLANTS TO FEND OFF APHIDS

GREEN TRANSITION Researchers at the University of Copenhagen have demonstrated that unique fungi strengthen the "immune systems" of wheat and bean plants against aphids. Fungi enter and influence the amount of a plant's own defences, resulting in fewer aphids. The results could serve to reduce agricultural insecticide use and bring Denmark a step further along the path towards its green transition.

Wheat field

Certain fungi are able to establish a close rapport with plants that results in fewer insect infestations and thereby less damage to crops. Until now, it was unclear how these fungi could be used to reduce insect infestations.

"In order for us to really use fungi to control agricultural pests in the future, we need to understand the mechanisms and processes behind their activity. So, it's very exciting that we have managed to advance a step closer", says Associate Professor Nicolai Vitt Meyling of UCPH's Department of Plant and Environmental Sciences.

Fungi strengthen the "immune systems" of crops

The researchers studied three types of fungi to compare their effects against aphid infestations on wheat and bean plants:

"It turned out that two of these fungi were able to effectively reduce aphid infestations by establishing themselves in plant roots and tissues. By combining greenhouse-based experiments with advanced chemical analyses, we can see that the fungi cause plants to increase production of their own natural defences, thus strengthening plant "immune systems". This translates into fewer aphids, which would otherwise weaken a plant", says Nicolai Vitt Meyling, who explains:

"When aphids suck up plant sap, plants lose energy, to the detriment of their root networks and overall growth. However, when fungi-treated plants were attacked by aphids, they were able to compensate by increasing root growth, so that they didn't lose growth potential. Plants left untreated with the fungi couldn't compensate for the attack," says Nicolai Vitt Meyling.

The researchers "treated" wheat and bean plants by applying fungal spores to seed, from which the plants were then germinated and cultivated. They then added a few aphids and observed how many more aphids developed over two weeks in the greenhouse. Thereafter, plant leaves underwent chemical analysis in collaboration with researchers from Aarhus University's Department of Agroecology.

"We see a clear correlation between an increased amount of defence substances in and fewer aphids on the plants treated with two of the fungi. Those plants left untreated with the fungi had lesser amounts of defence substances and more aphids. There is simply a marked up regulation of defence substances in a plant under aphid attack when these specific fungi are present. And, the same treatment produces the same result in both wheat and bean plants," says Nicolai Vitt Meyling.

Thus, the researchers could see that the effect is related to the fungi and not the plant species. The same fungi had the same effect in both the wheat and bean plants, despite the two types of plants not being related and expressing different kinds of defence substances.

Swapping out insecticide for fungi coated seed

The fungi also have an effect on insects that attack the root systems of plants. And, in combination with other environmentally-friendly cultivation methods, could help to reduce insecticide use in agriculture.

"The fungi has the potential to reduce the need for insecticides because treated seeds result in fewer aphids in the field. If we can develop a large-scale method of pre-treating seed with Danish seed producers, to coat plant seeds with these fungi before planting, we may hardly need to spray with insecticides," says Nicolai Vitt Meyling, who concludes:

"Limiting pesticide use is an important aspect of the green transition. This can be an effective and sustainable contribution towards such a reduction."

The next step is to engage in longer term field trials of treated plants. This will allow researchers to gauge the longevity of effects under realistic growing conditions.

Journal Reference:

The research results have been published in the renowned scientific journal New Phytologist.

SEEDS TRANSFER THEIR MICROBES TO THE NEXT GENERATION

Scientists have been pondering if the microbiome of plants is due to nature or nurture. Research at Stockholm University, published in Environmental Microbiology, showed that oak acorns contain a large diversity of microbes, and that oak seedlings inherit their microbiome from these acorns.

"The idea that seeds can be the link between the microbes in the mother tree and its offspring has frequently been discussed, but this is the first time someone proves the transmission route from the seed to the leaves and roots of emerging plants", says Ahmed Abdelfattah, researcher at the Department of Ecology Environment and Plant Sciences (DEEP) at Stockholm University.

The microorganisms found on the seed are often valuable for the plant, promoting its growth and protecting it against certain diseases. Each plant species harbours a distinct microbial community, with some of the microbes living on its surface and others inside the plant's tissues.

The finding also means that since the microorganisms from the seed are there first, they can constitute a barrier which influences subsequent colonization by other microbes from the environment. The experiment was done in oaks, since it's one of the most abundant tree species in the Swedish and European forests.

"The microorganisms from the seed are also expected to be very important for plant health and functioning", says Ahmed Abdelfattah.

The fossil record indicates that plants have been associated with fungi and bacteria - constituting the microbiome - for more than 400 million years. Several species the scientists found on the oak seeds are already shown by other studies to be involved in the protection against several plant pathogens, growth-promotion, nitrogen-fixing, and the detoxification or biodegradation of toxic environmental pollutants.

Demonstrating inheritance under natural conditions is challenging since seeds are exposed to and dependent on their surrounding environment when they sprout, especially the soil, which is a microbially rich environment. Therefore, it's nearly impossible to differentiate between which microorganism actually come from the seed or from the soil. The research team therefore used a novel culturing device, to grow oak seedlings in a microbe-free condition and keep the leaves separated from the roots. This allowed them to be certain that the microorganisms came from the seed, and that they could demonstrate that some seed microorganisms migrate to the roots, and some others to the leaves.

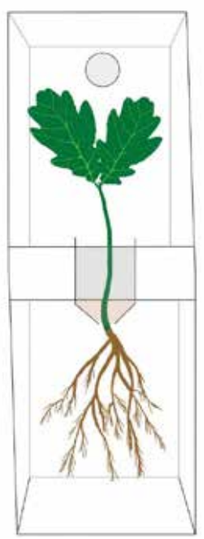
"Plant leaves and roots are already known to harbor distinct microbial communities, as shown by several recent studies. In this study however, we were surprised to see that it is also true at an early stage of the plant development, and that the seed could, at least partially, be responsible for these differences", Says Ahmed Abdelfattah

"Several breeding companies are taking into consideration the seed microbiome in their programs hoping to have super plants with better genes and better microbes. One technique used, is to treat seeds with beneficial microorganism with the aim that those microbes will eventually colonize the plant and exert their effects throughout the plant's life", says Ahmed Abdelfattah.

The next step for the research team is now to discern which is the major source of the of the microbiome - the environment or the seed.

Journal Reference:

Credit: Stockholm University: Find the article in Environmental Microbiology, "Experimental evidence of microbial inheritance in plants and transmission routes from seed to phyllosphere and root": https://doi.org/10.1111/1462-2920.15392 Photos by: Ahmed Abdelfattah



RESEARCHERS SOLVE RIDDLE OF PLANT IMMUNE SYSTEM

How do plants build resilience? An international research team led by the University of Göttingen studied the molecular mechanisms of the plant immune system. They were able to show a connection between a relatively unknown gene and resistance to pathogens. The results of the study were published in the journal The Plant Cell.

Scientists from "PRoTECT" - Plant Responses To Eliminate Critical Threats - investigated the molecular mechanisms of the immune system of a small flowering plant known as thale cress (Arabidopsis thaliana). PRoTECT is an International Research Training Group (IRTG) founded in 2016 with the University of Göttingen and the University of British Columbia in Vancouver. The aim of the study was to identify and describe a specific gene of a particularly disease-resistant plant. The team observed that plants that do not possess this previously little known gene strongly accumulate active acids. In addition, these plants show a significantly increased resistance to pathogens. However, this resistance is accompanied by extremely reduced growth.

"We have succeeded in deciphering the molecular connection between the gene product and the inactivation of the acids during normal plant growth," says Professor Ivo Feußner from the Göttingen Centre for Molecular Biosciences (GZMB).

Understanding this interaction provides scientists with a promising approach to improving the natural resistance of crops. "The basic results can be used to help breeders isolate less susceptible plants," says Lennart Mohnike, first author of the study. "This offers scientists an important way to increase food security and could lead to reduced pesticide use."

Lennart Mohnike collecting leaf material from bacteria infected plants

THE REGULATORY NETWORK OF SUGAR AND ORGANIC ACID IN WATERMELON FRUIT IS REVEALED

Recently, the innovation project watermelon and melon cultivation and physiology team of Zhengzhou Fruit Research Institute has made new progress in the metabolism regulation of sugar and organic acid in watermelon fruit.

The changes of sugar and organic acid during the fruit development were analyzed and the key gene networks controlling the metabolism of sugar and organic acid during the fruit development were identified.

These results provided a theoretical basis for watermelon quality breeding, which had important scientific significance for the development of watermelon industry and the improvement of watermelon breeding level in China.

The related research results were published in the journals of Horticulture Research and Scientia Horticulturae.

The sensory quality of watermelon fruit is determined by the content of sugar and organic acid, which determines the taste of watermelon during the development and maturation of watermelon fruit.

The sweet watermelon '203Z' and sour watermelon 'SrW' of its isogenic line were used as materials, the genes and gene networks co-expressed with glycolic acid metabolism were searched through WGCNA analysis of transcriptional and metabolite data.

Three gene expression networks were identified, including 2443 genes that were highly correlated with sugar and organic acid metabolism in watermelon fruits.

Seven key genes involved in sugar and organic acid metabolism of watermelon fruits were screened by significance and qRT-PCR analysis.

Among them, Cla97C01G000640, Cla97C05G087120 and Cla97C01G018840 were sugar transporters. Cla97C03G064990 was a sucrose synthase. Cla97C07G128420, Cla97C03G068240 and Cla97C01G008870 were highly correlated with malic acid and citric acid, which were the transporters and regulators of malic acid and citric acid.

These genes were verified in the natural population, and the results showed that the expressions of these 7 genes were significantly positively correlated with the contents of sugar and organic acid in watermelon fruit.

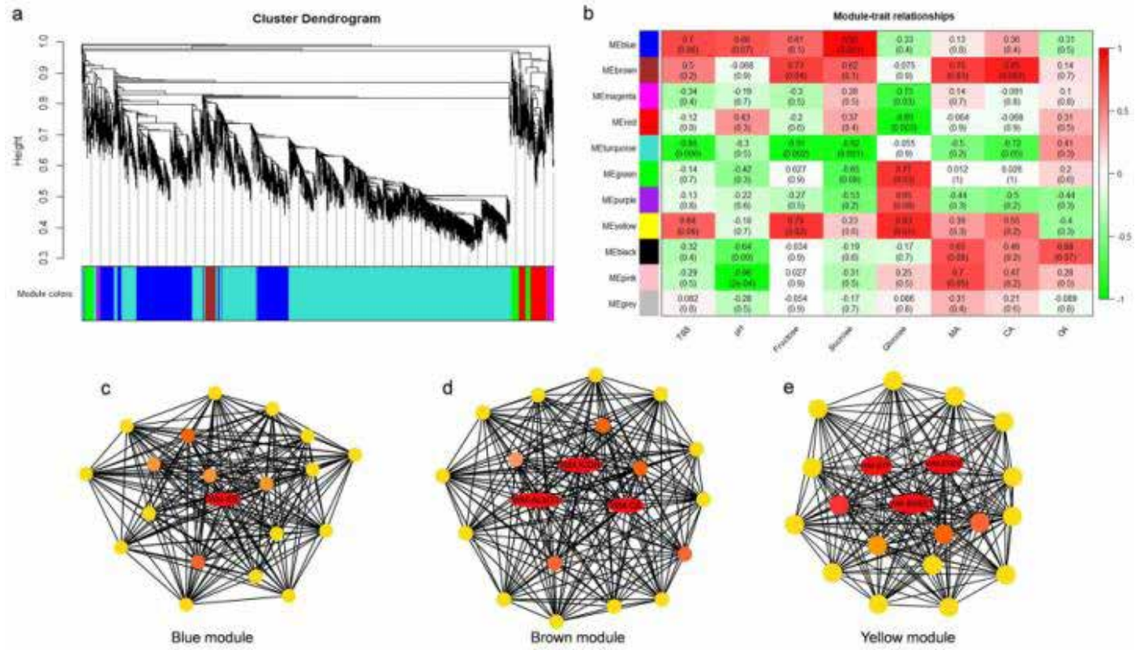


Figure 1 Gene networks and key candidate genes involved in sugar and organic acid regulation during watermelon fruit development

Credit: Zhengzhou Fruit Research Institute

FLOWERY DIETS HELP PREDATORY INSECTS HELP FARMERS KEEP PESTS IN CHECK

Good news for the green transition: Flowery diets help predatory insects help farmers keep pests in check Predatory insects have been shown to live longer when they have access to nectar and pollen, according to a new study by researchers at the University of Copenhagen. Thus, flowers don't just benefit insects, they help farmers farm sustainably. Predatory insects are skilled pest controllers whose hunting reduces the need for agricultural pesticides.

Until now, it was believed that predatory insects needed prey to survive. But in a systematic review conducted at the University of Copenhagen's Department of Plant and Environmental Sciences, researchers collected, compared and analysed data from studies around the world to conclude that most predators benefit greatly from flowers, and can even survive for extended periods of time on nectar and pollen alone. Thus, farmers can promote a consistent production of natural enemies to defeat pests by incorporating flowering strips and flowering margins in their fields:

"By planting flowering margins and strips alongside fields, one can ensure an ever-abundant supply of predatory insects such as hoverflies, lacewings, minute pirate bugs, phytoseiid mites and two-spot ladybugs. Pollen and nectar are supplements that beneficial insects can survive on when pests aren't around. And, the plants in margins and strips provide many other types of insects for to prey on as well. By planting a wide variety of flowers that bloom both early and late in the season, one can ensure for an optimal effect that ensures the survival of predators throughout the growing season," says Associate Professor Lene Sigsgaard of the Department of Plant and Environmental Sciences. She adds:

"This is good news for the green transition, as effective pest control can help reduce the use of agricultural pesticides. On top of the that, the presence of more flowers improves pollination and biodiversity, as they attract more insects and pollinators into fields."

The researchers underscore that in order for predatory insects to access flower nectar, easily accessible open flowers need to be planted, as predatory insects aren't equipped with the long feeding tubes that bees have. Examples of open and beneficial flowers are wild carrot, ox eye daisy, dill and dandelion.

Up to 8 times longer lives on the best flowers

Food from flowers boosts energy for predators. Specifically, the researchers found that across all predatory insects, females survive 2.2 times longer with access to flowers, and males 1.7 times longer, compared to insects that only have access to water, but no flowers.

Still, not all predatory insects and flowers are the same. Some predators manage to lay eggs with access to flowers alone. Of the 17 predatory insect species tested with more than one species of flowers, nine--including lacewings, two-spot ladybugs and minute pirate bugs--lived significantly longer with flowers. The lifespans of the remaining 8 species, including a predatory mite, were not significantly longer.

There are differences among flowers as well. With buckwheat, which has open flowers and is a cultivated crop, predator insects lived an average of 8.6 times longer than on water alone. Mallow, yarrow and ox eye daisy are also highly valuable flowers for predatory insects, while lotus and viper's bugloss, due to their deeper tubes, are less helpful.

'It's quite an elixir of life. Wisely planted flowers can contribute to robust crop production because predatory insects will live longer and better," says Lene Sigsgaard, who continues:

"It pays to design tomorrow's agriculture so as to accommodate wild flowering plants alongside fields. For the greatest impact, this needs to be done on an informed basis, which is why we are looking at how to design mixed flowering strips and flowering margins that benefit both predatory insects and pollinators. This will reduce the need for other forms of pest control while supporting biodiversity," says Lene Sigsgaard.

Use perennials and multiple species

The researchers recommend native, perennial flowers to create permanent habitats for predatory insects, places where they can winter as well. It is also important to have a wide variety of species that bloom during different seasons and benefit different insects. The researchers work with 30-40 different native species in the field, including grasses, which help make flower strips more robust.

The researchers are continuing to generate more knowledge about which flowers and flower combinations are particularly beneficial for insect life in general, and more specifically, for beneficial insects and their contribution to biological pest control and pollination.

Journal Reference:

The research results are published in the recognised journal Biological Control.

CRACKING A TOUGH NUT FOR MACADAMIA GROWERS

Macadamia researchers are breeding thinner shells for bigger kernels and tougher husks for resisting pests.

The University of Queensland's Professor Bruce Topp said these combined attributes would boost Australia's $270 million industry, which earns $190 million in export income annually.

"Two thirds of every harvested kilogram is in the weight of the macadamias' extremely tough shells. That's a lot of wasted productivity," Professor Topp said.

"The goal for many growers is to produce less shell and more kernel from each nut but with the shell still tough enough to resist pests."

Macadamias are native to south-east Queensland and northern New South Wales but are grown commercially in places including Hawaii, South Africa and Brazil.

UQ, industry and the Queensland Government are jointly funding the Queensland Alliance for Agriculture and Food Innovation research.

"Tough outer husks help protect the nuts from pests, and thinner, inner shells produce larger nuts and profits," said Professor Topp (pictured).

"Thinner shells however improve access for the macadamia nut borer, a native pest which causes a lot of damage to young fruit.

"This requires more on-farm management, but biological control strategies are used widely and successfully.

"Growers introduce wasps to control borer moths and owls to eat rats; rats and cockatoos quickly identify trees with thinner-shelled nuts."

Professor Topp leads the over-arching $2.2 million, Horticulture Innovation Australia–funded National Macadamia Breeding and Evaluation Program.

"Building on decades of macadamia research, we are trialling sophisticated genomic technologies in the field, aiming to boost Australian macadamia growers' productivity and profitability," he said.

Hort Innovation's Dr Vino Rajandran said the global macadamia industry was currently using cultivars more than 60 years old and just a few generations from the wild.

"As a comparison, almonds have been cultivated for millennia," Dr Rajandran said.

"Based on other horticultural tree crops, we estimate that the macadamia is only yielding around 30 per cent of its potential.

"We are identifying molecular markers for key growth and production traits in diverse, wild macadamia samples.

"We hope this research will make Australian-bred macadamia cultivars the commercial, global varieties of choice."

Macadamias are Australia's second-biggest nut export, predicted to be worth $350 million by 2025.

Professor Topp said the program also was breeding for genetic resistance to "husk spot", a fungal disease causing immature nut drop and cutting $10 million from industry profits a year.

It was also breeding smaller, warmer climate-adapted, high-yielding macadamia trees.

Professor Bruce Topp's research aims to improve production and profitability for the macadamia industry. (Photo: ABC Rural - Jennifer Nichols)

The goal is to breed a macadamia which produces nuts with thick husks, thin shells and large kernels. (Photo: ABC Rural - Jennifer Nichols)

Macadamia out of its husk.

Journal Reference:

This research is funded by Hort Innovation using the Macadamia Research and Development Levy, Australian Government contributions, with support from the Queensland Department of Agriculture and Fisheries and UQ.

BIOSENSORS MONITOR PLANT WELL-BEING IN REAL TIME

Researchers at Linköping University, Sweden, have developed biosensors that make it possible to monitor sugar levels in real time deep in the plant tissues - something that has previously been impossible. The information from the sensors may help agriculture to adapt production as the world faces climate change. The results have been published in the scientific journal iScience.

The primary source of nutrition for most of the Earth's population is mainly plants, which are also the foundation of the complete ecosystem on which we all depend. Global population is rising, and rapid climate change is at the same time changing the conditions for crop cultivation and agriculture.

"We will have to secure our food supply in the coming decades. And we must do this using the same, or even fewer, resources as today. This is why it is important to understand how plants react to changes in the environment and how they adapt", says Eleni Stavrinidou, associate professor in the Laboratory of Organic Electronics, Department of Science and Technology at Linköping University.

The research group at Linköping University led by Eleni Stavrinidou, together with Totte Niittylä and his group from Umeå Plant Science Centre, has developed sugar sensors based on organic electrochemical transistors that can be implanted in plants. The biosensors can monitor the sugar levels of trees in real time, continuously for up to two days. The information from the sensors can be related to growth and other biological processes. Plants use sugars for energy, and sugars are also important signal substances that influence the development of the plant and its response to changes in the surrounding environment.

While biosensors for monitoring sugar levels in humans are widely available, in particular the glucometer used by people who have diabetes, this technology has not previously been applied to plants.

"The sensors now are used for basic plant science research but in the future they can be used in agriculture to optimise the conditions for growth or to monitor the quality of the product, for example. In the long term, the sensors can also be used to guide the production of new types of plant that can grow in non-optimal conditions", says Eleni Stavrinidou.

The mechanisms by which plant metabolism is regulated and how changes in sugar levels affect growth are still relatively unknown. Previous experiments have typically used methods that rely on detaching parts of the plant. However, the sensor developed by the research group gives information without damaging the plant and may provide further pieces of the puzzle of how plant metabolism works.

"We found a variation in sugar levels in the trees that had not been previously observed. Future studies will focus on understanding how plants sugar levels change when plants are under stress", says Eleni Stavrinidou.

VENUS FLYTRAPS FOUND TO PRODUCE MAGNETIC FIELDS

The Venus flytrap (Dionaea muscipula) is a carnivorous plant that encloses its prey using modified leaves as a trap. During this process, electrical signals known as action potentials trigger the closure of the leaf lobes. An interdisciplinary team of scientists has now shown that these electrical signals generate measurable magnetic fields. Using atomic magnetometers, it proved possible to record this biomagnetism. "You could say the investigation is a little like performing an MRI scan in humans," said physicist Anne Fabricant. "The problem is that the magnetic signals in plants are very weak, which explains why it was extremely difficult to measure them with the help of older technologies."

Electrical activity in the Venus flytrap is associated with magnetic signals

We know that in the human brain voltage changes in certain regions result from concerted electrical activity that travels through nerve cells in the form of action potentials. Techniques such as electroencephalography (EEG), magnetoencephalography (MEG), and magnetic resonance imaging (MRI) can be used to record these activities and noninvasively diagnose disorders. When plants are stimulated, they also generate electrical signals, which can travel through a cellular network analogous to the human and animal nervous system.

An interdisciplinary team of researchers from Johannes Gutenberg University Mainz (JGU), the Helmholtz Institute Mainz (HIM), the Biocenter of Julius-Maximilians-Universität of Würzburg (JMU), and the Physikalisch-Technische Bundesanstalt (PTB) in Berlin, Germany's national meteorology institute, has now demonstrated that electrical activity in the Venus flytrap is also associated with magnetic signals.

"We have been able to demonstrate that action potentials in a multicellular plant system produce measurable magnetic fields, something that had never been confirmed before,"

said Anne Fabricant, a doctoral candidate in Professor Dmitry Budker's research group at JGU and HIM.

The trap of Dionaea muscipula consists of bilobed trapping leaves with sensitive hairs, which, when touched, trigger an action potential that travels through the whole trap. After two successive stimuli, the trap closes and any potential insect prey is locked inside and subsequently digested. Interestingly, the trap is electrically excitable in a variety of ways: in addition to mechanical influences such as touch or injury, osmotic energy, for example salt-water loads, and thermal energy in the form of heat or cold can also trigger action potentials. For their study, the research team used heat stimulation to induce action potentials, thereby eliminating potentially disturbing factors such as mechanical background noise in their magnetic measurements.

Biomagnetism -- detection of magnetic signals from living organisms

While biomagnetism has been relatively well-researched in humans and animals, so far very little equivalent research has been done in the plant kingdom, using only superconducting-quantum-interference-device (SQUID) magnetometers, bulky instruments which must be cooled to cryogenic temperatures. For the current experiment, the research team used atomic magnetometers to measure the magnetic signals of the Venus flytrap. The sensor is a glass cell filled with a vapor of alkali atoms, which react to small changes in the local magnetic-field environment. These optically pumped magnetometers are more attractive for biological applications because they do not require cryogenic cooling and can also be miniaturised.

The researchers detected magnetic signals with an amplitude of up to 0.5 picotesla from the Venus flytrap, which is millions of times weaker than the Earth's magnetic field. "The signal magnitude recorded is similar to what is observed during surface measurements of nerve impulses in animals," explained Anne Fabricant. The JGU physicists aim to measure even smaller signals from other plant species. In the future, such noninvasive technologies could potentially be used in agriculture for crop-plant diagnostics, by detecting electromagnetic responses to sudden temperature changes, pests, or chemical influences without having to damage the plants using electrodes.

Journal Reference:

Anne Fabricant, Geoffrey Z. Iwata, Sönke Scherzer, Lykourgos Bougas, Katharina Rolfs, Anna Jodko-Władzińska, Jens Voigt, Rainer Hedrich, Dmitry Budker. Action potentials induce biomagnetic fields in carnivorous Venus flytrap plants. Scientific Reports, 2021; 11 (1) DOI: 10.1038/s41598-021-81114-w

NEW CROPSCAN 3000X ON FARM WHOLE GRAIN ANALYSER

Next Instruments is pleased to introduce the NEW CropScan 3000X On Farm Whole Grain Analyser.

The CropScan 3000X has been introduced as a replacement of the CropScan 1000H Whole Grain Analyser which has been popular with grain farmers. The Cr3000X has been designed as a “little brother” to the popular CropScan 3000B and 3000BT. Using exactly the same optics and electronics, the Cr3000X provides excellent performance and a very simple user interface for measuring Protein, Moisture, Oil and Starch in wheat, barley, oats, sorghum, corn, soybean, canola, lupins, peas and others.

The most unique feature of the Cr3000X is the manually adjusted pathlength cell. Different grains require different pathlengths. The previous system, the Cr1000H, used a set of inserts or spacers to change the pathlength inside the grain flow cell. The Cr3000X uses a dial up mechanism which allows the operator to select the appropriate pathlength. The software prompts the operator to select the appropriate pathlength depending on the grain or oil seed to be analysed. This simple system has been copied from the Cr3000B which automatically adjusts the pathlength using a stepper motor.

The other advantage of the Cr3000X over the Cr1000H is the 7-inch Touch Screen PC user interface. The simple GIU provides operators the ability to select unlimited products with up to 5 constituents for each product, i.e., Protein, Oil, Moisture, Starch, Fibre and others. As well the built in Touch Screen PC has 8 GByte of storage, RS232, Ethernet and USB ports.

The CropScan 3000X can also be used with our CropNet Grain Data Management software on a second monitor. The in-built PC runs the CropScan 3000X software and CropNet simultaneously. When the Cr3000X predicts the Protein, Moisture, Oil etc results, it transfers the results to the CropNet software. The spreadsheet like format allows the operator to enter additional information including Field, Silo, Farm, Truck ID, Weight, Test Weight, Screenings, Retention, Variety, Grade and more. A virtual farm or silo complex is setup in the CropNet software that displays all silos, sheds, bins, bags or any other storage system.

As grains are segregated into each storage system, the running average for each constituent and the tonnage are stored and updated. As loads are shipped out the running average and tonnage are adjusted down. Simply click on any silo or bin and the running averages and tonnage will be displayed along with graphics options to show the content of each load of grain in and out of the silo.

The CropScan 3000X is the most powerful NIR grain analyser available at a price to suit medium to large farm. As the famous business guru Peter Druker once said. “You cannot improve something unless you can measure it.” The CropScan 3000X and CropNet software provides the complete set of on farm data at the click of a button.

CropScanAg Cloud Portal

The CropScan 3300H On Combine Analyser is transforming the way that farmers measure Nitrogen Availability and Uptake across their fields. The Protein layer provided across the field can be used to generate a wide range of field maps based on real Nitrogen measurements;

- Protein/Yield Correlation Quadrant Maps
- Nitrogen Use Efficiency Maps
- Nitrogen Removal Maps
- Sulphur Removal Maps
- Variable Rate Nitrogen Fertilization Prescription Maps

To assist farmers to organise, capture and download their data from the combine, Next Instruments has developed a new Portal for the CropScanAg Solutions Cloud Service. This portal is FREE to CropScan 3300H users who can create a CropScanAg Cloud Account and download the portal access address and sign-in code.

The portal allows users to download their Protein, Moisture, Oil etc data layers along with date, time and GPS coordinates.

ABANDONED CROPLAND SHOULD PRODUCE BIOFUELS

Growing perennial grasses on abandoned cropland has the potential to counteract some of the negative impacts of climate change by switching to more biofuels, according to a research group from the Norwegian University of Science and Technology (NTNU).

Researchers consider increased use of biofuels to be an important part of the solution to reduce CO2 emissions. But the production of plants for biofuels can have some unfortunate trade-offs.

Now, the NTNU researchers have come up with a scenario that would put less pressure on food production and plant and animal life.

"We can grow perennial grasses in areas that until recently were used for growing food but that are no longer used for that purpose," explains Jan Sandstad Næss, a PhD candidate at the Industrial Ecology Programme at NTNU. These areas are usually still potentially cultivable and have the advantage that they are already connected to farms, which means that the infrastructure is in place and they are close to markets.

The results from the study have now been published in Nature Sustainability.

Biofuels come in several varieties. Common to all is that plants are broken down and transformed into a product we can use as fuel in vehicles and machines, for example.

But corn, wheat, rapeseed and soybeans that become biofuels instead of food affect people's ability to feed themselves, making the choice for biofuels ethically questionable. Wild areas cleared to grow biofuels can compromise biodiversity.

In many of the scenarios that the researchers explored, the production of biofuels would not compete with food production or wilderness, but would use cropland that has been abandoned due to more efficient food production or because plant foods replace more land-intensive meat production.

The least controversial option for producing biofuels is the use of waste from industry, agriculture and forestry, but this does not generate nearly enough biofuel.

If we use areas that already have limited value for other purposes, the cultivation of biofuels will become more attractive for more people.

Until now, no one has calculate the extent of areas available for this type of grass cultivation. Næss and his colleagues Professor Francesco Cherubini and researcher Otávio Cavalett investigated the question by examining satellite images from around the world. Cherubini is also director of NTNU's Industrial Ecology Programme.

"We found 83 million hectares, or 830 000 square kilometres, of areas that until recently were used for food production but now no longer are," Sandstad Næss said.

These locations roughly correspond to the land area of Sweden and Norway combined, including Svalbard, or the equivalent of five per cent of the area currently used for food production worldwide.

These are areas that have been heavily affected by humans, so many species are already gone. Grass production could increase biodiversity.

The research group believes that most of these areas can be used to grow perennial grasses for biofuels instead of leaving them unused by humans. However, there is a large variation in how much this can cover of future biofuel demand.

Biofuel production on abandoned cropland "could provide the energy equivalent of between 6 and 39 exajoules each year. This corresponds to between 11 and 68 per cent of today's bioenergy needs and 2 to 47 per cent of the production of biofuels in 2050, given the assumption that we limit the temperature increase to 1.5 degrees Celsius," says Cavalett.

How much biofuel people can grow depends on many local factors and on how the areas are managed. Negative environmental impacts need to be weighed against the need for energy.

"We could generate around 20 exajoules every year if we increase land area by only 3 per cent and water use by 8 per cent. That scenario would mean we wouldn't disturb areas that are especially critical for biodiversity or that require a lot of irrigation," says Cherubini.

The researchers believe that growing perennial grasses for biofuels would simultaneously revitalize rural areas and provide more sources of income for farmers.

But this option won't happen by itself. Communities need to determine local climatic conditions and water availability, as well as local value chains and what kind of grass is best to grow there. These decisions therefore require that local and regional authorities collaborate to implement such a plan.

Journal Reference:

Jan Sandstad Næss, Otávio Cavalett and Francesco Cherubini. The land - energy - water nexus of global bioenergy potentials from abandoned cropland. Nature Sustainability. https://doi.org/10.1038/s41893-020-00680-5

SPILLING THE BEANS ON COFFEE'S TRUE IDENTITY

People worldwide want their coffee to be both satisfying and reasonably priced. To meet these standards, roasters typically use a blend of two types of beans, arabica and robusta. But, some use more of the cheaper robusta than they acknowledge, as the bean composition is difficult to determine after roasting. Now, researchers reporting in ACS' Journal of Agricultural and Food Chemistry have developed a new way to assess exactly what's in that cup of joe.

Coffee blends can have good quality and flavour. However, arabica beans are more desirable than other types, resulting in a higher market value for blends containing a higher proportion of this variety. In some cases, producers dilute their blends with the less expensive robusta beans, yet that is hard for consumers to discern. Recently, methods involving chromatography or spectroscopy were developed for coffee authentication, but most of these are labor- and time-intensive, or use chloroform for the extraction, which limits the types of compounds that can be detected. In some studies, researchers used nuclear magnetic resonance (NMR) spectroscopy to monitor the amount of 16-O-methylcafestol (16-OMC) in coffee, but its concentrations vary depending on geographic location and cultivar. So, Fabrice Berrué and colleagues wanted to build on their previous work with NMR to assess the chemical make-up of each coffee bean variety and confirm the blends of real samples.

The researchers extracted compounds from a test set of pure coffee and known blends with methanol and identified the compounds with NMR. The team found 12 compounds with measurable concentrations, and two had significantly different amounts between the coffee varieties. Elevated concentrations of 16-OMC were unique to robusta, while high concentrations of kahewol -- a compound previously found in coffee beans by other researchers -- were distinct in arabica. There was a direct, reproducible relationship between 16-OMC and kahewol concentrations found in the blends of the two varieties. The team then measured 16-OMC and kahewol levels, in addition to other flavour molecules, in 292 samples from producers around the world. They could successfully authenticate pure coffee, even with relatively low concentrations of the two indicator compounds. For samples in which the composition of blends was known, the team's predictions were within 15% of the actual ratio. The new method results in a more robust and reliable way to verify unadulterated coffee and predict blends than previously reported approaches, the researchers say.

Journal Reference:

Ian W. Burton, Camilo F. Martinez Farina, Subramanyam Ragupathy, Thirugnanasambandam Arunachalam, Steve Newmaster, Fabrice Berru&#2013265929;. Quantitative NMR Methodology for the Authentication of Roasted Coffee and Prediction of Blends. Journal of Agricultural and Food Chemistry, 2020; 68 (49): 14643 DOI: 10.1021/acs.jafc.0c06239

DRONE-BASED PHOTOGRAMMETRY: A RELIABLE AND LOW-COST METHOD FOR ESTIMATING PLANT BIOMASS

Remote sensing technology has become a vital tool for scientists over the past several decades for monitoring changes in land use, ice cover, and vegetation across the globe. Satellite imagery, however, is typically available at only coarse resolutions, allowing only for the analysis of broad trends over large areas. Remote-controlled drones are an increasingly affordable alternative for researchers working at finer scales in ecology and agriculture, but the laser-based technology used to estimate plant productivity and biomass, such as light detection and ranging (LiDAR), remain prohibitively expensive.

In research presented in a recently published issue of Applications in Plant Sciences, researchers used low-cost remote sensing technology to produce multispectral vegetation indices and 3D photomosaics of the vegetation in a tallgrass prairie, comparing aerial estimates of biomass with direct measurements taken in the field. Based on their results, photogrammetry is a reliable way to estimate biomass, landcover, and ecosystem productivity, with several potential cost-saving implications for conservation and agricultural science.

Researchers carried out remote sensing data collection on a tallgrass prairie restoration experiment at the Morton Arboretum in Lisle, Illinois.

"The restoration experiment is designed to determine whether or not phylogenetic diversity and functional diversity affect restoration outcomes," said senior author Andrew Hipp, the Plant Systematist and Herbarium Director at the Morton Arboretum.

To accomplish this goal, Hipp and his research team drew from a total of 127 prairie species, each of which was planted as a monoculture in 4 m2 plots. These species were also mixed in various combinations in multispecies plots of the same size, ranging from high, medium, and low phylogenetic diversity crossed with high and low trait diversity.

Lead author Lane Scher, a community ecologist at Duke University, saw the experiment's design as a unique opportunity to test the precision of photogrammetry-based estimates of biomass between monocultures and multispecies plots.

The researchers used a DJI Phantom 4 drone equipped with a standard camera as well as a multispectral sensor that would allow them to calculate various vegetation indices -- metrics based on ratios of light wavelengths that indicate the relative health and productivity of plant ecosystems.

By stitching together close to 600 overlapping images, the researchers created a set of mosaics of the study site, allowing them to calculate the height of the vegetation in each plot. By extrapolation, they were then able to estimate the total biomass of the tallgrass species.

Analytical comparisons made between the aerial- and field-based measurements indicate that estimates of biomass derived from photogrammetry explained up to 47% of the variation in biomass for multispecies plots, a fairly significant result that shows promise for this method.

"Of the metrics we used, volume was the best predictor of productivity, which is great news, because it's also the least expensive to measure," said Scher. Although the researchers used a multispectral sensor to obtain imagery for different wavelengths of light to calculate vegetation indices, their results suggest that a simple RGB camera is all that's needed to reliably estimate biomass.

These methods might not be as applicable to monocultures, however. The explanatory power of their model, which accounted for 47% of the variation in multispecies plots, dropped to 34% in monocultures, a trend that wasn't entirely unexpected by the team.

"In monocultures, you typically have only one layer of vegetation," said Scher. Plants of the same species and variety typically have the same growth form, with the result that most of the leaves compete for space in a single, crowded layer.

"In multispecies plots, however, vegetation can be more evenly spaced vertically," said Scher. Since 3D photogrammetry calculates volume as everything between the soil surface and the top layer of vegetation, plots with plants evenly distributed in height will likely give the most accurate estimates.

While future comparisons with similar LiDAR measurements will be useful in further constraining the accuracy of photogrammetry for the estimation of biomass, the present study outlines a simple, fast, and affordable method to reliably assess vegetation productivity at fine-scale resolutions across large study areas.

Credit:

Scher, C. L., N. Karimi, M.-C. Glasenhardt, A. Tuffin, C. H. Cannon, B. C. Scharenbroch, and A. L. Hipp. 2020. Application of remote sensing technology to estimate productivity and assess phylogenetic heritability. Applications in Plant Sciences 8(11): e11401. https://doi.org/10.1002/aps3.11401 Articles and materials published in Applications in Plant Sciences are licensed under a Creative Commons Attribution license (CC-BY-NC).

THE 2020/21 COTTON CROP – ADAPTING THE TECHNOLOGY

Australian growers have just finished planting the 2020/21 cotton crop, no doubt with plenty of optimism and relief after years of drought, but things could easily not go according to plan.

Background.

Two seasons ago there was not much cotton at St. George in southern Qld but one small crop had an average yield of 17.5 bales /ha. That means it almost certainly yielded over 18 bales/ha or 7.2 bales/ac in places, which is extremely substantial. It was well fertilised, irrigated on time, weeds were controlled and a late Pix, which is a growth regulator used in cotton, was applied.

It was also non Bollgard, so carried the Roundup Ready gene for weed control but not the Bollgard genes for larvae control. The field had not been cropped for the previous three years due to the drought and the season was hot and dry, which suits cotton. The few weeds were controlled by regular cultivations, or pupae busting as it is called in the cotton industry, because the life cycle of Heliothis armigera includes a pupal phase in the soil beneath the crop. Cultivation disrupts the life cycle by destroying the pupae. The crop was managed using full Integrated Pest Management so was sprayed only four times with a very good larvicide. That made it $150/ha cheaper to grow than Bollgard.

This result showed that under IPM sprayed non Bollgard cotton has a very high yield potential and can be very profitable. It also showed that a certain modern larvacide was very IPM compatible, because secondary pests such as whiteflies were never a problem. The same larvacide may even have suppressed the whiteflies, which confirms my experience with it at other locations and in other years.

I think it is also logical to reason that the ten or so years of growing Bollgard on the site before the drought, followed by the drought and the cultivations, reduced the numbers of Heliothis armigera pupae in the soil beneath the crop, which was a direct cause of the low Heliothis pressure.

The Refuge.

Almost all the Australian cotton crop is Bollgard 3, so requires a refuge which attracts moths, a large proportion of which is assumed to be homozygous susceptible to Bollgard and which will mate with any homozygous resistant survivors from the Bollgard. All progeny will be heterozygous and therefore totally susceptible to Bollgard. The refuge required when a grower plants Bollgard is either pigeon peas at 2.5% of the Bollgard area, unsprayed non Bollgard at 5% or sprayed non Bollgard at 100%, commonly called 50/50 cotton.

When a Bollgard resistant moth emerges from a pupa in the soil beneath the Bollgard crop it will search either the Bollgard again, or one of the refuges for a mate. Pigeon peas are the preferred refuge because they are supposed to be more favoured by Heliothis as a host crop compared to cotton and other common hosts like maize and sorghum. The purpose of the refuge has always been emphasised by the cotton entomologists.

However it is important to note that the number or proportion of Heliothis armigera moths in the refuge which is homozygous susceptible to Bollgard cannot be reasonably estimated from one year to the next. Alternate host crops including maize and sorghum are possible sources of H. armigera which are homozygous susceptible to Bollgard but the areas of all alternate hosts have been much reduced during the drought. The seasonal influx of Heliothis armigera moths to the cotton, most of which would be homozygous susceptible to Bollgard, has been extremely variable. There have been years when there have been literally no grubs in the pigeon pea refuge even in late February. We cannot be certain how effective the refuge is from one year to the next.

There is another problem with the pigeon peas. When planted in October, at the same time as the cotton, pigeon peas start flowering in late January. The cotton begins flowering in early December. Heliothis feed on floral structures, not leaves, as for example Spodoptera (armyworm) do, so any Bollgard resistant moths looking for a mate before late January will not find one in the pigeon peas. They will definitely find one in the Bollgard or the non Bollgard refuges and it may or may not be homozygous susceptible.

The pigeon peas only work as a refuge from late January onwards. I suspect under full IPM that might be enough. If not, the pigeon pea refuge may not be the mainstay behind the success of the Australian Bollgard cotton crop.

Common practice in Australia.

With Bollgard 2 the options were to plant 95% Bollgard with a 5% pigeon pea refuge or 90% Bollgard with a 10% unsprayed non Bollgard cotton refuge or 50% Bollgard plus 50% sprayed non Bollgard.

With the introduction of Bollgard 3 in 2015/16 the required refuge sizes were halved. Therefore the scientists believed that the inclusion of the third gene made the refuge less important or, if they had contrary opinions they were over- ruled and the decision to halve the refuges was commercially driven. The requirement for pupae busting was also removed if cotton was picked early.

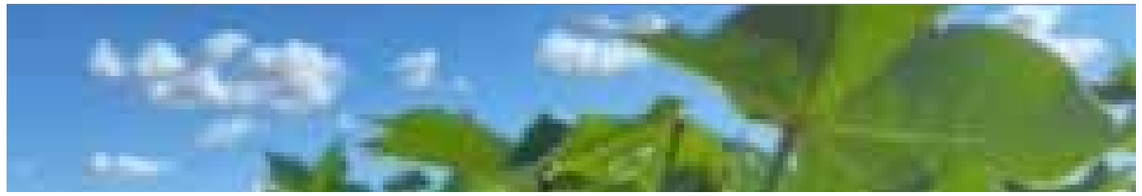
Most of the Australian crop is Bollgard 3 and much of that is planted with a 2.5% pigeon pea refuge. When compared to the non Bollgard crop at St. George it is fairly obvious that a lot of profit is being sacrificed by growing so much Bollgard instead of some Bollgard and some sprayed non Bollgard. It also seems obvious that non Bollgard, both sprayed and unsprayed, which flowers at exactly the same time as the Bollgard, would almost certainly be a better refuge than pigeon peas.

The argument in favour of pigeon peas is that Bollgard resistance frequencies have been fairly stable for well over five years. Of course that is true, but have the resistance frequencies been stable mostly because of the pigeon pea refuge or mostly because of the cultivations?

The American experience.

We know what will happen when a Bollgard resistance management plan is not adopted in full. The following information is taken from an article published in The Australian Cottongrower magazine (June - July 2020) by Dr. Sharon Downes and colleagues about the US cotton crop. Heliothis is evolving resistance to Bollgard because the resistance management plan has not been adopted in full and is not enforced. Both the success from adhering to this plan and the failure from not adhering to it have been clearly demonstrated.

In the US the seed companies still supply Bollgard 2 as well as Bollgard 3 to growers and the Bollgard 2 has often been sprayed



one or two times in the season with Altacor, which is a very good larvicide, to control survivors. This means Heliothis has become resistant to the first two genes, which are the best two, because the third one has higher background resistance, so Heliothis needs only to mutate once more to become totally resistant to Bollgard 3. There is clearly no understanding of the principle. If only Bollgard 3 were grown, mutations to all three genes would need to occur simultaneously for resistance to develop, which is mathematically much less likely than mutations to two genes.

The good news from the US is that another pest, pink bollworm, has been completely eradicated by Bollgard using non Bollgard cotton as a refuge and with strong cultivation. There was also pheromone mating disruption and mass release of sterile male pink bollworm moths. But in a country where both Bt cotton, that is Bollgard, and Bt maize are grown, and Heliothis is a major pest of both, the scientists believe that too few growers plant non Bt cotton or non Bt maize as a refuge.

Less than .1% of cotton growers in the US are telephoned by the regulator, Monsanto or Bayer, to estimate how much adherence there is by all cotton growers to the Bollgard Resistance Management Plan. This sampling method and sample size are ridiculous. In Australia we have observers in the field to verify adherence to the Australian Bollgard resistance management plan.

Clearly the fault for non adherence to the Bollgard RMP lies totally with the seed companies and the corporate regulator, not the farmers. That fault could be eliminated with the stroke of a pen. That it has not been eliminated speaks to the power of big business in the USA.

Ensuring the future of Australian Bollgard.

I suggest that the success of Bollgard in Australia to date is unlikely to have been mostly due to the pigeon pea refuge but more likely due to the planting of Bollgard 3 only, extensive cultivation and the action of Heliothis parasites and predators, the beneficial insects, through December and January. Advisors and growers who recommend and use full IPM with unsprayed or sprayed non Bollgard cotton as the refuge should never have a care growing Bollgard 3.

Whether or not the pigeon pea refuge flowers later than the cotton probably doesn't matter, provided the advisor and grower recommend and use full IPM. The life cycle of Heliothis is about 42 days long, depending on temperature, so it is possible for a Bollgard resistant moth to lay an egg on the first cotton flower bud in mid to late November at the earliest, then a life cycle later another Bollgard resistant moth be out looking for a mate in a refuge in early January. That is perhaps three weeks before the first pigeon pea flower opens, so when pigeon peas are the refuge, the period early to mid January is when the Heliothis parasites and predators are needed most. We need IPM with Bollgard just as much as we did with conventional cotton.

The 50% sprayed non Bollgard refuge seems to be rarely taken by growers even though it can be very profitable and is easily compliant with the Bollgard Resistance Management Plan. Even if it has to be sprayed more than four times, some band spraying is almost always possible and there is still a good profit margin compared to Bollgard. Using the modern larvacides in an IPM plan gives excellent larvae control and suppression of whiteflies.

The third refuge choice, namely 5% unsprayed non Bollgard, is also rarely taken, and I suspect in a few cases is not totally unsprayed with a larvicide. Has this, or might this one day cause a problem?

To date it has not, if done on a very large area it might, if done without IPM and cultivation it definitely would.

The US experience has shown us that the refuge and cultivation are the most important elements of a Bollgard resistance management plan. However the problem in Australia is not a few hundred hectares of "unsprayed" refuge being sprayed, it is the thousands of hectares of Bollgard which have been sprayed with Altacor in recent years, always supposedly because of "big egglays". Altacor is the best larvicide in the world, by all measures, yet it is being unnecessarily exposed to selection pressure which definitely will lead to resistance.

In the Australian summer the natural mortality rate of eggs can be easily 90%. There has not been any evidence of Bollgard 3 failing since it was introduced, Bollgard resistance frequencies have been stable, so why spray?

An extension of the 5% non Bollgard refuge option is to plant the refuge in strips 24 m wide within the Bollgard field, rather than in a separate block up to 2 km away as is presently most common. Like the Bollgard, the strips would be sprayed only for sucking pests and their location would maximise the movement of Heliothis parasites and predators, the beneficial insects, between the Bollgard and the refuge.

Of course this design is pointless if full IPM is not practised when managing sucking pests in the Bollgard and the strips. Spraying sucking pests is never urgent. The best IPM options are sulfoxaflor (Transform) and indoxacarb (Steward), band sprayed with a 24m boom or with a boom on the cultivator.

The new regulations which halve refuge sizes and minimise cultivation because a third gene has been added to Bollgard are unscientific and irresponsible. They promote volume over efficiency and risk management. Why do we need 2.5% more Bollgard when we can grow 15 bales/ha? As in the USA, the corporates are controlling Bollgard in Australia, not the scientists.

I thank Pat McGuiness for his helpful comments and ideas.

ENZYMES TO INCREASE NUTRIENT UPTAKE AND RESIDUE BREAKDOWN

AN emerging new product category for farmers, enzymes are destined to play an invaluable role in Australian agriculture – to convert unavailable nutrients like phosphate into plant-available forms, or to break down carbon residues and soil organic matter into available nutrients.

Enzymes are produced naturally in the soil by microbes and plant roots. By applying additional enzymes, growers are able to accelerate and enhance these natural processes.

USA life-sciences company Elemental Enzymes has isolated and patented many enzymes that improve the efficiency of nutrient-use in crops and pastures; provide better growth and returns from applied nutrients in fertilisers; speed up stubble breakdown; and boost overall soil health.

Depending on the type, enzymes can be applied in a variety of ways to suit current farming practices – including directly onto the soil surface in water or herbicide; in-furrow with liquid or solid fertiliser; as a side-dressing; or as a seed treatment.

Elemental Enzymes Australia national sales and marketing manager Chris Ramsey said the company's products replicated enzymes naturally secreted by plants and microbes, providing readily-available, highly-concentrated forms that disperse through soil, and quickly getting to work in a range of soil moisture and pH (5-10) conditions.

"The advantages of applying enzymes vs microbes are that enzymes are more consistent, and disperse more rapidly and widely in the soil. Reactions will begin as soon as they are applied and will continue for days up to weeks."

"Enzymes applied with fertiliser at planting start to work immediately and continuously near the seed, accelerating the release of plant-available nutrients so plants germinate into a nutrient-rich zone for better emergence and establishment."

Used by farmers in the USA for several years, two enzyme products Lumen and Res+ were tested in Australia last season, and will be introduced here by Elemental Enzymes, as soon as the necessary protocols are in place.

Lumen – an enzyme for use with liquid fertilisers or as a stand-alone side dressing – will enhance the uptake of water and nutrients by plant roots, improving plant growth and yield, and the health of soil and plants.

"This concentrated blend of two important enzymes will trigger soil organic matter to release bio-available nutrients and water to the plant, and stimulate native microbial activity. At the same time, it will act around the outer layers of the root tip to create ideal soil conditions for plant root growth.

"Suitable for all dryland and irrigated broadacre and row crops, Lumen will be ideal for planting and as side dressings during critical growth and nutrient-demand periods. Supplying the right amount of enzyme, where and when it is needed, will maximise the use of nutrients in fertilisers and from soil organic matter and residues."

Res+ will improve and accelerate residue breakdown in a wide range of environmental conditions,

kick-starting soil microbial activity and increasing potential yield of newly-planted crops.

"The liquid product contains a residue-degrading enzyme; chelated nutrients (including 5% N) to provide soluble nutrients to fungi and microbes for optimal stubble degradation; plus a humectant to lock in moisture and speed up natural degradation. The residue-degrading enzymes expose the lignin and cellulose for more rapid degradation of stubble by microbes.

"After harvest, Res+ sprayed onto stubble 0 to 4 weeks before the next sowing, or added to pre-planting knockdown and pre-emergent herbicides, will start stubble breakdown and trigger nutrient release, providing nutrient-rich soil prior to planting for improved crop or pasture establishment."

Chris said these first two Elemental Enzymes products would potentially be available for limited release in Australia for this winter broadacre cropping season.

"We will notify the market as soon as product is available in Australia."

Stalks of wheat stubble with red dye indicating the degree of degradation of cellulose after 7 days.
(Left) stubble untreated. (Right) stubble treated with enzymes, exposing lignin and cellulose enabling more rapid degradation by microbes.

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