DISCOVER — ENGAGE — IMPACT

PROMOTING PLANT PROBIOTICS

UQ researchers are calling for better regulation in the Australian crop probiotics industry to boost farmers' confidence and safeguard our future food supply through healthier crops.

Farmers should rely on science – rather than hype – according to UQ researchers who want to see commercial crop probiotics better regulated, and contribute to agriculture innovation aimed at achieving high-yielding crops with minimal environmental footprint.

The human gut is teeming with bacteria, both good and bad, and many of us turn to probiotics to boost our good bacteria. Research is ongoing to ensure that probiotics are delivering on the promise of improving our health. Farmers apply this same principle to plants, using crop probiotics containing beneficial microbes – or, micro-organisms – to boost plant health and growth.

However, many crop probiotics are ineffective, and while some help one crop they may inhibit another. Farmers can also be uncertain about whether a product is appropriate for their crop because manufacturers aren't currently required to provide sufficient product information and evidence that the product is helping crops.

Professor Susanne Schmidt, PhD student Shelby Berg and the team at UQ School of Agriculture and Food Sciences are working to reverse this trend. Experimenting with both sugarcane and vegetable crops, they have found that lax regulations around product testing, labelling and marketing in Australia limit the benefits of crop probiotics.

The team are developing mutually beneficial partnerships with industry bodies, such as one of Australia's largest horticulture nurseries, Wide Bay Seedlings, who want to use fewer harmful chemicals on their crops and deliver more resilient seedlings to their customers. This partnership could help improve product effectiveness, transparency and regulation in the Australian market.

"Our research has found that the quality of crop probiotics varies wildly," Professor Schmidt says.

"Many do not deliver the promised benefits, potentially depriving our farmers of genuine products developed and tested with scientific methods. Companies selling effective products are competing with those who just have a good marketing pitch.

"Biosafety is also an issue as it seems that probiotics importers can claim there aren't disease-causing microbes in their product, without hard proof."

The European Union's (EU) legislation around scientific testing stands in stark contrast to Australia's. Various EU countries require ten or more field trials, conducted over two growing seasons in different climates and soil types, to take place before a product is allowed to enter market. However, the Australian Pesticides and Veterinary Medicines Authority assess this need based on the crop's economic importance, and suggest up to ten field trials 'may be required.' It does not specify that tests have to be performed in Australia or that the information has to be made available.

It's these issues and discrepancies that have spurred Professor Schmidt and the team to research the intricacies of plant-microbe interactions and delve deeper into Australia's crop probiotics industry. Their research challenges the 'one size fits all' approach to crop probiotics in Australia, and aims to advance the design of effective crop probiotics.

"We want to support the transition of agriculture towards practices that are based on ecological principles, improve crop health and performance, and reduce the input of agrochemicals that cause damage to the environment and people," Professor Schmidt says.

In collaboration with sugarcane and nursery industries, Professor Schmidt, Mrs Berg and the team have tested commercial probiotics as well as microbes that naturally occur in Australian soils to evaluate if they have plant growth promoting effects.

"Microbes naturally live in soil and are also included in many crop probiotics," Mrs Berg says.

"Using DNA-technology, we can track microbes from the commercial probiotic product, to the soil and the crop, and determine if the probiotics change the microbial communities to boost more beneficial bacteria or fungi. Lastly, we quantify if there are direct crop benefits – faster growth, increased resilience, or improved yield," Mrs Berg says

When the right microbes are applied in the right conditions, crop probiotics can help plants overcome stresses, such as drought, high temperatures, insects or pests, soil toxicity and nutrient limitation.

"There is scientific evidence that beneficial bacteria can help crops – for example,

Pseudomonas putida enhances the growth of wheat under heat stress, and some types of Bacillus subtilis produce cytokinin, a beneficial plant hormone that reduces the effect of drought-induced suppression of growth," Mrs Berg says.

But while these benefits have been regularly reported in laboratory studies – and are promoted on the labels of products – the real-world outcome can be entirely different. The microbes in probiotics have to compete with resident microbes in soil and effectively communicate with the crop. There is no guarantee that probiotics tested overseas are effective in Australian climates, soils and crops.

"Scientifically valid experimentation needs more emphasis – that is, in relevant settings, over several years and across multiple regions and soils," Professor Schmidt says.

During their testing, the team discovered that commercial products and microbes that the team had isolated from Australian soils, varied in their effect on crops exposed to different conditions, meaning more investigation is required to prove their usefulness for farmers.

"We're searching for microbes that improve the performance of seedling in the nursery and when planted into fields," Professor Schmidt says.

"In recent experiments at Wide Bay Seedlings, one of Australia's largest horticulture nurseries, three commercial probiotics and one of our candidate microbes did not improve seedling performance.

"We are currently investigating whether this is because microbes and plants do not interact, or whether the microbes are only helping seedlings when they are stressed. Understanding the mechanisms will inform the next steps towards effective products."

When testing commercial probiotics at a North Queensland sugarcane farm in collaboration with Herbert Cane Productivity Services Limited (HCPSL), the team looked at whether the microbes can proliferate in soil or with sugarcane.

"None of the bacteria in the products took hold in soil or roots, but we saw some indirect effects, as the fungal community associated with sugarcane roots changed," Professor Schmidt says.

"Whether this finding is meaningful can only be answered with further investigation. The field experiment was limited to one year, and crops receiving microbes did not grow better than the ones that didn't."

Following these experiments, the team is now taking a deeper look at the traits of microbes and their potential applications.

"We identified numerous microbes with beneficial traits and are testing them for their potential as crop probiotics. The second line of research is to work out how microbes can best be formulated into efficient products," Professor Schmidt says.

"With human probiotics, encapsulation ensures that microbes pass the stomach and are safely released into our gut where they are active.

"We are exploring this principle for crop probiotics in collaboration with UQ material engineers."

"Overall, we believe that a more nuanced approach is required to make this technology work, with effective delivery of probiotics designed for particular crops and environments," Professor Schmidt says.

Industry engagement is the next step.

"Collaborating companies like Wide Bay Seedlings will benefit from government incentives that aim to boost research and development (R&D) in agriculture, and companies that deliver effective probiotics will have an advantage," Professor Schmidt says.

"Our hope is that further R&D will lead to more rigorous, multi-year testing, much like the EU's process, which is regulated and standardised. We also hope this research will help drive policy change in Australia to adopt the EU model within the next three to five years.

"The flow-on effect would mean clearer and more consistent product labelling that details delivery methods and required dosage, with benefits for farmers, the environment and consumers," Professor Schmidt says.

She cautions that the industry needs to remain mindful of the bigger picture.

"Those who are looking for a silver bullet may be disappointed. Probiotics are not going to solve all problems, but they certainly have potential to help agricultural industries to step up to the challenge of feeding our growing global family."

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(Image: Shelby Berg; words: Jai Morton)

Highlights to date:

2015: The team publishes foundational research characterising bacterial and fungal communities in sugarcane roots and soils in Scientific Reports and Environmental Microbiology.

2016: The team tests commercial probiotics in a sugarcane field in collaboration with Herbert Cane Productivity Services Ltd., and at the Wide Bay Seedlings nursery.

2016: Foundational research is published by lead author Dr Chany Paungfoo-Lonhienne in the Scientific Reports article 'Cross talk between sugarcane and a plant-growth promoting Burkholderia species'.

2016: The team participates in the Australia-wide 'Biomes of Australian Soils Environment soil microbial diversity database' published in Gigascience.

April 2017: The team publishes article in The Conversation expressing concern about crop probiotics in Australia.

May 2017: Led by Dr Richard Brackin, the team publishes article 'Soil biological health – what is it and how can we improve it?' in Proceedings of the Australian Society of Sugar Cane Technology.

August 2017: Led by UQ microbiologist Professor Phil Hugenholtz, article is published in Nature Communications revealing that plants have evolved to share a core microbiome.

In progress: The team is further developing publications outlining the results of probiotics research, while initial funding received (UQ, Wide Bay Seedlings) will also advance knowledge for a comprehensive project to develop effective product/s and delivery technology.

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