DISCOVER — ENGAGE — IMPACT

GUARDING OUR CROPS

UQ scientists joined forces to develop a breakthrough that has the potential to bolster global food security.

An estimated 795 million people across the globe do not have enough food to lead a healthy life.

That's one in every nine people.

It's a sobering statistic, and one that has troubled Queensland Alliance for Agriculture and Food Innovation (QAAFI) agricultural biotechnologist Professor Neena Mitter for years.

"Coming from India, agriculture is in my DNA," Professor Mitter said.

"I'm passionate about being able to drive solutions that can make a difference to farmers. That led me to come to Australia to fulfil my dreams of doing innovative research to make a difference.

"Crop viruses are part of the pest and pathogen burden that reduces global food production by a massive 20 to 40 per cent and, with so many people going without, we simply can't afford for our global food resources to go to waste."

Professor Mitter has joined forces with other scientists at QAAFI and the Australian Institute for Bioengineering and Nanotechnology (AIBN) to find a solution to this threat to global food security.

Together they have a developed a breakthrough called BioClay, an agricultural nanotechnology innovation that could help reduce food production losses to pests and pathogens, without the toxic environmental impacts of current chemical sprays.

Professor Mitter said, until now, the platforms available to protect crops were either through using insecticides and pesticides, or through genetic modification. But both these methods have certain hurdles.

"With insecticides, the issues involve toxicity and resistance," she said.

"Existing insecticides are broad-spectrum insecticides that can damage not only the pests we are targeting, but can also impact other flora and non-pest insects.

"With genetic modification, there are issues surrounding acceptance and regulation."

BioClay uses a plant defence mechanism known as RNA (ribonucleic acid) interference, or gene silencing, which has been used to develop genetically modified, transgenic, disease-resistant crops.

But in this case, Professor Mitter's team is delivering gene silencing as a non-genetically modified, non-toxic spray by partnering it with clay nanoparticles, co-developed by former UQ Professor Max Lu and AIBN Professor Zhi Ping (Gordon) Xu.

"The key element here is that double-stranded RNA (dsRNA) is the trigger molecule for gene silencing – we just take that sequence from the pathogen, load that sequence on the clay molecule, and then we have this wonderful spray that we can use to protect crops," Professor Mitter said.

"The possibilities for BioClay are endless. But our first point of call is protection against viruses, especially in vegetable crops.

"The only way farmers can protect their fields from viruses is either by uprooting the plant, or by using pesticides.

"BioClay actually uses the sequence from the virus itself. We load it onto the clay nanoparticles and we spray it. It acts like a vaccination for plants, whereby the dsRNA is slowly released onto the surface of the leaf, it enters into the plant, and the plant is primed for defence. So once we have sprayed, the clay particle acts as a controlled-release mechanism.

"This clay is absolutely degradable. The clay left on the surface simply degrades in the presence of natural carbon dioxide and moisture."

Professor Mitter paid tribute to Professor Lu, UQ's former Provost and current University of Surrey Vice-Chancellor, for his support in the early stages of the development of BioClay, and for initiating the partnership with other UQ scientists at the AIBN.

"I was giving a lecture on gene silencing in 2011 and Professor Lu happened to be listening to that seminar," Professor Mitter said.

"We later had a meeting and I highlighted that I wished we could deliver the gene silencing method as a spray. That's where the genesis of the idea was born, and he suggested I meet with his AIBN colleague Professor Xu."

Professor Xu's contribution was to develop a nanoscale clay matrix that is ideally suited to protect dsRNA once it is sprayed onto a crop.

The specially designed matrix forms minuscule, stacked layers that can be compared to puff pastry. These degrade naturally, but in the process they dramatically extend the dsRNA's protection period.

"When the idea of BioClay was being developed, the issue with using dsRNA as a spray was that if you spray it on a plant it isn't stable; it will disintegrate within three to five days," Professor Xu said.

"We were able to provide a delivery vehicle that is loaded onto the plant and can last on the leaf's surface for 30 to 40 days, providing an elongated window of protection."

BioClay has received significant support from UniQuest, UQ's main commercialisation company based at St Lucia. UniQuest has helped drive the commercialisation of BioClay through a partnership with Nufarm Ltd, a worldwide manufacturer of crop protection products.

Nufarm's global lead for transformational innovation Mike Pointon said issues with chemical-based crop protection were increasing across the world.

"We are seeing targets evolve chemical resistance, there is regulatory pressure on active ingredients due to toxicity concerns, and the cost of discovery for new chemicals is enormous," he said.

"That means Nufarm is very interested in new crop protection technology. BioClay circumvents key problems caused by chemical sprays as there are no toxic compounds or breakdown products associated with it.

"It does not leave problematic residues on food. It is applicable across plant crops, from cereals through to horticulture. It is highly specific, affecting only the dsRNA-targeted pathogen. And, should resistance emerge, the dsRNA can be tweaked to get around it."

"Best of all, the same approach has the potential to be applied to other classes of disease-causing pathogens, such as fungi."

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THE STORY SO FAR:

2011: The idea of using clay nanoparticles to deliver RNA interference as a spray is first conceived

2012: UQ scientists receive Gates Foundation Grand Challenges Explorations Award to develop the BioClay formulation for combating biotic stresses – the only Gates Foundation award of its kind given in the area of agriculture in Australia (a total of 23 projects, out of more than 2700 global applicants, receive awards in 2012)

2014: UQ scientists receive a Queensland Government Accelerate partnership grant, with Nufarm Ltd joining as an industry partner

2015–16: It works! BioClay spray is shown to protect plants from viruses on both sprayed and new leaves in glass houses

2017: Article about BioClay in *Nature Plants* attracts worldwide attention

2017–ongoing: Commercial formulation and registration of BioClay to target viruses is developed, as well as the translation of BioClay to target other pests and pathogens