Indigo launches water efficiency product for cotton

Indigo, a company based in Boston, has launched its first commercial product – Indigo Cotton – which helps improve the plant’s water use efficiency.

The company utilises fungal endophytes within plant tissue to help optimise crop health and improve productivity. To date, Indigo has tested these microbes on more than a dozen different crops across three continents in four growing seasons. According to Indigo reports, the company’s cotton trials have consistently shown 10 per cent or greater yield increases under targeted stress conditions, including water scarcity.

The Indigo Cotton product has been planted on more than 50,000 acres in five US states this year.

The product was born in the lab of Texas A&M entomologist Dr Greg Sword. In an Australian twist to the story, Greg’s work on fungal endophytes in cotton originated in Australia while he was on the faculty at the University of Sydney. And the product will soon be available in Australia (see box story). Greg was kind enough to answer a few questions on the development of Indigo Cotton.

Q: Can you give some details of your initial trial results which led you to seek a commercial partner?

A: I first published a paper in 2013 (Ek-Ramos et al. 2013) about the fungal endophyte collection that I had made from cultivated cotton grown in Texas, the biggest cotton producing state in the country. At the end of that paper, I mentioned that the next step in the research was to start looking at some of the effects that these endophytes might have in conferring stress resistance to the plants – because at the time their roles in cotton and other plants had been more or less completely ignored.

When I was contacted in 2013 about the fungal endophyte collection by Geoff von Maltzahn from Flagship Enterprises (the precursor to what is now Indigo Ag), my lab had already done some work showing that some of the endophytes could confer resistance to cotton against insects and nematodes. Most importantly, I had already conducted two years of field trials on my own, something which was relatively rare in fungal endophyte research, and clearly shown that increases in yields were possible in plants treated with fungal endophytes.

The result was a licensing and research agreement between Texas A&M University AgriLife Research and what is now Indigo Ag giving them exclusive rights to commercialisation and allowing us to conduct collaborative research on the various endophyte strains.

Q: And a bit of background on the Sydney University connection?

A: I was first introduced to fungal endophytes by Peter McGee from Sydney University. He was responsible for some of the seminal work showing that fungal endophytes collected from plants including cotton could be involved in conferring resistance to insects. At the time, I was also a faculty member there in the School of Biological Sciences. Peter was looking for an entomologist to collaborate with, and we co-advised a PhD student on a fungal endophyte project.

One of the papers from that work (Gurulingappa et al, 2010) has gone on to be a pretty important early paper demonstrating the potential for fungal endophytes to colonise and confer insect resistance in a variety of crops (wheat, corn, tomato, cotton, bean and melon). Peter McGee is now retired, but I have been giving him regular updates about how the fungal endophyte work that he originally introduced me to has grown.

Q: How do the endophytes work? That is, what is the process by which the endophyte increases cotton yield? Does it improve the water extractive ability of the roots or does it change the physiology of the plant so that it uses less water?

A: This is the great unknown right now. A mountain of evidence is accumulating showing that the manipulation
of fungal endophytes in plants can have positive effects on plant growth, stress resistance and yields. Yet, precisely how, mechanistically, this occurs is still under investigation by my lab and may others. There are many hypotheses, and they are not at all mutually exclusive, meaning that several mechanisms could be operating at once.

In some cases it may be that specific chemicals produced by the fungi are important, but in other cases it may also be that the fungi alter how the plants uses its own defense mechanisms to protect against stress such as water loss. Another possibility could be that the presence of the target fungus affects the ability of other microbes to colonise the plant, and it is these other microbes that actually causing the effects we observe.

Independent of Indigo Ag, my lab is currently actively engaged in federally-funded research looking at how the presence of fungal endophytes in cotton alters plant hormone signaling and gene expression in the plant in response to drought stress as well as insect attack.

Q: Why cotton? Does it work as well in other plants?
A: The specific choice of cotton was more or less an accident of history. In 2011, I began my appointment as the Charles R. Parencia Endowed Chair in Cotton Entomology at Texas A&M, so cotton was the logical choice to go exploring for endophytes! If I’d been appointed as an endowed chair in avocado entomology, maybe we’d be talking about avocados right now! Jokes aside, I’d been appointed as an endowed chair in avocado entomology, so cotton was the logical choice to go exploring for endophytes! If we had to protect against stress such as water loss. Another possibility could be that the presence of the target fungus affects the ability of other microbes to colonise the plant, and it is these other microbes that actually causing the effects we observe.

Q: Where did you find the endophytes? Are they naturally occurring in cotton (and other) plants?
A: All plants sampled to date have been shown to harbor endophytes. In fact, is not incorrect to view a plant as a scaffold housing an incredibly diverse array of microorganisms. The fungal endophytes I cultured from cotton were naturally occurring. When we inoculate them back to the plant, all we are doing is trying to bias the plant to being colonised by the microbes we want to have in there, but they all originally came from the plant in the first place.

We have also clearly shown that a single strain of fungal endophytes capable of colonising many different species of unrelated plant, so they are not species specific. But the effects that the endophytes may have are not necessarily the same across all plants. They may be beneficial in one crop, but have no discernible effects in other plants.

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Q: Without giving away any secrets, is this a once-only, or the first in line of useful products?
A: I can’t speak to what Indigo has in the pipeline, but it is safe to say, and we have already published data indicating, that there are multiple different endophyte strains that are capable conferring different types of beneficial effects to plants.

Q: The press release says no changes to planting rate, fertiliser or pesticide use. But wouldn’t a more vigorous plant require extra inputs?
A: In principle you are probably correct, but another way to look at it is that given the same level of inputs and/or costs by a grower (which can be constrained by many things including the availability of water or $$$), those plants that have been treated with a given endophyte will perform better than untreated plants. A positive effect on yields without increasing input costs to a grower should be a net gain.

Investor interest

Indigo is obviously very excited about the product, and so are investors. As Indigo rolled out its cotton product, the company also announced that it had closed a $100 million Series C investment—the largest private equity financing in the agriculture technology sector. These funds will be used to expand ongoing research and development efforts, extend Indigo’s team, and to scale commercial operations in preparation for the launch of the company’s second product offering—Indigo Wheat—which is being planted this year.

According to Indigo spokesperson, Natacha Gassenbach, the company has now tested their beneficial microbes on more than 12 different crops on three different continents over five growing seasons, and the results are consistently showing 10 per cent and higher yield benefits on crops grown in targeted stress conditions.

“For farmers, the yield productivity will help improve grower profitability while increasing capacity to feed a growing population amid increasingly challenging weather conditions,” says Natacha. “For consumers, we can begin to make vital changes in how our food is grown; like being more efficient with water, and reducing the reliance on nitrogen fertiliser and pesticides over time.

“In the cotton trials this year, we are encouraged by visible differences in root and stem development and overall plant health in treated versus untreated acres. We have just begun to collect preliminary data from the fields in Southeastern US and plan to collect initial data from Texas by the end of November. The full results should be available by early/mid January.”

Round bales of the first Indigo-treated cotton to be picked. Full results should be available early in the new year.
The company is experimenting with different models that allow them to share risk and reward with growers. This is now a familiar theme for growers in the new world of biochem products.

Indigo is applied as a microbial seed coating, just like any fungicide or insecticide. When the seed germinates, the microbes colonise the plant, and multiply. By leveraging each microbe’s unique performance attributes, the presence and diversity of these beneficial microbes yield more abundant, healthier crops that are more resistant to stresses like insufficient water, low nitrogen, high temperature and salty soils.

Indigo is expected to have application in both dryland and irrigated situations because it is claimed to allow the plants to use the water available to them more efficiently.

The company is planning an ambitious rollout of the product.

“We’re already harvesting Indigo Cotton in the US,” says Natacha, “and are in the midst of planting Indigo Wheat, which will be harvested starting (northern) summer 2017. We are planning to launch in several additional crops and multiple geographies within the next few years.”

And when are we likely to see Indigo in Australia, or is it already here?

“Australia is one of the key priority markets for Indigo and we plan to conduct field trials in 2017 pending regulatory approval. We are also looking into promising collaborations to expand our innovation reach. For example, we have announced a partnership with Flinders University (see box story).”

**INDIGO COMES TO AUSTRALIA**

South Australian research that improves wheat, pasture and other crop yields has sown the seeds for global distribution deals and a timely partnership with US agricultural technology company Indigo Ag Inc.

The research, led by Flinders University with State Government and industry partners, could reap rewards for food production around the world.

The global licensing agreement between Flinders and Indigo revolves around a series of specially selected plant microbes (endophytes) that can promote more robust plant growth for major grain and pasture staples – without the cost of additional chemical fertilisers and pesticides.

Thousands of endophyte strains, which occur naturally within healthy crop plants, had to be tested to arrive upon the ‘winning formula’ – first in lab trials and then in the field.

“With a significant gap between current food production and the anticipated needs of the growing world population, there is a real urgency to bring new innovation to agriculture,” says David Perry, CEO and Director of Indigo. “Partnerships and collaborations like the one with Flinders are essential in developing microbiome products that can serve growers, consumers and the environment,” he says.

Under the terms of the agreement, Indigo and Flinders will partner in further development of the elite SA strains, with the goal to bring to market products that are designed to complement a plant’s natural processes to improve resilience across each phase of plant development while boosting crop yields.

The elite SA strains have been extensively studied in legumes and have the potential to be beneficial to other crops. The research was conducted by Flinders University and the South Australian Research and Development Institute (SARDI) – the research division of Primary Industries and Regions South Australia (PIRSA) – with funding from Flinders and the Grains Research and Development Corporation.

The research commenced more than a decade ago when Professor Chris Franco, using his background in antibiotic development in the pharmaceutical industry, experimented with taking ‘beneficial microbes’ or microbiotics from human health into the plant world.

“The partnership with Indigo is very exciting for our plant microbe discoveries as it can support both IP development and large-scale trials in the field both in South Australia and overseas,” Professor Franco says. “Our early studies confirmed the potential of the discoveries, with field trials with microbes treated as vital seed inoculants for lucerne production showing very promising results.”

In other small-scale trials, the local researchers also found certain microbes interacted with other microbes to dramatically improve nitrogen fixation in pastures and legumes, with increased yields of up to 50 per cent seen in lucerne pasture and soybeans.

SARDI scientist Ross Ballard says the new microbes, when added to routine inoculation, improved nodulation and overall plant growth.

The SA team also discovered other microbes for wheat and barley that can lift harvests by up to 10 per cent and some of them control common diseases that regularly reduce yields.

The microbes can be incorporated at seeding time, including as coating on the seeds with the intent to promote faster and healthier growth.

“It’s always very difficult to take new research into the field, so we’re very happy to have some big backers on board to explore the potential of our discoveries,” Professor Franco said.

“Finally we have got a real opportunity to get this sustainable technology onto the world stage,” he says, acknowledging the contribution of Flinders and SARDI researchers Mr Ballard, Dr Steve Barnett, Sophia Zhao and former PhD student Hoang Xuyen Le.