

A boost from within

“Of particular interest is the role endophytes play in nutrient acquisition.”

Technical Bioscience insider

There are many times in a crop plant's life that it may need a nutritional boost. *CPM* finds out how an endophyte seed treatment can do just that, making the plant more efficient at using nutrients and it does this throughout the life of the plant.

By Lucy de la Pasture

Recently the authors of a paper published in *Microbial Biotechnology* (2019) came to the same conclusion proponents of ecology-based farming systems have already fully embraced — that the networks between microbes and plants have been weakened by the long-term use of inorganic fertilisers.

Although the focus for farming more sustainably is often placed on reducing pesticide inputs, high levels of fertiliser use is another hurdle to overcome. Many farms have become inexorably dependent on inorganic fertilisers since mixed farming systems were dropped in the post-war period in favour of more specialised farms and increased production.

The quest for net zero has further enhanced interest in a reduced dependency on inorganic fertilisers. Nitrogen fertiliser-use when it's plugged into carbon-accounting tools generally tips crop production the wrong side of carbon neutral, explains Unium director, John Haywood.

“Lots of attention has been given to the physical and chemical properties of the soil but the role of biology has, until recently, been largely overlooked. Now research

into the soil microbiome is one of the most exciting areas in plant science and has enormous potential to help agriculture harness biology to produce crops in a more sustainable way.”

What does the science say?

Around and within every plant is a structured microbial community — the plant microbiota, explains John.

“Healthy plants host diverse communities of microorganisms that colonize every accessible plant tissue. This association between the plant and microbes gives fitness advantages to the plant host, including growth promotion, nutrient uptake, stress tolerance and resistance to pathogens.

“There's a growing body of evidence that farming practices have inadvertently damaged microbial habitats. It's only recently become clear how much this delicate balance between the plant and microbes can contribute to productivity when it's functioning properly,” he says.

One of the key tiny players in the plant microbiome are endophytes, which are microbes that inhabit the internal tissues of plants without causing disease. Nearly all plants possess endophytes and, in most cases, they are seed transmitted so begin to promote growth and plant health as soon as seeds germinate, explains John.

“Other endophytes can be recruited from the soil and are of a similar benefit to plants, which are numerous. Of particular interest is the role endophytes play in nutrient acquisition, with some endophytes capable of fixing atmospheric nitrogen as well as solubilising phosphates, increasing their bioavailability.”

Seed endophytes are of particular interest as they're transmitted from generation to generation. “By being seed-borne, these endophytes assure their presence in new

plants. This vertical transmission from parent to progeny, should select against pathogenicity and favour mutualism as these endosymbionts depend entirely on their host for survival and reproduction,” explains John.

“Many of the processes grain is subjected to before planting, such as cleaning and dressing with fungicide treatments, disrupts the natural microbially community on the grain. This is recognised by some growers who serially home-save seed, which already hosts microbial communities adapted to the farm's environment and management practices.”

The mutualistic benefits which endophytes applied to seed could offer crop plants has kicked off an interest in endophyte seed treatments around the world.

From Science to Bioscience

Research by Prof Sharon Doty at the University of Washington led to the discovery of strains of endophyte from non-nodulating plants, but with the capability of fixing nitrogen. She first noticed poplar and willow



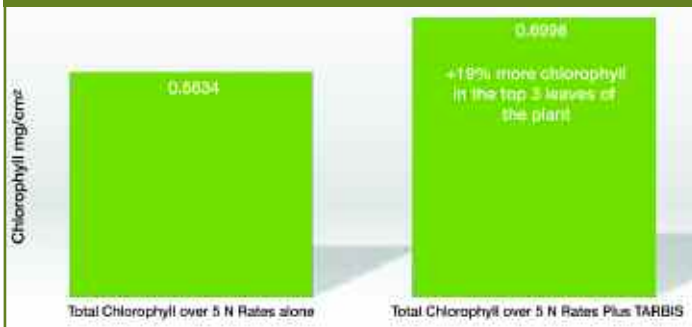
John Haywood says research into the soil microbiome has enormous potential to help agriculture harness biology to produce crops in a more sustainable way.

Effects of Tiros treatment on NUE



Source: Nottingham University, 2019

Total chlorophyll levels in top three leaves



Nitrogen response trial on a heavy land site in Lincolnshire. Leaves sampled second week of June.

Source: Greencrop, 2021

thriving along the stony banks of the Snoqualmie River, which carries snow melt from the mountains in western Washington State, she explains.

"The river has a very low nutrient content, containing less than 0.5 mg/l total nitrogen. The rocks and sand deposited by the river also supply little to no nutrients, yet poplar and willow colonize this raw substrate readily.

"Vigorous growth in the absence of the nitrogen isn't possible, indicating there must be a likely symbiotic partnership with N-fixing bacteria, but this usually occurs in plants with root nodules."

Since neither willow nor poplar roots form nodules, it seemed to indicate another mechanism was at work, she says. More recently, a similar association of N-fixing microorganisms with non-nodulating plants has been confirmed in Sharon's research. Through in-vitro culture, Sharon's team isolated a wide range of symbiotic microbes, including endophytic *Rhizobium tropici*, yeasts, and a variety of other microbial species sourced from within wild poplar and

willow branches.

"Over the past two decades of characterising these strains, we've determined that some of these microbes make nitrogen and phosphorous bioavailable, increase photosynthesis and water use efficiency, as well as promote plant growth, yields, and health under drought and nutrient stresses," she explains.

These promising endophytes were taken up by Intrinsyx Bio (USA), based at the NASA Ames Laboratory, who has developed the technology into seed treatment, foliar, in-furrow, granule and biochar-incorporated formulations, encouraged by the potential endophytes bring to both crop production systems and for growing food during space travel.

Unium are EU partners to Intrinsyx and launched the endophyte technology in the UK as Tiros seed treatment, last year.

Proving the concept

Further proof of concept has been gained under UK conditions over the past four years, initially in glasshouse studies at the University of Nottingham and then independent

replicated small plot work, as well as larger farmer evaluations.

So what can growers expect from the Tiros endophyte treatment? Endophytes can promote plant growth naturally through improved nutrient acquisition, phytohormone production and stress tolerance, leading to fast germination and establishment, explains John.

The ability of Tiros to influence nutrient use efficiency (NUE) throughout the life of the plant has been evaluated over the past two seasons, explains John. "Endophytes improve nutrient use efficiency (NUE) which means the leaves have a higher accumulation of nitrogen where Tiros is applied than in untreated plants. This is also the case for other nutrients, including phosphate and potash, which may be particularly useful where phosphate is locked up in the soil.

"Our initial work at Nottingham University last year indicated a 20% reduction in nitrogen use is possible without a significant loss in biomass occurring. After these very positive nitrogen trials, we're repeating the same replicated trial this year in Suffolk, in conjunction with F1 Seed."

The trial investigates different nitrogen application rates, with an untreated control and four different nitrogen rates.

"The results showed a very strong influence of the endophytes on the nitrogen-use efficiency curve for the crop. We're repeating the work in Lincolnshire this year on a direct drill very heavy land site and from a visit in early June, visually it looks very promising — with higher biomass and increased chlorophyll content in the treated compared with the untreated crop.

"This work is critical to help determine how we can develop recommendations to maximise nitrogen use efficiency, reduce pollution risk, enhance the farm's carbon footprint and prepare for any fertiliser restrictions that may or may not be imposed in the future."

John firmly believes that different classes of biostimulants or biological products can be synergistic in their effect but that a lot more work needs to be done to evaluate the interactions between products to find the best strategies. With this in mind, Unium are undertaking more trials to evaluate the interactions of Tiros-treated varieties with other products, such as Twoxo and 3alo-T6P in wheat or rhizobia in pulses.

But it won't stop there, says John, the company is also exploring the potential of new endophytes and new formulations in the quest to bring profitable solutions to growers that support more sustainable agricultural practices.

"A new foliar product is expected to be available for the 2022 season," adds John. "Seed treatment has the advantage of supporting the crop for a longer period of growth, but the foliar formulation has also generated very promising data over the past two years of trials."

Pioneers in the field

Cambridgeshire farm manager Russell McKenzie had a first look at Tiros in the 2019-2020 season, when he planted 12ha of Tiros-treated RGT Saki winter wheat alongside his usual single purpose dressing.

"We've seen emergence effects before with Take Off and Vibrance Duo so I thought it would be interesting to have a look. In our no-till system, emergence isn't always that fast and if drilling gets late, then speed of emergence becomes more important."

The Tiros treatment was evident using the NDVI imagery available in Bayer's Climate Field View, says Russell, with the area looking greener in the spring. At harvest the treatment gave a 0.4t/ha yield benefit over the single purpose dressing, rising to 0.65t/ha when the foliar nutrition programme was overlaid.

Was it enough to convince Russell to adopt Tiros commercially? His reply is ►

Yield response over untreated



Uplift from Tiros treatment in independent trials series carried out 2019-2020.

Source: Unium, 2021

N dose response after foliar endophyte (Tabis)



Winter wheat independent trials in Suffolk during 2020

Source: Unium, 2021

► considered. “We regularly test our own seed before deciding to put a treatment on. We’re moving more down the biological route and Tiros seems to bring a fair bit to the party. It certainly pushes seedlings out of the ground quickly and encourages better root development. There’s good science behind the technology as well as the data to back it up.

“There’s a lot of discussion about agchem at the moment and a realisation that new technologies are going to help us move away from over-reliance on chemistry. Unium is looking for viable solutions to help growers make the change,” he says.

This season Tiros trials are taking place in oilseed rape with LSPB, where two different varieties and three seed

treatments are being evaluated. “There was certainly an improvement in establishment, with higher plant numbers where Tiros was used. It appears to be a step-forward from Take Off and Matrix seed treatments.”

Russell also noticed a difference at flowering, where Tiros-treated plants held onto flowers slightly longer than the other two treatments — it seemed to help the flowering sequence, he says.

A common observation is the long-lasting effects of the endophyte seed treatment. John often describes Tiros as a ‘back-up generator’ that’s running all the time within the plant. So when nitrogen and other nutrients are limiting, then the endophytic bacteria provide a solution — helping the plant keep going and then recover once conditions become more favourable.

The potential of Tiros hasn’t been overlooked by the big players in the industry either. Jonathan Halstead, head of northwest Europe at Syngenta, has been impressed so far with what he’s seen of Tiros in its trials programme.

“Our industry is working hard to play its part in reducing carbon emissions and environmental impact while continuing to provide high quality, nutritious and safe food. To realise this goal we have to bring the best of our



Bill Angus is keen to move away from the simplistic approach of throwing inputs at wheat to a more balanced approach using strategically valuable inputs.

traditional practices together with new technologies and thinking,” he says.

“The area of nutrient efficiency is one of these areas. I see technologies like Tiros as a great example of where we can make significant gains for plant health, productivity and the environment as we look to reduce carbon emissions and move to carbon neutral agriculture.”

Jonathan views Tiros as a complementary seed treatment to the Syngenta Vibrance range, containing sedaxane. “In our latest trials we’re looking at the interaction between Vibrance and Tiros to see if they can work together. Our data so far has really impressed us and we’re starting to see multiple benefits for growers in terms of plant growth, nutrient uptake and



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input management.

"This is a very exciting frontier, and one which Syngenta will continue to explore with technology providers like Unium Biosciences," he adds.

Independent wheat breeder Bill Angus has also been keeping a keen eye on Tiros trials taking place at his variety trials site in Suffolk. He believes the starting point for profitable crop production is good genetics (varieties) as the first step in an integrated approach to agronomy — a process he describes as 'Agronomising Genetics.'

"We're keen to move away from the simplistic approach of throwing inputs at wheat to a more balanced approach using strategically valuable inputs," he explains.

"We're running trials with our new winter wheat variety Garibaldi and, to date, we're encouraged. Grain yield is reliant on producing biomass and we need to get the crop off to a good start. Tiros combined with an appropriate chemical seed treatment will be the way forward as we provide technical support for our new 'genetics'," concludes Bill. ■

Bioscience insider

As the chemistry toolbox continues to shrink, a mesmerising array of new bio-solutions are coming to market, offering a range of benefits and complementary additions. Evaluating just how effective they are, and where they're best placed can be tricky, however.

This series of articles opens a window on the science behind these innovations. *CPM* has teamed up with Unium BioScience to explore the background, unravel the physiological processes and provide analysis on the results of trials. Above all, these articles give the grower an inside view on some of the exciting opportunities biosolutions offer in the field.

Tiros has been scientifically developed to contain a consortium of endophytes which have been proven to enhance establishment, boost biomass, chlorophyll and nutrient use efficiency of plants throughout the life of the crop. It forms a foundation for more sustainable farming systems by enabling farmers to be less reliant on fertiliser inputs yet maintain productivity.

Learn more by joining the Unium technical group <https://www.uniumbioscience.com/unium-technical-group>



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