> *"70% of yield potential worldwide is lost due to abiotic stress."*

Innovation Research Briefing

Primed to survive

Scientists are beginning to uncover how an extract of brown seaweed is acting on the genes and biochemical pathways in plants. *CPM* looks at the latest research findings and discovers how these may help growers now and in the future.

By Lucy de la Pasture

There's a good deal of interest in using biostimulants on-farm. While their beneficial effect has long been noticed by many growers, there's been precious little knowledge about how they're actually working or how to get reliable results from using them.

The advances in molecular research have led to the emergence of a few R&D-led specialist manufacturers, who stand out in a crowded marketplace where efficacy doesn't currently have to be proven. These companies are intent on understanding how the biochemical pathways in plants are influenced by the application of their products and discovering the genes responsible.

Irish company BioAtlantis is one of these R&D-led companies and is working at providing solutions in the areas of maternal immunity transfer for animals and humans and plant stress mitigation, all using naturally derived compounds, explains Dr Kieran Guinan, research manager at BioAtlantis.

"We entered the biostimulant market in 2007 with crop stress mitigation as a central strategy. For over a decade we've been conducting R&D aimed at understanding the stress related problems in different forms of life," he explains.

Drought conditions

For UK and Irish growers, the drought conditions and heat experienced last season brought home the effects abiotic stress can have on crops, with potato yields widely reported to be down by 20% either side of the Irish sea. Even though growers are focused on biotic stresses caused by pests and disease, on a global scale these are relatively insignificant compared to the impacts of abiotic stress.

"A staggering 70% of the yield potential on the main arable crops such as corn, wheat, barley & soybean worldwide is lost due to abiotic stress, with just 10% to biotic stress," says Kieran.

All abiotic stresses give rise to a high accumulation of harmful Reactive Oxygen Species (ROS) in plants, creating an 'oxidative imbalance' in plant cells.

"This oxidative imbalance damages DNA, proteins and cells, ultimately reducing plant growth and yield, and even causing plant death in extreme cases," explains head of BioAtlantis' plant research department, Dr Sujeeth Neerakkal.

The company is working with scientists from across Europe who are investigating the mode of action of an extract of *Ascophyllum nodosum*, a large, common cold-water seaweed or brown alga in the family *Fucaceae*, which is found in the North Atlantic.

They've identified that an extract of *A. nodosum*, which is harvested on the Irish coast and processed and marketed by the company as Super Fifty, can significantly improve a crop's resilience to abiotic stress when applied 3-5 days before a stress event.

"Super Fifty has been proven to reduce ROS and oxidative damage, making the plant more tolerant to upcoming stress, but exactly how it's doing this has been unknown," says Sujeeth.

And that's where the scientists come in. At the University of Potsdam in Germany, Prof Bernd Müller-Röber's team has discovered a link between the application of Super Fifty and the action of distinct genes in their work on the EU-funded 'CropStrengthen' project.

The goal of CropStrengthen was to develop novel methods for increasing crop strength and resistance to abiotic stresses using non-GM technologies, explains Bernd. ▸

BioAtlantis has been conducting R&D aimed at understanding the stress related problems in different forms of life for over a decade, says Kieran Guinan.

Bernd Müller-Röber says protecting crops against drought is becoming more important with climate change.

▸ To do this the researchers at Potsdam investigated what happens in plants at a molecular and physiological level when they were 'primed' with plant strengtheners, or biostimulants as they are commonly called in the UK.

The first step in the research was to test the effect of the biostimulant on 'model' plant *Arabidopsis thaliana* and crops at different developmental stages, under stress and optimal growing conditions. Because the *A. thaliana* genome was fully mapped in 2000, the functions of many of the model plant genes are already known, which makes it much easier for the scientists to determine which genes are influenced when Super Fifty is applied.

"Plants were analysed using cutting-edge omics technologies which included the high-throughput profiling of the transcriptomes and metabolomes, combined with advanced bioinformatics. In addition, we performed phenotypic studies to determine the effect of biostimulant treatment on developmental and growth parameters," explains Bernd.

An important task for the scientists was to establish a robust experimental protocol so that they could figure out the effect of Super Fifty at the various stages of plant development.

"In particular, we had to optimise the doses and application procedures of the seaweed-based biostimulant to determine under which conditions stress tolerance was improved in diverse plants. Another important aspect was to determine possible growth-stimulating effects of the biostimulant in the absence of abiotic stresses. We were also interested to learn about any potential negative side-effects that treatment could have on crops," he says.

So what did they discover in the CropStrengthen project? "One of the most notable — and really unexpected — results of our research was the discovery that biostimulants prepared from brown algae significantly improve the resilience of crops to drought stress. This really came as a big surprise to us," comments Bernd.

Plants treated with the biostimulant are better prepared — or in scientific jargon 'primed' — to respond to an upcoming (future) abiotic stress challenge. Several genes with similar functions are important for this reaction in *Arabidopsis* and cultivated vegetable crops, such as tomato.

Climate change

"The discovery that the biostimulants increase plant drought tolerance is in itself an important finding," highlights Bernd. "In the future, such products will likely be employed to improve growth and yield of other crops that need to be protected against drought. This is certainly becoming more and more important under climate change conditions, where periods of drought and high temperature become more frequent.

"Furthermore, we need to better understand how biostimulants affect the activity of genes; such knowledge may then be used to improve drought tolerance in plants by breeding or genome editing," he says.

Although the research has shed some light on the action of Super Fifty, precisely how the genes that are influenced by its application are related to crop stress tolerance mechanisms isn't yet known in detail.

"How exactly the biostimulants activate the stress-protective genes is still unknown. We already know which genes are affected by the biostimulant and some of these genes are known to play a role in stress tolerance. However, there is so much in the data that we need more time to determine the roles of the individual genes with respect to stress tolerance induced by biostimulants. Exploring this will be an interesting endeavor for the future," he says.

"We need to test the roles of selected genes in model and crop plants, using molecular and genome editing tools. By looking at the genes affected in diverse plants, we may be able to identify master regulators controlling the drought-protective effect of the biostimulants. Those we will prioritize for our future studies.

"We must learn how these genes specifically improve the drought tolerance, which physiological and developmental pathways they control and in which tissues they act. This research is of great importance for breeding crop varieties that can better cope with environmental impacts due to climate change," believes Bernd.

Dr Tsanko Gechev was also involved in the CropStrengthen project as its scientific manager at Potsdam but he's now returned to Bulgaria to work at the newly established Center of Plant Systems Biology and Biotechnology (CPSBB), where he's conducting further research on Super Fifty.

"We've established that it contains

Recent work has shed more light on the priming mechanism that makes plants more resistant to abiotic stress, explains Tsanko Gechev.

Summary of Super Fifty research results

- Trials on tomato have demonstrated that priming induced plant tolerance to drought for up to seven days.
- After seven days, relative water content in leaves was significantly higher in treated compared with non-primed plants, and ion-leakage was also reduced.
- Root traits contributing to crop establishment under drought were improved.
- The production of ROS, which can stunt plant growth during drought, was significantly reduced by applying the product in advance of stress.
- Primed plants showed better growth under stress compared with non-primed plants.
- In wheat management programmes, foliar applications helped to increase yield on a consistent basis. Trials at University of Hohenheim, Germany (2016) and Agri-Food and Biosciences Institute, Northern Ireland (2017) demonstrated increases in yield of 12.5% to 29% respectively.

Research Briefing

To help growers get the best out of technology used in the field, manufacturers continue to invest in R&D at every level, from the lab to extensive field trials. *CPM* Research Briefings provide not only the findings of recent research, but also an insight into the technology, to ensure a full understanding of how to optimise its use.

CPM would like to thank BioAtlantis for sponsoring this Research Briefing and for providing privileged access to staff and material used to help bring it together.

BioAtlantis has developed SuperFifty technology to mitigate against the effects of abiotic stress, helping crops reach their genetic yield potential. Proven benefits include enhanced yield, fruit-set and marketable fruit size.

Recommendations for growers

- Apply SuperFifty® at sensitive growth stages to enhance performance, improving return on investment.
- Apply 3-5 days before anticipated stress to prevent crop damage during stress.

The label provides more information on application rates and timings. For further information, contact info@bioatlantis.com

BioAtlantis
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Scientists have shown that the application of Ascophyllum nodosum *before it comes under stress primes the plant to cope better.*

something that induces the stress defence system in plants, so we're using a number of molecular techniques to try and find the actual mechanism. These include RNA-sequencing and bioinformatics to look at the differential expression of genes and the analysis of metabolites using gas and liquid chromatography-mass spectrometry.

"We're then able to combine the results of metabolite analysis with gene expression analysis to find out the biochemical pathways involved when Super Fifty is applied to plants," he explains.

Tsanko is able to confirm that the action of the biostimulant on the biochemical pathways in the plant is very complex and involves a number of genes.

"The research is due to be published in peer-reviewed journals later this year so while I can't reveal the details now, I can say that we have an increased understanding in how the priming effect (which makes the plant more resistant to abiotic stress) is happening," he says.

Tsanko says that he's worked with a number of compounds that can induce priming and has been surprised at the efficiency of Super Fifty, describing it as 'a product that really works.'

"It's amazing what you can do with nature — this extract of *A. nodosum* is providing a safe, non-toxic, non-GM solution to abiotic stress," he comments. ■