Plant biostimulants and their potential role in sustainable agricultural production systems

Informed by the KTN Plant Sector Advisory Board,
led by the KTN AgriFood team

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At KTN, we connect ideas, people and communities to help drive net zero innovation. In this article we look into plant biostimulants and their potential role in sustainable agricultural production systems.

Plant biostimulants

Growers and farmers face a number of challenges, including an increase in nitrogen vulnerable zones, finite reserves of potash and phosphate rock used in conventional fertilisers, a decrease in the arsenal of crop protection active ingredients, accelerating climate change and a rise in societal demand for a more sustainable crop production. To address these issues, there has been an upsurge of agricultural technologies and products. Plant biostimulants are a group of products that have raised both intense interest and criticism from growers.

According to the European Biostimulants Industry Council (EBIC), a plant biostimulant is: 'a material that contains substance(s) and/or microorganisms whose function, when applied to plants or to soil is to stimulate plant natural processes to enhance or benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress and/or crop quality, independent of its nutrient content'. Biostimulants are usually applied in small quantities and *per se* do not supply significant crop nutrition. Some biostimulants may also confer tolerance to biotic stresses.

Various types of plant biostimulants exist (Table 1, by ADAS in a report commissioned by AHDB) and can be classified as either non-microbial or microbial. Non-microbial biostimulants are usually naturally produced organic compounds but can also be synthetic compounds (e.g. nitrophenolates). Microbial biostimulants are living organisms and are often found within the plant microbiome (discussed in KTN's Microbiome Strategic Roadmap).

Table 1. Types of biostimulants (source: AHDB, 2016).

Non-microbial	Microbial
Seaweed extracts	Plant growth promoting bacteria
Humic substances	Non-pathogenic fungi
Phosphite and other inorganic salts	Arbuscular mycorrhizal fungi
Chitin and chitosan derivatives	Protozoa and nematodes
Anti-transpirants	
Protein hydrolysates and free amino acids	
Complex organic materials	

The regulatory environment

In the UK, fertilisers for sale do not have to be registered and currently plant biostimulants are not regulated. Therefore as long as the manufacturer does not claim any direct pesticidal disease control effects they can, generally speaking, be commercialised in the UK. This lack of regulation may also be seen as a concern, since beneficial microbes from other crops and/or continents can in theory be imported and freely applied in UK fields. Additionally, there is currently a lack of labelling standards (e.g. no legal requirement to declare amino acid or co-formulant levels in biostimulant products). The plant biostimulant sector has inherent quality control challenges, for example how to specify products containing complex mixtures of hydrolysates when the active ingredient is unknown? Without appropriate regulation there are few controls what may lead to growers not seeing the benefits of such technologies. A standardised approach amongst the UK countries with respect to labelling, testing, and selling of permits for imported microbes may address some of the concerns affecting the plant biostimulant market.

In the EU plant biostimulants are currently regulated according to national legislation, making it complicated and expensive for companies to introduce new products to market. However, this is set to change in the coming years. Alignment of regulations was introduced in 2019 when the European Commission introduced the plant biostimulants category in the EU Fertilising Products Regulation (Regulation (EU) 2019/1009) that will be brought into force in 2022. However, it is not yet known if the various EU countries exclusively adopt EU regulations in preference to their national laws.

A global growing market

The global plant biostimulants market was estimated at £1.85 billion in 2019 and expected to reach a value of £3.5 billion by 2025 (Markets and Markets). The market has been dominated by Europe but the rest of the globe is catching up, particularly Southeast Asia. In terms of products the amino acids segment has the largest market share in value.

According to EBIC the European biostimulants market is still dominated by SMEs. Some consider it a 'gold rush era' for the market, with recent stories of SMEs raising impressive sums of cash (e.g. Indigo raising > £140 million in 2017). However, the interest of larger companies has dramatically increased in recent years as demonstrated by the acquisition of Valagro by Syngenta in 2020. Other big companies (e.g. Bayer CropScience, BASF, UPL,) have their own offers in the market.

Perspectives from the KTN Plant Sector Advisory Board

To identify technology and innovation needs and opportunities, the KTN AgriFood team works with sector advisory boards that include members from industrial organisations across supply chains, academic organisations, and government bodies. A recent consultation with KTN's Plant Sector Advisory Board focused on the topic of biostimulants revealed that most board members were aware of specific plant biostimulant products/ brands, indicating that these products are gaining recognition in the UK market. Board members stated that nutrient uptake and use efficiency were the effects that would likely bring the greatest benefits to UK agriculture, followed by tolerance to abiotic stress and crop quality.

When asked about barriers to adoption, the board noted that proof of efficacy has been the main challenge to the entrance of these products in the market. Other challenges included unclear regulation, return on investment, integration with other farm management systems, environmental/ human safety, understanding the broad range of products with a huge variability of modes of action, and unsubstantiated claims.

Proof of efficacy challenges

According to the 2016 AHDB Crop Biostimulants report, of the 11 plant biostimulant types identified only three (‘Chitin and chitosan derivatives’, ‘Anti-transpirants’, and ‘Plant growth promoting bacteria’) demonstrated a good evidence of efficacy when tested on cereals and oilseed rape. Though more research is needed, it demonstrates that concerns about the effectiveness of some biostimulants is perhaps valid.

Why is the proof of efficacy of such products in the glasshouse and/or field so hard to demonstrate? Unlike other agri-inputs, biostimulants do not supply the crop with what it needs; instead, they enhance plants’ ability to acquire and assimilate what they need from the surrounding environment. It is therefore critical to understand the interactions between these products and the environment (e.g. nitrogen fixation in the presence of excess nitrogen, or application timing relative to plant growth stage, or establishing stable microbial soil amendments in the presence of other soil microbiota). As an additional complication, some products are a complex cocktail of different microorganisms and/ or non-microbial biostimulants in which the interactions between components are not fully understood. This is particularly critical in the case of microbial biostimulants, where viability during storage and transport, ease of use by the end-user, implications to seed viability, and compatibility with currently machinery are often a concern.

Performance may also depend on the crop germplasm. It thus requires an ecosystem approach to undertake performance analysis. The release of products not fully tested may taint the plant biostimulants market, particularly in the current unregulated UK market.

Opportunities for plant biostimulants

Although there are clear challenges associated with the adoption of biostimulants, there are also many exciting opportunities. For example, CABI has created 'The UK Crop Microbiome CryoBank', aware of the vast potential of the complex plant microbiome. This CryoBank will supply biological and bioinformatic tools for the creation of new solutions to improve soil and crop health and eventually yield.

A number of research projects concerning plant biostimulants have been funded in recent years, with the majority focusing on rhizobia and mycorrhiza for which the scientific basis and efficacy *in situ* has been widely established. Nevertheless, more work is needed to provide a holistic understanding of the interactions between biostimulant products, soil health, and crop genetics within the context of end market requirements. Investment in the study of other types of plant biostimulants may be a route to further innovation in this field

Plant biostimulants have the potential to offer huge benefits to UK agriculture, however appropriate testing in multiple field trials, seasons, and conditions prior to release is essential. In a market highly dominated by SMEs this costly endeavour may prove difficult without public funding. Competitions like the recently launched 'Farming Innovation Pathways (FIP)' (delivered through the ISCF Transforming Food Production programme, in partnership with Defra) offer a great opportunity for companies working in that space to see their research funded. To help companies find the right partners, KTN has created a LinkedIn group.

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For more information about this topic, please contact Pedro Carvalho.