BIOSTIMULANTS: A COMPLEX ECOTOXICOLOGICAL CHALLENGE

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What are biostimulants?

Biostimulants are generally defined as being able to stimulate plant nutrition processes independently of the product's nutrient content with the aim of improving one or more of the following characteristics[1]:

- Nutrient efficiency
- Tolerance to abiotic stress
- Crop quality
- Crop growth/yield

Types of biostimulant

Group	Product type
Non-microbial	Seaweed extracts
	Humic substances
	Phosphite and other inorganic salts
	Chitin and chitosan derivatives
	Anti-transpirants
	Protein hydrolysates and free amino-acids
	Non-essential chemical elements
	Complex organic materials
Microbial	Plant growth promoting bacteria and rhizobacteria (PGPR)
	Non-pathogenic fungi
	Arbuscular mycorrhizal fungi (AMF)
	Protozoa and nematodes

Table 1: Definitions of product types as reported in AHDB Review No 89[1]

What are the ecotoxicological challenges?

Biostimulant products are made up of various components, in highly variable compositions

- Very little literature is available on the ecotoxicology of biostimulants
- Where information is available it tends to focus on the individual component(s) of such products
- The complexity and variability of components in a biostimulant product means small changes may have large consequences
  - E.g. concentrations of seaweed extracts in biostimulant products are rarely detailed exactly and appear in conjunction with many other components, including macro- and micronutrients
  - The variety of seaweed species (Fig 1) and the composition of these within any extract are vast and therefore a direct comparison with the known ecotoxicity data, in comparison to application levels and uses, is not possible

Figure 1: Examples of toxicity screened seaweed species[2]

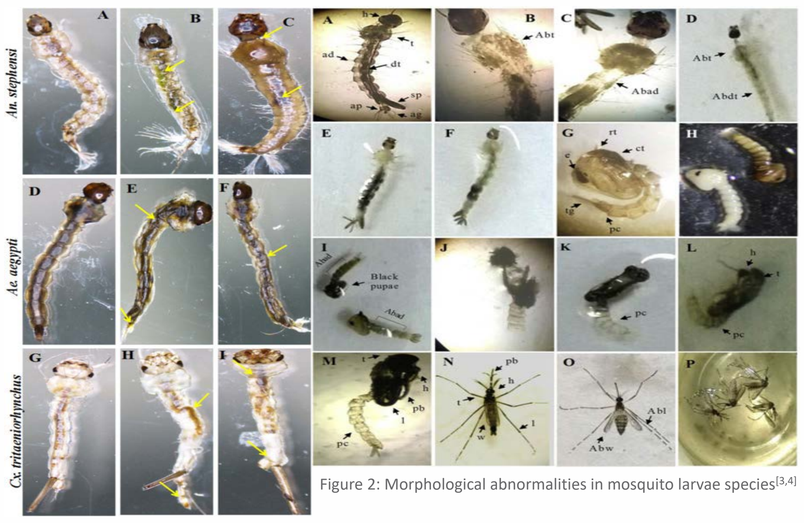

Figure 2: Morphological abnormalities in mosquito larvae species[3,4]

Sub-lethal, long-term chronic and cumulative effects

- Although the acute exposure data, to *individual* biostimulant components, are generally above the Environmental Hazard Classification threshold of 1 mg/L, thus not classified as hazardous to the aquatic environment, there may still be concerns regarding high and sustained application levels, which is of significance as there are no product usage regulations in place
  - E.g. Phytotoxicity has been found in orchids and peppers exposed to super-optimal levels of chitosan derived biostimulants, and wheat treated with humic acid
  - A wide range of sub-lethal effects reported for seaweed extracts, including morphological effects (Fig 2), growth inhibition, behavioural abnormalities, reproductive dysfunction and neurological effects
  - Humic substances can affect plant physiology, disrupting cell division and reducing growth, germination, transpiration, nutrient uptake and resistance to water stress
  - Plant growth promoting (rhizo)bacteria affect earthworm biocycles and survival of several invertebrate juvenile/larval stages

Indirect and secondary toxicity effects

- Many biostimulants have pesticidal properties
  - Useful for the dual action of plant growth promotion and crop protection, however, any non-selectivity of pesticidal effects could be detrimental to non-target species
- Adverse effects on community composition
  - E.g. Plant growth promoting (rhizo)bacteria directly alter microbial community composition with unknown effects
- Interactive effects with other stressors
  - Toxins bound to humic acids have adverse effects
  - Potential to increase bioavailability of other contaminants, e.g., Pb and Zn in poultry litter, contaminants in biochar
  - Potential accumulation through the food chain
- Toxic metabolites

Figure 3: Chicken on poultry litter[5]

What do we need to understand?

- Application quantities
- Persistence
- Bioaccumulation
- Environmental fate and degradation
  - Metabolic pathways and toxicity
- Interaction with products applied in conjunction
  - E.g. plant protection products

How do we risk assess biostimulants?

- Testing should be on a product by product basis to account for highly variable compositions
- Is a standard suite of ecotoxicology tests appropriate?
- How to incorporate understanding changes to community composition and structure?

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