BioStimulants versus BioControl Agents- Two Sides of a Coin

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According to the proposed draft of the fertilizer regulation EC 2003/2003[1], **biostimulants** will be defined as products (containing substances or microorganisms) that "are not as such nutrients, but nevertheless stimulate plants' nutrition processes", and that"aim solely at improving the plants' nutrient use efficiency, tolerance to abiotic stress, or crop quality traits". However, if they also increase plant disease resistance, either by stimulating the plant's own ability to defend itself against a pathogen or by direct action against the pathogen, i.e. in the case of dual-function substances or microorganisms, they are to be treated as **plant protection products**to which EC regulation 1107/2009[2]applies. Here, the question arises whether a product that is marketed solely to support plant nutrition can be treated as a biostimulant even if plant protective activities have been described in the literature for the active ingredient (but are not claimed for the product). If that is not the case, i.e. if such a product would not be eligible as a biostimulant, problems will automatically arise. Treatments that will improve plant vigour by improving plant nutrition will not only increase plant stress tolerance, but at the same time also plant disease resistance. An example microorganism would be mycorrhiza fungi which are explicitly mentioned as biostimulants in Annex II of the draft fertilizer regulation[1], but which are known to also improve plant disease resistance.

An example substance would be chitosan. The term chitosan describes a family of biopolymers and oligomers consisting of varying numbers and ratios of glucosamine and *N*-acetylglucosamine residues. Depending on the number of residues in the molecule (its degree of polymerisation) and the ratio of the two monomeric units (its degree of acetylation), and possibly also depending on the sequence of the two units within the oligomer or polymer (its pattern of acetylation), chitosans can have different biological activities. Some chitosans can inhibit microbial growth (being funigstatic and bacteriostatic rather than being fungicidal or bactericidal), some chitosans can induce disease resistance in a plant (either by acting as an elicitor triggering resistance reactions, or by acting as a priming agent enabling plant cells to react more efficiently against pathogens), some chitosans can improve abiotic stress tolerance in plants (e.g. against drought or heat stress), and some chitosans can promote plant growth (e.g. root and/or shoot growth) and/or development (e.g. more fruit and/or earlier ripening).

Modern biotechnological methods of chitosan production and/or modification as well as new techniques for chitosan in depth structural analysis allow to produce well-defined (second generation) chitosans having defined and reliable, specific bioactivities, but lacking others. In this way, it is e.g. possible to produce chitosans which have no antimicrobial activities but which do have plant strengthening (i.e. growth promoting and stress tolerance and disease resistance inducing activities). It will probably also be possible to generate chitosans with more pronounced ability to induce stress tolerance and less marked ability to induce disease resistance, and *vice versa*. However, it is highly unlike that it will be possible to dissect these activities fully. The reason behind this is the intimate cross-talk of intracellular signal transduction pathways in plant cells. Even if it were possible to identify a specific chitosan oligomer (or any other compound) that is recognised by a specific receptor which triggers a signal transduction chain leading to metabolic answers increasing abiotic stress tolerance, and to identify another chitosan oligomer (or any other compound) that is recognised by a different receptor which triggers a different signal transduction chain leading to different metabolic answers increasing disease resistance - treatment of the plant cell with either of the two chitosan oligomers will invariably lead to a mixed response, possibly with stronger emphasis on one of the two reactions and less pronounced expression of the other, but not with just one answer(Fig. 1). Clearly, thus, there is a strong interconnection between abiotic stress tolerance and disease resistance.

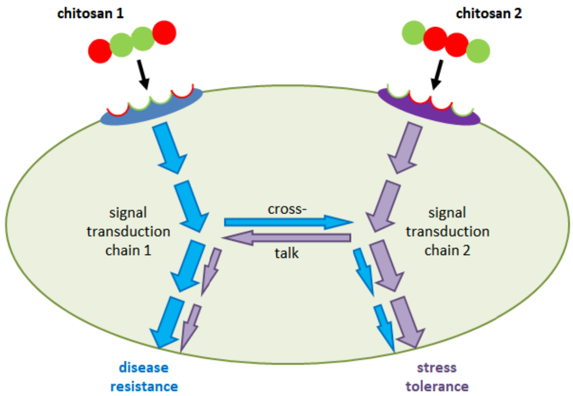

Figure 1: Cross-talk between intracellular signal transduction pathways establishes a signal transduction network, so that induction of abiotic stress tolerance automatically also induces disease resistance, and *vice versa*.

In fact, such a relationship is long known. Under optimum fertilisation conditions, plants grow best and are also healthiest, having the strongest ability to defend themselves against disease and to withstand abiotic stress. Both under-nourished and over-fertilized plants, however, are more prone to disease and stress induced damage. Thus, it is simply not possible to clearly distinguish between **biostimulant action** (as it is suggested to be defined) and biocontrol action (as it is defined now). It would appear more realistic to first distinguish two types of **biocontrol activity**, namely

- (i) direct action against the microbial pathogens and
- (ii) indirect action by strengthening the plant's own ability to defend itself.

(This would be similar to antibiotic treatment (i) *versus*vaccination (ii) in human medicine.) Products containing substances or microorganisms acting on the pathogenic microorganisms would fall under category (i), while products containing substances or microorganisms acting on the plant would fall under category (ii) (Table 1). The former would have to be treated as **plant protection products** under EC 1107/2009while the latter would be treated as **biostimulants**, falling under EC 2003/2003. In this way, consumer safety would also be maintained, as only category (i) products with direct antimicrobial mode of action have potentially toxic activities.

This categorisation would solve the problem that (almost) all products which induce tolerance to abiotic stress also induce resistance to disease - which would otherwise, if the categories defined in the current draft of the EU regulations would enter into force, lead to the situation that (almost) no biostimulants would exist. The alternative solution, namely to categorize products solely according to the claims made by the producers instead of what is known about the bioactivities of the active ingredients, would fail to protect the safety of consumers and the environment, as potentially toxic category (i) products could be registered as biostimulants under the fertiliser regulations which, reasonably, puts less emphasis on toxicity testing. (While the situation would be rather clear then for substances, it might still not be entirely clear for microorganisms which might act directly against pathogenic microbes but not via toxic principles but rather by competition in which case a categorisation as a plant protectant would not be appropriate.)

aim of treatment	disease protection		stress protection
target of treatment	pathogen	crop plant	
mode of action	inhibition of microbial growth	induction of disease resistance	induction of stress tolerance
toxicity	yes	no	
risk potential	high	low	
category	biocontrol (i)	biocontrol (ii)	biostimulant
regulatory framework	1107/2009	2003/2003	

Table1: Proposed categorisation of substances and microorganisms with biocontrol *versus*biostimulant activities depending on whether they act on the microbial pathogen or on the crop plant.

[1] http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:52016PC0157&from=EN

[2] http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:02009R1107-20140630&from=EN