European Biostimulants Industry Council

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EXPLAINER

Phosphite-based plant biostimulants: an overview of the science and farmer value

Background: There is compelling science today that certain phosphite[1] products (taking into account use cases) provide plant biostimulant effects improving nutrient use efficiency and tolerance of abiotic stress. Moreover, the use of phosphites in fertilising products has been demonstrated to be safe for both humans and the environment by the long history worldwide of safe application of phosphite-based agricultural products with other functions.

Why it's important: Paragraph 6, of Part II of Annex I of Regulation (EU) 2019/1009 (the EU Fertilising Products Regulation--FPR) states "Phosphonates shall not be intentionally added to any EU fertilising product. Unintentional presence of phosphonates shall not exceed 0,5 % by mass." This language was introduced with the assumption that these substances could only be used for plant protection purposes, an assumption that is now invalidated by growing scientific evidence.

In this paper, we summarize the scientific research elucidating the mode of action of phosphite-based plant biostimulants and explain the value that these products can have for achieving the EU's objectives of increasing nutrient use efficiency. In trials on wheat and oilseed, nitrogen use efficiency improved about 5.5%, yields were higher, and farm income increased 186 euros/hectare and 56 euros/ha respectively. Increased root mass also improved water use efficiency and tolerance of drought stress.

Together, this evidence demonstrates the utility of rethinking the wording of the FPR to allow for phosphite-based plant biostimulants as a major tool for achieving the Farm to Fork Strategy objectives of increased nutrient use efficiency and climate smart agriculture.

A summary of the science

Research conducted independently at Nottingham University (UK) and Christian Albrechts-Universität (Kiel, Germany) demonstrates that phosphite provides several plant biostimulant effects[2] related to enhanced root growth, nutrient use efficiency, and tolerance of abiotic stress. Professors from each university presented their teams' research at a workshop organised by EBIC on 18 June 2021.

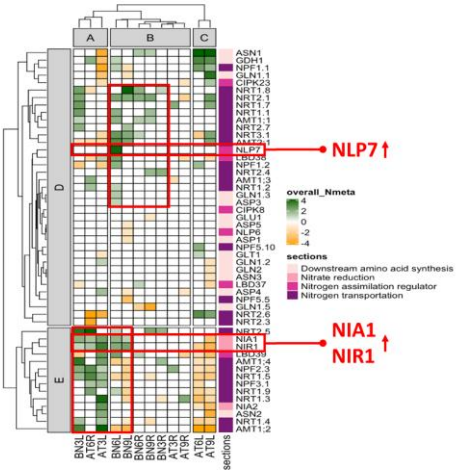
[1] Although they are technically different substances, the terms "phosphonates" and "phosphites" are now used interchangeably because the two substances cycle constantly back and forth between the two forms. In this paper, we use "phosphites" to distinguish products that have plant biostimulant functions and that have been formulated with the phosphite salt forms.

[2] We use the word "effects" to mean changes that the product brings about in the plant or the soil/rhizosphere compared to a control; this is related to, but different from, the term "function", which refers to a specific legal framework.

The research by the Universities of Nottingham and Kiel has shown that the use of phosphite as a plant biostimulant has a dramatic effect on the uptake and efficient use of nitrogen, saving up to 40kg/ha from leaching or volatilisation.

The Nottingham research focuses on the interdependent physiological effects of root development, nutrient use efficiency, and tolerance to abiotic stress and the underlying mode of action. In two examples, the Nottingham researchers studied wheat and oilseed rape (canola). In both cases, they applied 450 g/ha of potassium phosphite as a potassium salt through a foliar application. The wheat was treated at growth stage (GS) 12[3] and harvested at GS 23. The oilseed was treated at GS 13 and harvested at GS 25. Root growth was 30% higher in the treated wheat and 40-50% in the treated oilseed, relative to untreated controls. The difference in root mass was most obvious where the crops were nutrient-constrained, an indicator of improved nutrient use efficiency. Similarly, phosphite treatment of water-stressed wheat also resulted in longer roots and improved water use efficiency by 15-20%. The Nottingham researchers identified the role of Cis-Zeatin (a type of cytokinin) in the mode of action.

For their part, researchers in Kiel are looking at root growth, nutrient use efficiency, and yield, as well as the underlying mode of action. They have conducted more than 20 trials in oilseed over 15 years with foliar applications similar to those used by the researchers in Nottingham. The Kiel team also looked at the effects of both foliar applications and seed treatments in wheat. On average, the oilseed resulted in a 5.6% increase in yield and 5.5% increase in nitrogen use efficiency compared to controls. Wheat was studied in comparison with an untreated control and a control representing “current farm practice”. Adding phosphite to the current farm practice resulted in 1.35 t/ha higher yield using 40 kg/ha less nitrogen fertilizer and a 32 % improvement in nitrogen use efficiency. Studying the effects of seed treatment, Kiel also found important gains in root mass (+7.4 % mean increase at GS20[4] and +50 % mean increase in root mass at GS29).



The Kiel researchers then studied gene expression to understand the mode of action. They found that three genes key to nitrogen transport and assimilation were significantly upregulated by the application of phosphite:

- NIA1 encodes nitrate reductase (NR)
- NIR1 encodes nitrite reductase
- NLP7 regulates nitrate assimilation

Nitrate reductase (NR) is a key enzyme within the nitrogen assimilation process which is critical to plant metabolism and growth. Indeed, they found an 8% increase in nitrate reductase (NR) activity within 9 days of phosphite treatment in oilseed and a 10% in wheat.

Each university has published a white paper summarizing its work, and they are in the process of publishing their studies in peer-reviewed journals. They recently presented their findings to policymakers at a workshop held by EBIC on 18 June 2021. View a summary of the workshop and download the white papers.

[3] The extended BBCH scale was used to define the growth stages.
[4] The extended BBCH scale was used to define the growth stages.

Calculating the potential value to EU farmers and Farm to Fork objectives

Due to regulatory constraints, phosphite plant biostimulants are currently applied to only 4% of arable land in Europe today. That means that the potential benefits from generalizing its use are enormous.

While farmers want to grow crops sustainably, their value calculations understandably focus on their return on investment, which entails several factors including:

- Better prices for higher quality produce;
- Higher yields per hectare (which can also be the result of enhanced tolerance to abiotic stress);
- Reduced operating costs through more efficient use of inputs.

Phosphite plant biostimulants can contribute to all three factors. The Kiel research shows that an additional 20.7 kg N/ha (grain) was taken up by the crop and harvested; nitrogen content is a common indicator of wheat quality, for example, for breadmaking. As described above, phosphite plant biostimulant yields were on average significantly higher and nitrogen use efficiency was higher.

According to calculations done by the University of Kiel, treating wheat with phosphite plant biostimulants resulted in additional farm income of 186 euros per hectare (and this research was done when the price of nitrogen fertilizers was much lower than they are today). The benefit for oilseed farmers was 56 euros per hectare on average over 15 years.

In the light of increasingly volatile weather conditions, treatment with phosphite plant biostimulants can also be seen as a form of insurance, especially for wheat, since wheat breeding programmes have not been successful in developing drought tolerance.

According to European Commission data, there are about 24 million hectares of wheat[5] planted in the European Union and 5.5 mn ha oilseed[6]. If we apply the values obtained by the University of Kiel to that surface area, the potential value for farmers from using phosphite plant biostimulants is an additional 4,464 million euros income for wheat farmers and 308 million euros for oilseed growers.

Phosphite plant biostimulants can also help European policymakers reach their policy goals, especially related to increased nutrient use efficiency and fewer impacts on the environment. Again, taking the numbers from the Kiel trials, saving 40 kg of nitrogen per hectare of wheat grown could potentially save as much as 1.36 million tonnes of nitrogen[7] across Europe while simultaneously increasing yields and helping crops weather Europe's increasingly hot and dry summers.

At times when global market conditions drive the cost of nitrogen fertilizers up, as is currently the case, nitrogen savings can not only help farmers cope but can help minimize cost shocks to consumers as rising production costs of staples like wheat have ripple effects on the cost of bread, pasta, and other processed foods containing wheat and flour.

While real-world results are likely to be less impressive than what can be accomplished under trial conditions, even a fraction of the benefits described above would make an important contribution to improving the sustainability of major crops and improving farmer incomes.

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[5] https://agridata.ec.europa.eu/extensions/DashboardCereals/CerealsProduction.html.

[6] https://agridata.ec.europa.eu/extensions/DashboardCereals/OilseedProduction.html

[7] According to Eurostat, 10.2 million tonnes of nitrogen fertilizer were applied in 2018 in the EU. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Agri-environmental_indicator_-_mineral_fertiliser_consumption

Can phosphite plant biostimulants be used while respecting maximum residue limits?

In 2014, the European Commission was asked to consider whether phosphonate could legally be used as a fertilizer. At that time, the regulatory framework indicated that anything that was not a plant nutrient (as defined in Regulation (EC) 2003/2003) fell under the scope of the plant protection Regulation (EC) 1107/2009. In the meantime, plant biostimulants have explicitly been moved out of the plant protection regulation and under Regulation (EU) 2019/1009, the Fertilising Products Regulation. Today, the phosphite plant biostimulants products described above clearly meet the criterion outlined in the Commission's January 2015 memo on phosphonates that their use was regulated by the plant protection regulation "unless it can be proven that the product is intended to be used solely for purposes other than those listed in Article 2(1) of the PPPR (that is, other uses than that of protecting plants through the fungicidal properties of that active substance)…".

In the research done on the plant biostimulant mode of action, the phosphite product was applied at rates of just **450 grams per hectare** at growth stages 12 (two leaves emerged on the seedling) and 13 (three leaves emerged on the seedling). These are very different conditions of use then those that led to concerns in 2014 about exceedances from misuse of phosphonates in fertilising products. Applying phosphite plant biostimulants at a half-kilo per hectare in an early growth stage – typical for plant biostimulant applications -- allows growers to respect maximum residue limits (MRLs) in crops where those limits have been set to reflect product use. Crops with a default MRL (assuming no use) are a different case where finding any trace of phosphite even after a legitimate application of a phosphite plant biostimulant could be misconstrued as a misuse of a plant protection product. This problem needs to be resolved for crops where a plant biostimulant application of phosphite has a scientific basis but should not prevent the recognition of the scientific demonstration of plant biostimulant modes of action for phosphites under certain conditions.

EBIC member companies have conducted 8 GLP studies and 31 non-GLP monitoring studies on phosphonate residues in broadacre crops treated with phosphite plant biostimulants. In all cases, the levels were well below the presumed safety level of 75 mg/kg indicated by EFSA in its 2013 opinion on phosphonates. In almost all cases, the residues were also below defined MRLs, where those were set to reflect a commercial use on that crop. This data and the historical use of phosphite plant biostimulants around the world (and of phosphonate products used as a plant protection product) demonstrate the safety of phosphite and phosphonate salts.

Conclusion

There is compelling science today that certain phosphite products (taking into account use cases) provide plant biostimulant effects improving nutrient use efficiency and tolerance of abiotic stress. Moreover, the use of phosphites in fertilising products has been demonstrated to be safe for both humans and the environment. Manufacturers can provide growers with instructions to use EU Plant Biostimulants in such a way that they can respect MRLs, as required by point 3 of Part I of Annex III of Regulation (EU) 2019/1009 as amended by Commission Delegated Regulation (EU) 2021/1768.

It is therefore justified to amend Regulation (EU) 2019/1009 to allow phosphonates to be contained in PFC 6 Plant Biostimulants.