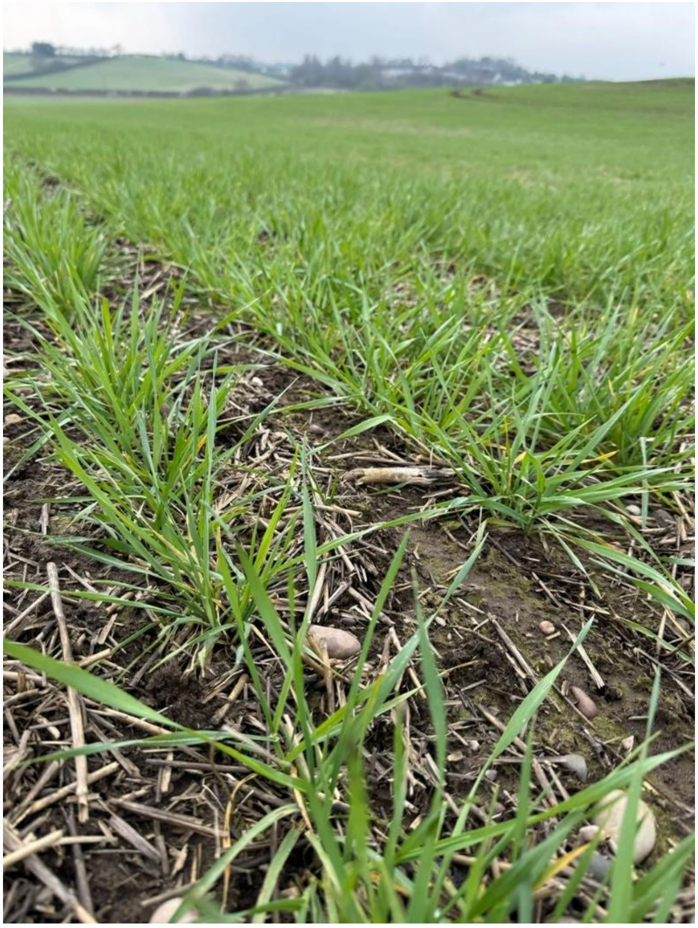
PART OF THE DUCHY FUTURE FARMING PROGRAMME

Part of the H3 project

Field lab: Investigation of Bio-stimulants to increase crop yield, biomass, and availability of phosphate in an arable crop.

Final report

[June 2025]



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Summary

Take home messages

This field lab produced results in line with other UK trials of biostimulants on arable crops. Inconsistent impacts on cereal crops, with the greatest benefits reported in vegetable and potato crops, especially in more arid climates. While biostimulants did demonstrate a yield improvement on the trial sites they were measured, these were not significant or consistent. Biostimulants are not a standalone solution and must be integrated into a broader, regenerative system that supports overall soil health.

Context

This field lab formed part of the H3 Project – Landscape-Scale Regenerative Farming. Specifically, it fed into WP3, which evaluates regenerative practices across landscapes in terms of soil health, environmental benefits, and food quality. Five farmers across Shropshire, Staffordshire, and Oxfordshire took part, each trialling two biostimulants alongside an untreated area on arable cereal crops.

Trial design

The design used randomised, replicated field plots using tramlines. Each site included:

- A control (no treatment)
- Two different biostimulant treatments
- Three replicates per treatment

Measurements included:

- Total yield
- Visual assessments of above/below-ground biomass
- Leaf phosphate levels (flag leaf analysis)
- Soil phosphate availability (Olsen P)
- Cost per hectare of application
- Grain analysis: yield, Hagberg Falling Number, protein content, screenings, specific weight, moisture, hardness

Findings

Weather and soil conditions made 2024's trials challenging. A wet autumn prevented timely application of one biostimulant, and several crops were not established until spring. Some farmers reported blockages with biostimulant formulations, particularly when treating small areas. Yield data showed small increases at some sites, but none were statistically significant. Grain quality parameters also showed no clear treatment effects.

Recommendations & next steps

More independent trials and investment in research is needed. On individual farms when trying a biostimulant product on farm, start by talking with established biostimulant suppliers to align your goals with the right product. Join farmer networks to learn from others' successes and failures. Discuss biostimulants with your advisor if you have one. Ensure equipment is compatible (e.g. sprayer filters), and research which products work best on which crops and soil types.

Useful resources

- Soil Association Biostimulation Tech Guide - Technical guide - biostimulants | Soil Association
- H3 Landscape Regenerative Farming Project Page - H3: Research on Healthy Soil, Healthy Food, Healthy People
- Innovative Farmers Field Labs- Biostimulants trial

Farmer comment - Rory Lay – Farmer

"*Visually, there was hardly any noticeable difference in the crop".* That said, "*with the dry conditions this year, there may have been effects that were not immediately visible*". Rory added, "*the formula, blocked the filter too easily, especially when we were only treating a hectare or so*". Therefore, ensure products are compatible with available equipment. This comment underscores the need to consider practical challenges and the influence of environmental conditions when evaluating biostimulant performance.

Main report

1 Field lab aims

To assess the effect of two commercially available biostimulants on yield, biomass, and phosphate availability in cereal crops under UK conditions.

2 Background

Farmers in this trial were seeking to reduce chemical inputs and investigate whether biostimulants could support nutrient availability, particularly phosphate, and increase biomass and yields. Due to prolonged wet conditions, autumn applications were missed, and some crops were late established.

Products were chosen based on prior scientific research.

Despite promising global data, UK specific on farm evidence for arable crops remains limited. This trial sought to generate independent data under real farming conditions.

3 Methodology and data collection

Trial Objective

This trial aimed to evaluate the effect of two biostimulant products on crop nutrient uptake, using tissue analysis to determine nutrient status across treated and untreated plants. The primary focus was on macronutrient balance and micronutrient availability in response to treatment.

Trial Design

The trial was set up as a small plot comparative field trial with the following treatments:

- **Treatment A:** Biostimulant 1
- **Treatment B:** Biostimulant 2
- **Treatment C:** Untreated Control (no biostimulant)

Each treatment was applied to a separate plot under consistent agronomic conditions to ensure fair comparison. Plots were managed according to standard cultivation practices for the crop, with uniformity maintained in planting, and base fertilisation across all plots.

Biostimulant Application

Both biostimulants were applied as per manufacturer recommendations. Application timings were chosen to align with early vegetative growth to maximise potential effects on nutrient uptake and root development. Unfortunately, due to the wet autumn the autumn application was not applied.

No additional nutrient amendments were made to the biostimulant plots beyond the routine base fertilisation.

Sampling Protocol

Leaf tissue samples were collected at a key vegetative stage to evaluate early nutrient uptake and the physiological response to treatments. Sampling was carried out as follows:

- **Timing:** Mid-vegetative stage (4–6 weeks post-treatment), prior to flowering.
- **Sample Collection:**
  - 20–25 fully expanded, healthy leaves were sampled from each plot.
  - Sampling was done during dry conditions in the morning to avoid contamination or diurnal nutrient fluctuation.
  - Leaves were taken from similar canopy height and light exposure across all treatments.

Each sample was stored in clean, labelled bags and transported promptly to the lab for analysis.

Laboratory Analysis

Tissue samples were analysed by an accredited laboratory. The following nutrients were quantified:

Macronutrients:

- Nitrogen (N)
- Sulphur (S)
- Phosphorus (P)
- Potassium (K)
- Calcium (Ca)
- Magnesium (Mg)

Micronutrients:

- Manganese (Mn)
- Iron (Fe)
- Copper (Cu)
- Zinc (Zn)
- Boron (B)

Results were reported as % dry matter for macronutrients and mg/kg for micronutrients. Interpretations were based on crop-specific optimal ranges, with categories of Deficient, Low, Normal, High, or Excessive provided by the testing laboratory.

In addition to tissue sampling, soil sampling was carried out, composite soil samples were collected from each treatment area following standard agronomic sampling protocols, using a W-pattern to ensure representative coverage. Samples were analysed for key indicators including:

- Soil pH
- Extractable Phosphorus (P)
- Exchangeable Potassium (K)
- Exchangeable Magnesium (Mg)

These soil nutrient levels were used to help interpret plant tissue results and to assess whether observed nutrient deficiencies were due to inherent soil limitations or potential treatment effects. Soil pH was also monitored to evaluate any potential acidifying effects of treatments on the rhizosphere environment.

At harvest, grain quality parameters were also measured for each treatment. Samples were tested for:

- Protein content (%)
- Hagberg Falling Number
- Specific weight
- Percentage screenings

This analysis was intended to assess whether biostimulant treatments influenced end use quality or commercial value of the grain. All grain quality testing was performed using standard grain laboratory methods.

Limitations and Controls

Environmental Variability Between Sites
The trial sites experienced different environmental conditions (e.g. temperature, soil type, rainfall), which likely influenced biostimulant performance. These site-specific factors make direct comparison difficult and reduce the generalisability of the findings.

Application Conditions
Biostimulant effectiveness particularly for products containing live microbial components is highly dependent on timing and environmental conditions such as soil temperature and moisture. Cool or dry conditions at the time of application may have inhibited microbial activity and root colonisation.

Short-Term Nutrient Snapshot
Tissue sampling was conducted at a single point in time, offering only a snapshot of nutrient status. This limits insight into nutrient dynamics or longer-term physiological responses.

Potential Practical Interference
Some practical challenges were noted, such as blocked filters during application, which may have affected consistency and dose delivery, especially with the microbially enhanced products.

Controls

- **Untreated Control Plot**
  Each site included an untreated control plot managed identically to the treated plots, excluding biostimulant application. This provided a reference point for evaluating the effect of the treatments.
- **Uniform Agronomic Management**
  All plots at each site were managed under the same cultivation regime, with consistent sowing dates, fertiliser applications, and crop protection measures. This helped ensure that differences in plant performance could be more reliably attributed to the treatments.
- **Soil and Tissue Sampling**
  Both soil and tissue samples were collected using consistent, standardised protocols across all plots to minimise sampling bias and ensure comparability.
- **Moisture-Corrected Yield Data**
  Grain yield figures were corrected to a standard 13% moisture content, allowing for fair comparison between treatments and across sites.

4 Results and discussions

Crop Yield Results

Two of the farms yield results are as follows.

Farm A

- Untreated (UT): 10.00 t/ha
- (Biostimulant 1): 11.00 t/ha
- **(**Biostimulant 2): 11.73 t/ha

Farm B

- Control: 4.70 t/ha
- Biostimulant-treated**:** 4.79 t/ha

Observations

On farm A, both biostimulants outperformed the untreated control, the one biostimulant delivered a 17.3% increase in yield compared to untreated. These are promising results, particularly as cereals often show limited yield response to biostimulants. On farm B, only a marginal increase (1.9%) in yield was observed with biostimulant application. The difference is not statistically significant without replication and may fall within expected variability. This reflects the common challenge of inconsistent performance of biostimulants in cereal crops, especially when conditions (e.g. temperature, moisture) are suboptimal for microbial activity. Environmental conditions, soil health, or baseline fertility may have aligned more favourably at site A to support microbial or flavonoid activity.

Grain Quality Results

No significant differences were found in protein content, Hagberg Falling Number, specific weight, or % screenings between treated and control plots. This indicates that biostimulant application did not improve grain marketability or milling quality under the conditions of this trial. A small pH difference (0.3 units lower in treated plot) was observed in one sample but due to lack of replication, it’s not possible to determine if this was a treatment effect or simply field variability. Practical issues were noted with product application, including filter blockages, which may have affected consistency and effectiveness in the field.

Conclusions for all trials:

While the concept of using biostimulants to stimulate nutrient uptake and improve yield remains promising in theory, the results from this trial do not provide sufficient evidence of a clear benefit in cereal systems. Both nutrient balance and yield outcomes failed to show statistically significant improvement, and no quality traits were enhanced.

The weather and soil conditions negatively impacted the ability to both establish and the ability to apply the biostimulant for the product which needed multi applications throughout the season. Ideally an autumn application would have been applied to boost root growth. Another issue was it was a high pressured season for the triallists with conflicting pressures and therefore sampling and gathering trial information was not always the easiest.

In economic terms, even where slight yield increases were observed, these gains would not offset the cost of product application, resulting in no net margin benefit for the grower.

The Tissue analysis results revealed limited or inconsistent nutrient benefits across treatments. In several cases, biostimulant applications led to imbalanced nutrient profiles, particularly a suboptimal nitrogen-to-sulphur (N:S) ratio. The untreated control consistently showed a more balanced nutrient status, with adequate nitrogen and marginal but sufficient sulphur, suggesting that biostimulant application did not consistently enhance nutrient uptake or improve plant physiological status.

Yield data~~,~~ showed mixed outcomes at farm A, where both biostimulants resulted in higher yields than the untreated control. The one biostimulant produced a 10% yield increase and the other delivered a 17.3% yield gain, indicating a potentially positive yield effect under favourable conditions.

At farm B the yield increase from biostimulant use was minimal (1.9%), suggesting no meaningful advantage over the untreated control.

These contrasting results highlight a key theme, whereby biostimulant performance is highly context dependent. Environmental conditions, particularly soil moisture and temperature, are likely to have influenced microbial establishment and plant responsiveness. Application timing, soil microbial activity, and baseline crop health also play critical roles in determining efficacy.

While the results are encouraging and suggest a yield benefit under certain conditions, the data and tissue analysis findings reflect the inconsistency that is often seen with biostimulant use in cereals. Moreover, practical challenges such as product handling (e.g. blocked filters) and sensitivity to field conditions may limit their usage at this time.

Therefore, no consistent improvement in plant nutrient status was observed, Yield benefits may be achievable, but only under specific conditions, likely when the crop is actively growing, stress is present, and soil conditions are favourable to microbial and biochemical activity.

Further replicated trials are needed to validate results, refine product formulations, and establish clearer guidelines for effective use in cereal systems.

Discussion:

Biostimulants are a growing area of interest in sustainable agriculture, offering a potential means to enhance crop resilience, nutrient use efficiency, and yield without reliance on synthetic fertilisers. They act by interacting with plant signalling pathways, functioning as chemical messengers that trigger adaptive responses to environmental stresses such as drought, temperature extremes, or pest pressures. These internal plant responses often involve the production of secondary metabolites and stress related hormones that improve the plant's ability to cope with suboptimal conditions.

In addition to direct effects on the plant, biostimulants play a significant role in influencing the rhizosphere**,** the biologically active zone around the root. They can nourish and support beneficial soil microbial communities that are essential for nutrient cycling, disease suppression, and the maintenance of soil structure. Enhancing microbial activity can indirectly improve plant health by increasing nutrient availability and promoting root development.

Biostimulants can be derived from natural sources (e.g. seaweed extracts, humic acids, amino acids, or plant metabolites) or be synthetically formulated. Regardless of origin, their purpose is to improve plant function through non-nutrient modes of action. However, the success of any biostimulant depends heavily on environmental conditions, timing of application, and the physiological state of the plant.

The most successful biostimulant on the trial contained, contains two active components:

- A microbial inoculant
- A flavonoid-based liquid extract

The microbial component is highly sensitive to soil moisture and temperature, with optimal colonisation of the root zone occurring only when environmental conditions are favourable. Cool or dry soils reduce microbial survival and multiplication, which in turn limits their potential to influence nutrient cycling or plant microbe signalling. In this trial, suboptimal weather during application may have compromised microbial effectiveness.

The flavonoid-based liquid extract is absorbed directly by the plant when it is actively photosynthesising. Flavonoids are known to influence plant physiology, particularly through the stimulation of secondary metabolites associated with stress tolerance. In theory, they can enhance the plant's internal defences and improve resilience to abiotic (e.g. drought) and biotic (e.g. pathogen) stressors.

Despite these theoretical benefits, the practical application of biostimulants in cereal systems remains complex**.** Crops like wheat are known for their limited responsiveness to biostimulants, partly due to tightly regulated internal signalling systems and relatively narrow yield margins. Even when physiological changes occur, they may not translate into measurable yield gains. Furthermore, cereals are highly influenced by multiple overlapping environmental factors, making it difficult to isolate the effects of a single input like a biostimulant.

In this trial, no clear improvement in plant nutrient status was observed. The untreated control showed the most balanced nutrient profile, while both treated samples exhibited nutrient imbalances that may have limited the plant's growth potential. Specifically, the N:S ratio was suboptimal in both treated plots, indicating that even if nitrogen uptake improved, sulphur limitation may have restricted its effective utilisation.

Anecdotal evidence from other farms has suggested that biostimulant 1 may produce slight yield gains under ideal conditions, but results have been inconsistent. In addition to environmental sensitivity, the current formulation also presented practical challenges, such as filter blockages and application difficulties. These factors likely contributed to variability in field performance.

The product developers have acknowledged these limitations and are reportedly working on a revised formulation that excludes the microbial component for greater simplicity and reliability in cereal systems. This evolution reflects a broader trend in biostimulant development towards more targeted, crop-specific products that are easier to apply and less dependent on highly specific field conditions.

In conclusion, while the theoretical basis for biostimulant use remains sound, and certain components such as flavonoids have well-documented physiological effects, consistent, measurable benefits in cereals are still difficult to achieve. The findings of this trial align with wider industry observations, biostimulants may offer marginal or context-dependent gains in cereals, but more research is needed to determine how to reliably activate beneficial plant responses and translate them into economic returns.

Individual site findings

Below are several results from the individual sites.

Figure 1: Farm one: Available Nutrients tissue analysis with a biostimulant

SAMPLE NAME: WYNDLEY TREATED **CROP: WINTER WHEAT**

ANALYSIS		RESULT	INTERPRETATION (Deficient / Low / Normal / High / Excessive)	COMMENTS
Nitrogen (N)	[N:S Ratio]	3.35 %	2.20 / 2.70 / 5.00 / 7.00	Nutrient status satisfactory.
Sulphur (S)	[6.6 : 1]	0.511 %	0.28 / 0.32 / 0.36 / 0.50	S is excessive. Possible causes: excessive available soil Sulphate.
Phosphorus (P)		0.362 %	0.23 / 0.30 / 0.56 / 0.95	Nutrient status satisfactory.
Potassium (K)		0.859 %	2.50 / 2.80 / 5.00 / 8.00	K is deficient. Possible causes: low soil K, low K application excessive N applied, cold wet spots.
Calcium (Ca)		1.53 %	0.16 / 0.25 / 0.80 / 1.40	Ca is excessive. Possible causes: diseased or dead tissue sampled old plant tissue sampled.
Magnesium (Mg)		0.323 %	0.10 / 0.13 / 0.18 / 0.40	Mg is high. Possible causes: diseased or dead tissue sampled old plant tissue sampled.
Manganese (Mn)		134 mg/kg	20 / 26 / 60 / 100	Mn is excessive. Possible causes: high N/P applications on low pH or low OM soils, low soil pH, soil or fungicide contamination .
Iron (Fe)		72.2 mg/kg	10 / 25 / 250 / 350	Nutrient status satisfactory.
Copper (Cu)		7.23 mg/kg	3.00 / 4.00 / 10 / 15	Nutrient status satisfactory.
Zinc (Zn)		37.3 mg/kg	20 / 29 / 50 / 70	Nutrient status satisfactory.
Boron (B)		7.42 mg/kg	4.00 / 6.00 / 10 / 15	Nutrient status satisfactory.

Figure 2: Farm one: Available Nutrients tissue analysis without a Biostimulant

SAMPLE NAME: WYNDLEY UNTREATED **CROP: WINTER WHEAT**

ANALYSIS		RESULT	INTERPRETATION (Deficient / Low / Normal / High / Excessive)	COMMENTS
Nitrogen (N)	[N:S Ratio]	3.55 %	2.20 / 2.70 / 5.00 / 7.00	Nutrient status satisfactory.
Sulphur (S)	[7.5 : 1]	0.476 %	0.28 / 0.32 / 0.36 / 0.50	S is high. Possible causes: excessive available soil Sulphate.
Phosphorus (P)		0.350 %	0.23 / 0.30 / 0.56 / 0.95	Nutrient status satisfactory.
Potassium (K)		0.906 %	2.50 / 2.80 / 5.00 / 8.00	K is deficient. Possible causes: low soil K, low K application excessive N applied, cold wet spots.
Calcium (Ca)		1.36 %	0.16 / 0.25 / 0.80 / 1.40	Ca is high. Possible causes: diseased or dead tissue sampled old plant tissue sampled.
Magnesium (Mg)		0.370 %	0.10 / 0.13 / 0.18 / 0.40	Mg is high. Possible causes: diseased or dead tissue sampled old plant tissue sampled.
Manganese (Mn)		108 mg/kg	20 / 26 / 60 / 100	Mn is excessive. Possible causes: high N/P applications on low pH or low OM soils, low soil pH, soil or fungicide contamination .
Iron (Fe)		70.6 mg/kg	10 / 25 / 250 / 350	Nutrient status satisfactory.
Copper (Cu)		7.24 mg/kg	3.00 / 4.00 / 10 / 15	Nutrient status satisfactory.
Zinc (Zn)		34.6 mg/kg	20 / 29 / 50 / 70	Nutrient status satisfactory.
Boron (B)		8.03 mg/kg	4.00 / 6.00 / 10 / 15	Nutrient status satisfactory.

Figure 3: Comparison of Leaf Tissue Analysis in Treated and Untreated Areas

Nutrient	Untreated Result	Treated Result	Interpretation	Change
Nitrogen (N)	3.55%	3.35%	Both satisfactory	Slight decrease
Sulphur (S)	0.476%	0.511%	Both excessive	Increased slightly
Phosphorus (P)	0.350%	0.362%	Both satisfactory	Slight increase
Potassium (K)	0.906%	0.859%	Both deficient	Slight decrease
Calcium (Ca)	1.36%	1.53%	Untreated: HighTreated: Excessive	Increased
Magnesium (Mg)	0.370%	0.323%	Both high	Decreased slightly
Manganese (Mn)	108 mg/kg	134 mg/kg	Both excessive	Marked increase
Iron (Fe)	70.6 mg/kg	72.2 mg/kg	Both satisfactory	Slight increase
Copper (Cu)	7.24 mg/kg	7.23 mg/kg	Both satisfactory	No meaningful change
Zinc (Zn)	34.6 mg/kg	37.3 mg/kg	Both satisfactory	Slight increase
Boron (B)	8.03 mg/kg	7.42 mg/kg	Both satisfactory	Slight decrease

Observations

The treated sample showed small changes in macro and micronutrient levels**,** with minor increases in phosphorus and zinc. However, the continued deficiency in potassium and the excessive levels of manganese and sulphur remain the key findings. These results suggest the biostimulant had limited measurable impact on nutrient balance under the conditions of this trial.

Figure 4 – Farm 1: Available Soil Nutrients Treated and Untreated

SOIL ANALYSIS REPORT

Laboratory Sample Reference	Field Details			Index			mg/l (Available)		
	No.	Name or O.S. Reference with Cropping Details	Soil pH	P	K	Mg	P	K	Mg
371074/24	1	**WYNDLEY TREATED** *14.0 hectares* *Into Winter Wheat*	**5.7**	**5**	**0**	**1**	**81.2**	**28**	**34**
371075/24	2	**WYNDLEY UNTREAT** *14.0 hectares* *Into Winter Wheat*	**6.0**	**5**	**0**	**1**	**94.4**	**49**	**46**

Observations

Soil pH dropped from 6.0 (untreated) to 5.7 (treated), making the treated soil slightly more acidic. This may explain the reduced availability of K and Mg, as acidic soils often bind these nutrients more tightly.

Potassium (K) levels are particularly concerning, both index and available K dropped substantially in the treated plot (from 49 to 28 mg/l). This matches the plant tissue test, where K remained deficient in both treated and untreated.

Magnesium (Mg) is also slightly reduced post-treatment, again consistent with tissue analysis.

Phosphorus (P) remained very high in both, but the treated soil showed a notable which might be from crop uptake or treatment interaction.

The biostimulant-treated soil showed a modest drop in pH and reduced availability of key nutrients, especially potassium and magnesium, which are already deficient. These shifts could impact nutrient uptake and align with the limited yield differences observed.

Figure 5 – Farm 2: Biostimulant – 1 Grain Nutrient Results

Element	Result (D.M. Basis)	Critical Value	Interpretation	Comments
Nitrogen	1.54 %	1.9 *	1.0 1.5 2.0 2.5 3.0	The critical value for N of 1.9% is variety dependent. Probably the best critical value to use for wheat varieties, is the lower of the two protein values given for each variety in the AHDB recommended list.
Phosphorus	0.321 %	0.32 *	0.15 0.3 0.45 0.6 0.75	Values of less than 0.32% in dry matter indicate a need for further checks on P nutrition
Potassium	0.534 %	0.38 **	0.15 0.425 0.7 0.975 1.25	RB209 assumes a standard value of 0.55% K in grain. Values less than 0.38 indicate a need for further checks on K nutrition, especially in soil analysis
Sulphur	0.10 %	0.12 *	0.05 0.1875 0.325 0.4625 0.6	Grain sulphur is important for storage protein formation. Sulphur is required in proportion to grain protein formation, hence N supplies. Low grain S is <0.12%
Magnesium	0.110 %	0.08 **	0.05 0.1 0.15 0.2 0.25	Values of less than 0.08% indicate low levels in grain. With further experience, grain Mg may provide a useful check on soil levels.
N:S Ratio	15.4:1	17:1 *	2.0 7.75 13.5 19.25 25.0	A good Sulphur supply would mean an N:S ratio lower than 17:1. Anything greater than 17:1 suggests that the crop may have suffered from Sulphur deficiency
Copper	3.77 mg/kg	2 **	1.0 3.25 5.5 7.75 10.0	Grain copper <2mg/kg indicates possible deficiency
Manganese	36.1 mg/kg	20 *	5.0 26.25 47.5 68.75 90.0	Values of less than 20mg/kg indicate a need for further checks. Grain levels may provide a useful check on leaf tissue analysis
Zinc	17.9 mg/kg	15 **	9.0 26.5 41.0 55.5 70.0	Zinc values <15mg/kg are low, but whether these should be regarded as limiting is uncertain
Boron	0.52 mg/kg	***	0.0 1.75 3.5 5.25 7.0	There are currently no guidelines for Boron interpretation
Calcium	0.041 %	***	0.02 0.065 0.11 0.155 0.2	There are currently no guidelines for Calcium interpretation
Iron	22.9 mg/kg	***	10.0 77.5 145.0 212.5 280.0	There are currently no guidelines for Iron interpretation.

Figure 6 – Farm 2: Biostimulant – 2 Grain Nutrient Results

Element	Result (D.M. Basis)	Critical Value	Interpretation	Comments
Nitrogen	2.00 %	1.9 *	1.0 1.5 2.0 2.5 3.0	The critical value for N of 1.9% is variety dependent. Probably the best critical value to use for wheat varieties, is the lower of the two protein values given for each variety in the AHDB recommended list.
Phosphorus	0.333 %	0.32 *	0.15 0.3 0.45 0.6 0.75	Values of less than 0.32% in dry matter indicate a need for further checks on P nutrition
Potassium	0.535 %	0.38 **	0.15 0.425 0.7 0.975 1.25	RB209 assumes a standard value of 0.55% K in grain. Values less than 0.38 indicate a need for further checks on K nutrition, especially in soil analysis
Sulphur	0.10 %	0.12 *	0.05 0.1875 0.325 0.4625 0.6	Grain sulphur is important for storage protein formation. Sulphur is required in proportion to grain protein formation, hence N supplies. Low grain S is <0.12%
Magnesium	0.115 %	0.08 **	0.05 0.1 0.15 0.2 0.25	Values of less than 0.08% indicate low levels in grain. With further experience, grain Mg may provide a useful check on soil levels.
N:S Ratio	20.0:1	17:1 *	2.0 7.75 13.5 19.25 25.0	A good Sulphur supply would mean an N:S ratio lower than 17:1. Anything greater than 17:1 suggests that the crop may have suffered from Sulphur deficiency
Copper	3.48 mg/kg	2 **	1.0 3.25 5.5 7.75 10.0	Grain copper <2mg/kg indicates possible deficiency
Manganese	29.3 mg/kg	20 *	5.0 26.25 47.5 68.75 90.0	Values of less than 20mg/kg indicate a need for further checks. Grain levels may provide a useful check on leaf tissue analysis
Zinc	17.4 mg/kg	15 **	9.0 26.5 41.0 55.5 70.0	Zinc values <15mg/kg are low, but whether these should be regarded as limiting is uncertain
Boron	0.57 mg/kg	***	0.0 1.75 3.5 5.25 7.0	There are currently no guidelines for Boron interpretation
Calcium	0.041 %	***	0.02 0.065 0.11 0.155 0.2	There are currently no guidelines for Calcium interpretation

Figure 7 – Farm 2: Untreated Grain Nutrient Results

Element	Result (D.M. Basis)	Critical Value	Interpretation	Comments
Nitrogen	1.99 %	1.9 *	1.0 1.5 2.0 2.5 3.0	The critical value for N of 1.9% is variety dependent. Probably the best critical value to use for wheat varieties, is the lower of the two protein values given for each variety in the AHDB recommended list.
Phosphorus	0.319 %	0.32 *	0.15 0.3 0.45 0.6 0.75	Values of less than 0.32% in dry matter indicate a need for further checks on P nutrition
Potassium	0.496 %	0.38 **	0.15 0.425 0.7 0.975 1.25	RB209 assumes a standard value of 0.55% K in grain. Values less than 0.38 indicate a need for further checks on K nutrition, especially in soil analysis
Sulphur	0.12 %	0.12 *	0.05 0.1875 0.325 0.4625 0.6	Grain sulphur is important for storage protein formation. Sulphur is required in proportion to grain protein formation, hence N supplies. Low grain S is <0.12%
Magnesium	0.111 %	0.08 **	0.05 0.1 0.15 0.2 0.25	Values of less than 0.08% indicate low levels in grain. With further experience, grain Mg may provide a useful check on soil levels.
N:S Ratio	16.6:1	17:1 *	2.0 7.75 13.5 19.25 25.0	A good Sulphur supply would mean an N:S ratio lower than 17:1. Anything greater than 17:1 suggests that the crop may have suffered from Sulphur deficiency
Copper	3.40 mg/kg	2 **	1.0 3.25 5.5 7.75 10.0	Grain copper <2mg/kg indicates possible deficiency
Manganese	39.0 mg/kg	20 *	5.0 26.25 47.5 68.75 90.0	Values of less than 20mg/kg indicate a need for further checks. Grain levels may provide a useful check on leaf tissue analysis
Zinc	21.7 mg/kg	15 **	9.0 26.5 41.0 55.5 70.0	Zinc values <15mg/kg are low, but whether these should be regarded as limiting is uncertain
Boron	<0.5 mg/kg	***	0.0 1.75 3.5 5.25 7.0	There are currently no guidelines for Boron interpretation
Calcium	0.041 %	***	0.02 0.065 0.11 0.155 0.2	There are currently no guidelines for Calcium interpretation
Iron	29.7 mg/kg	***	10.0 77.5 145.0 212.5 280.0	There are currently no guidelines for Iron interpretation.

Observations

Biostimulant 1 shows low nitrogen and borderline sulphur**,** suggesting protein production may have been compromised. Biostimulant 2 has good nitrogen but a very high N:S ratio, indicating sulphur is limiting in relation to nitrogen uptake. Finally, the Untreated is the most balanced overall, nitrogen is sufficient, sulphur is just adequate, and other elements fall within normal ranges.

This suggests that the biostimulants may have influenced microbial dynamics or N mineralisation. The biostimulants did not result in a more balanced or bioavailable nutrient profile or correct existing deficiencies**,** and in some cases, may have worsened nutrient ratios (especially N:S). One of the main take aways is to try and balance existing nutrient deficiencies before introducing biostimulants.

Figure 8: Farm Three: Available Nutrients tissue analysis without a Biostimulant

ANALYSIS		RESULT	INTERPRETATION					COMMENTS
			Deficient	Low	Normal	High	Excessive	
Nitrogen (N)	[N:S Ratio]	3.59 %	2.20	2.70	5.00	7.50		Nutrient status satisfactory.
Sulphur (S)	[11.0 : 1]	0.328 %	0.25	0.28	0.35	0.50		Nutrient status satisfactory.
Phosphorus (P)		0.254 %	0.23	0.30	0.56	0.85		P is low. Possible causes: low soil P, low P application wet soils, low soil pH (<5.5) or high pH (>7.2).
Potassium (K)		2.20 %	2.50	2.80	5.00	8.00		K is deficient. Possible causes: low soil K, low K application excessive N applied, cold wet spots.
Calcium (Ca)		1.13 %	0.20	0.30	1.20	1.80		Nutrient status satisfactory.
Magnesium (Mg)		0.078 %	0.10	0.13	0.18	0.40		Mg is deficient. Possible causes: low soil Mg, low soil pH, use of high Ca lime, naturally low Mg soil high soil K, high available N.
Manganese (Mn)		48.9 mg/kg	20	26	60	100		Nutrient status satisfactory.
Iron (Fe)		63.6 mg/kg	10	50	250	350		Nutrient status satisfactory.
Copper (Cu)		5.73 mg/kg	3.00	4.00	10	15		Nutrient status satisfactory.
Zinc (Zn)		25.9 mg/kg	20	29	50	70		Zn is low. Possible causes: low soil Zn, high soil pH leaching, high soil P, low soil organic matter.
Boron (B)		7.45 mg/kg	4.00	6.00	10	20		Nutrient status satisfactory.

Figure 9: Farm Three: Available Nutrients tissue analysis with a Biostimulant

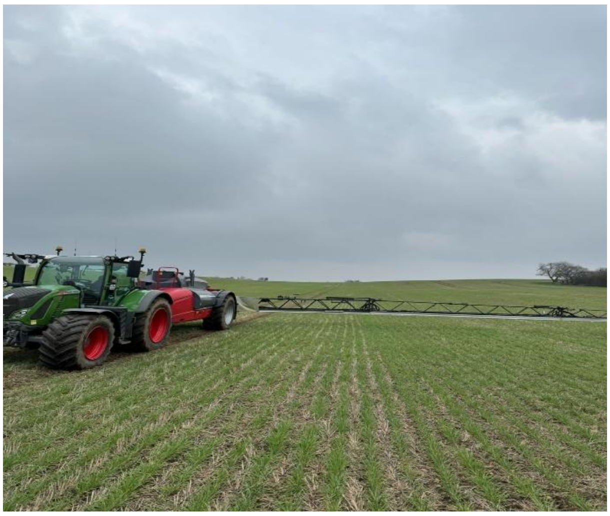
leaf Tissue Analysis – Biostimulants

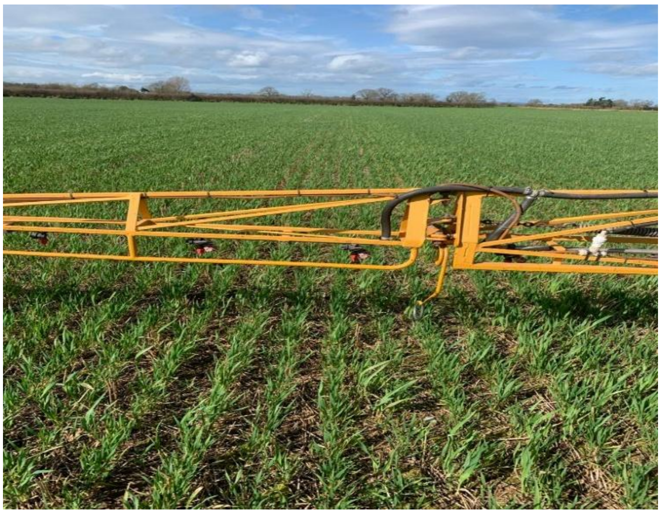
ANALYSIS		RESULT	INTERPRETATION					COMMENTS
			Deficient	Low	Normal	High	Excessive	
Nitrogen (N)	[N:S Ratio]	3.72 %	2.20	2.70	5.00	7.50		Nutrient status satisfactory.
Sulphur (S)	[10.8 : 1]	0.345 %	0.25	0.28	0.35	0.50		Nutrient status satisfactory.
Phosphorus (P)		0.260 %	0.23	0.30	0.56	0.85		P is low. Possible causes: low soil P, low P application wet soils, low soil pH (<5.5) or high pH (>7.2).
Potassium (K)		2.25 %	2.50	2.80	5.00	8.00		K is deficient. Possible causes: low soil K, low K application excessive N applied, cold wet spots.
Calcium (Ca)		1.19 %	0.20	0.30	1.20	1.80		Nutrient status satisfactory.
Magnesium (Mg)		0.084 %	0.10	0.13	0.18	0.40		Mg is deficient. Possible causes: low soil Mg, low soil pH, use of high Ca lime, naturally low Mg soil high soil K, high available N.
Manganese (Mn)		46.2 mg/kg	20	26	60	100		Nutrient status satisfactory.
Iron (Fe)		73.7 mg/kg	10	50	250	350		Nutrient status satisfactory.
Copper (Cu)		5.98 mg/kg	3.00	4.00	10	15		Nutrient status satisfactory.
Zinc (Zn)		24.7 mg/kg	20	29	50	70		Zn is low. Possible causes: low soil Zn, high soil pH leaching, high soil P, low soil organic matter.
Boron (B)		7.07 mg/kg	4.00	6.00	10	20		Nutrient status satisfactory.

Observations

The general trend is most nutrients increased slightly with the biostimulant, especially Nitrogen, Sulphur, Calcium, and Iron. Iron saw a noticeable improvement (up ~10 mg/kg), which may reflect enhanced availability due to increased microbial chelation or improved root uptake, a possible biostimulant effect. There were minor increases in most nutrients suggest slightly enhanced uptake or availability. No deficiencies were corrected, but a few improved slightly.

The biostimulant may have had a mild positive effect, particularly on micronutrient ~~mobilisation.It~~mobilisation. It likely wasn't enough to overcome underlying deficiencies, which may require more targeted fertilisation or soil amendments.





Application of Bio-stimulant on Winter Wheat

5 Conclusions

This trial set out to evaluate the impact of two biostimulant treatments on plant nutrient uptake, with a particular focus on nitrogen (N), sulphur (S), and overall nutrient balance, as compared to an untreated control. Tissue analysis provided a snapshot of nutrient status at the vegetative stage.

The results indicate that neither biostimulant treatment delivered a clear benefit over the untreated control. In fact, the untreated sample showed the most balanced nutrient profile overall**,** with sufficient nitrogen, adequate sulphur, and micronutrients largely within acceptable ranges. This suggests the baseline fertility of the site may have been adequate to support crop nutrient uptake without additional biostimulant input under these conditions.

Biostimulant 1 resulted in low nitrogen and borderline sulphur**,** potentially compromising protein synthesis and early crop development. This suggests either reduced nitrogen uptake or competition for nitrogen, possibly due to microbial shifts or an imbalanced stimulation of microbial activity. The net result was a reduction in available nitrogen at a critical growth stage, which may have impacted growth potential.

Biostimulant 2 maintained a high nitrogen content but exhibited a very high N:S ratio (10.8:1), indicating that sulphur was limiting in relation to nitrogen. Although nitrogen appeared readily available, the lack of sufficient sulphur likely reduced the efficiency of nitrogen utilisation. This imbalance can restrict amino acid synthesis and result in suboptimal growth, even when nitrogen levels are high.

Across all treatments, several key nutrient deficiencies persisted, including low levels of phosphorus (P), potassium (K), magnesium (Mg), and zinc (Zn). These were not corrected by either biostimulant, reinforcing the conclusion that the products used were not sufficient to address existing nutrient limitations on their own.

In summary:

- The untreated control showed the most nutritionally balanced profile.
- Biostimulant 1 may have reduced nutrient availability.
- Biostimulant 2 introduced imbalance, increasing N uptake without corresponding S.
- No clear evidence of improved nutrient uptake or correction of deficiencies was observed from either treatment.

The trial highlights the importance of baseline soil and tissue testing prior to biostimulant application, and the need for a targeted nutrient plan to accompany biostimulant use. Without addressing limiting factors such as sulphur and magnesium, the potential benefits of biostimulants may not be realised — and in some cases, may even create new imbalances.

Future work should incorporate:

- Yield or biomass comparisons
- Soil health and microbial activity analysis
- Multi-point sampling over time to track nutrient dynamics
- Integration of biostimulants within a broader nutrient management strategy
- Replicated trials under controlled conditions
- Understanding crop stage, soil moisture, and microbial activity thresholds for biostimulant efficacy
- Simplifying formulations to improve usability and consistency in field conditions

At present, use of these specific biostimulants in cereal systems should be considered experimental and site-specific, rather than a universally recommended input.

6 Tips and recommendations

- Ensure sprayer filters are compatible with the product.
- Only apply biostimulants when soil and crop conditions are suitable.
- Speak with trusted suppliers and farmers before purchasing.
- Record and monitor results carefully to understand effectiveness.
- Collaborate with local farmer networks or trials to share learnings.
- Boost organic matter (compost, cover crops)
- Use in combination with nutrient balancing (not as a standalone).
- Target at early root establishment or stress periods**.**
- Choose products with proven microbial support**,** amino acids**,** or humic/fulvic acids depending on crop stage and objective.
- To confirm its value long-term, farmers need to consider tracking:
    - Yield or biomass differences
    - Root development
    - Microbial activity
    - Soil pH and structure