Form over function

Crop nutrition

The results of trials in 2021 indicate that Polysulphate could be playing a part in increasing nitrogen use efficiency. *CPM* looks back on the first year's data.

By Lucy de la Pasture

There's nothing like high fertiliser prices to focus the mind and make sure that the plant is getting 'just enough' nutrition in a form that the plant can readily use. It's as much about nutrient use efficiency as the absolute quantities applied.

Research has been going on at Agrii's Stow Longa site to try and improve on the standard fertiliser practices used on many farms which rely on soil indices and what has been the nutritional bible, RB209.

Now there's some excitement that decades of conventional wisdom could be set to be challenged when it comes to fertilising milling wheat for yield and to achieve grain protein. Initial trials have found the use of Polysulphate fertiliser has enabled nitrogen rates to be cut by more than a third without compromising performance.

The trials were initially conceived to consider how nitrogen use efficiency could be improved in response to tightening environmental regulations. This gained an economic impetus following Russia's invasion of Ukraine which sent wholesale gas prices soaring. Natural gas is the principal component in the production of ammonium nitrate which at £650/t and when applied at 250kgN/ha equates to £471/ha, more than double the cost in 2021.

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Polysulphate trials

Mined off the north-east coast at Boulby in Yorkshire, the mineral polyhalite is sold worldwide by ICL as Polysulphate. It's used as a mineral fertiliser containing nutrients: 48% SO_3 as sulphate; 14% K_2O, from sulphate of potash; 6% MgO. from magnesium sulphate; and 17% CaO from calcium sulphate.

As a relatively new form of fertiliser, its contribution to performance has been the subject of trials spanning several crop types and Agrii has been considering its contribution to a programme with other nutrients in a series of replicated trials.

"Across winter wheat, hybrid barley and spring oats (both naked and covered), the plots that received Polysulphate consistently produced the highest yields," says David Felce, who co-ordinated the Agrii trials at Stow Longa.

It's the potassium component that specifically captured Agrii's attention, he says. "At 14% K_2O, its contribution is modest, yet crops that received Polysulphate repeatedly outperform those that received far higher quantities of K_2O.

"Potassium uptake in winter wheat peaks during flowering at about 300 kg/ha, more in a high-yielding crop. Most growers would apply significantly less than this, yet where availability of K is constrained, we see that nitrogen utilisation is poor and yields are reduced," notes David.

"That prompts the question, how much of what is in the soil can we expect to be available to the plant? My answer to that is 'it depends'.

"Availability of all nutrients is a function of many interrelated factors, and one of the most important of these is water. However, potassium availability is heavily influenced by the calcium in soils and calcareous soils are typical of much of lowland Britain.

"While important in many soil functions, calcium binds strongly to cation exchange sites, reducing availability of less strongly bound nutrients, such as potassium, magnesium and ammonium nitrate," says David.

The soils at Agrii's Stow Longa Technology Centre, near Huntingdon, are a classic example of the contradiction that is nutrient status and nutrient availability. The Hanslope series clay isn't nutrient poor, with an index of 2+ for potassium and magnesium. It can be expected to release about 30kg K2O/ha annually, he explains. Despite the long-term use of the plough, soil organic matter is typically upwards of 5%.

"The straw isn't removed, so the only K to be replaced is that taken away with the grain. This is roughly 5.6 kg/t of grain, so isn't extreme. The high soil calcium level, typically above 5000ppm, however, greatly influences availability. We know from historical work that above 3500ppm the amount of potassium available is reduced."

At 14% K_2O, the contribution from Polysulphate fertiliser is modest, yet crops that received it repeatedly outperform those that received far higher quantities of K_2O, says David Felce.

Nitrogen is by far the most important nutrient in crop production, but there's an economic and a regulatory incentive to reduce its use.

Even before the war in Ukraine sent prices rocketing, proposals intent on cutting nitrogen use to protect the environment were under consideration. The Clear Air (Human Rights) Bill, if enacted, will introduce limits on ammonia emissions from agriculture, while the Defra consultation on urea fertiliser proposes that urea ammonium nitrate (UAN) is treated with an inhibitor from 2024. Both will influence application rates, performance and production costs.

The manufacturing, transportation and application of ammonium nitrate is a significant source of CO_2. Using less is the easiest and fastest way to address this reality, believes David.

Lifecycle analysis suggests that if growers use 50kgN/ha less, it could reduce emissions of CO_2e by 300kg/ha. Doing so without compromising output means taking a different approach to crop nutrition, he adds.

For David and his colleagues, this meant revisiting the accepted principles surrounding the relationship between macro- and micro-nutrients in a bid to take a fresh look at how to improve fertiliser performance.

"This very quickly took our thinking beyond nitrogen use and into nutrient use efficiency in its widest sense. We wanted to understand if Polysulphate was more than the sum of its parts, we wanted to know if it would support milling wheat production at lower nitrogen rates," he says.

To answer the question, Agrii took a nitrogen rate that most growers would apply to a milling wheat in a second cereal situation — typically 264 kgN/ha — and reduced it by 50kgN/ha. This was then reduced further to a lower limit of 150kgN/ha.

To avoid suggestions that it was really a sulphur trial, all plots received a normalised application. Three treatments received potassium, along with magnesium and calcium from Polysulphate, while one received a heavy dose of potash. The final two treatments in the trial received only nitrogen and sulphur.

Role of calcium

Tissue tests were taken through the season to give an indication of nutrient levels in the plant at the time of testing. "The crops which received only nitrogen and sulphur were always in need of more nitrogen than the other crops. This supports our understanding that potassium and calcium are important in supporting nitrogen uptake within the plant," says David.

"Winter wheat's need for calcium is significant and while the soils at Stow Longa are rich in it, there isn't always a relationship between what's in the soil and what's in the crop.

"The plant's need for calcium is important as it supports many functions and, unlike with some other nutrients, the plant's requirement keeps climbing through to grain fill. Applying Polysulphate in this situation can only be beneficial," he believes.

The findings from the first year of the trial are interesting, says David. Using the Group 1 variety Skyfall; sown in late October across a range of rotational positions spanning second, third, fourth, fifth and sixth wheat; it was possible to meet yield and grain quality expectations from just 164kgN/ha (see table).

Treatments three and four tell the story in its clearest form, according to David. "Here, grain yields and protein are broadly the same, but the use of Polysulphate in treatment three enabled nitrogen rates to be cut by 50kg/ha. This contributed to an extra £129/ha in gross margin.

"Where the same amount of N was used (164kg/ha) in treatment five, but with only sulphur in support, the yield was nearly 1t/ha lower and protein reduced from 13.7 to 10.9, with gross margin consequently down from the £1030 achieved in treatment three to £643/ha.

"The real hero here is 14kg of K_2O contained in the Polysulphate. It has outperformed the 80kg K_2O in the standard programme (treatment four). This could be due to the additional magnesium and calcium, the balance of them, their sulphate form, or likely a combination of all these factors," he says.

The results have prompted further discussion which future trials will consider. "It's worth noting that this is one year's result and the nitrogen use efficiency scores this season are not so dramatic. However, what the early results from this harvest do show is a dramatic yield response to the use of Polysulphate, with variations linked to product timing and cultivation practice.

"Our ambition is to develop an approach and understanding of plant nutrition that works at lower nitrogen rates and given a changing climate, is both resilient and cost effective," concludes David. ■

Stow Longa wheat nutrition trial 2020/21

	Fertiliser Treatments *	N (kg/ha)	Yield (t/ha)	Protein (%)	NUE (%)	Gross Margin (£/ha)
1	**Standard N/Polysulphate** *Polysulphate (100kg/ha); liquid N (150kg/ha); foliar N (14kg/ha); liquid N (50kg/ha*	214	8.47	12.0	67	803
2	**Reduced N/Polysulphate** *Polysulphate (100kg/ha); liquid N (150kg/ha; foliar N (14kg/ha)*	164	8.29	12.4	83	840
3	**Reduced N/back-loaded/Polysulphate** Polysulphate (100kg/ha); liquid N (60kg/ha); foliar N (14kg/ha); liquid N (90kg/ha)	164	8.90	13.7	98	1030
4	**Standard N/High K** *NKS (343kg/ha); liquid N (60kg/ha): foliar N (14kg/ha); liquid N (80kg/ha)*	214	8.65	13.7	78	901
5	**Reduced N/ no K** *Liquid N (150kg/ha); foliar N (14kg/ha)*	164	7.98	10.9	70	643
6	**Low N/ no K** Liquid N (150kg/ha)	150	7.83	10.6	71.5	699

Trial comprised 108 data points.

Source: Agrii, 2021