Sulphur – an essential nutrient for legumes

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Introduction.

It is well understood that a balanced supply of available nitrogen and sulphur (S) is essential for the synthesis of true proteins from the precursor amino acids. A lack of sulphur limits the production of two of the amino acids which are required constituents of all proteins – cysteine and methionine. Since before the introduction and use of mineral fertiliser nitrogen the deposition of sulphur to agricultural (and other) land was well in excess of crop and animal requirements and sulphur was not discussed as a crop nutrient.

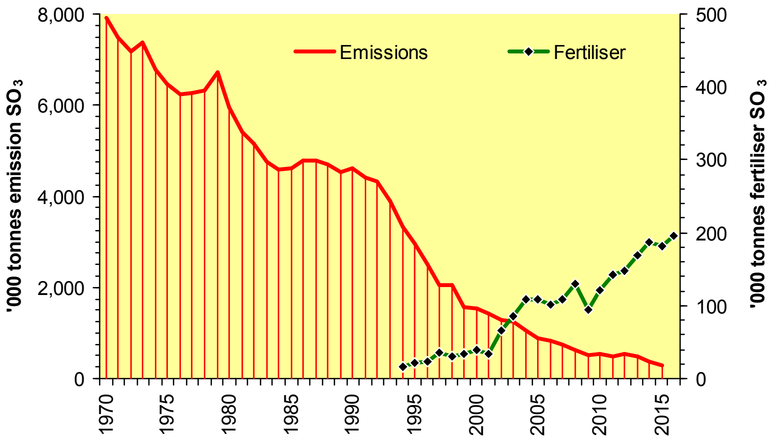

Figure 1: *UK sulphur deposition and use of sulphur fertiliser*

However, by 2015 the UK sulphur emissions had declined to little more than 100 kt S/yr and the need for sulphur fertiliser is recognised and applied by many growers (Figure 1). The majority of the fertiliser sulphur requirement to date has been met using ammonium sulphate. Containing both nitrogen and sulphur this is a useful product for use on crops which require both nutrients, but not for legumes which, because of their Rhizobial associations, do not normally receive any nitrogen fertiliser. However the British Survey of Fertiliser Practice (BSFP) reported in 2015 that the dressing cover for sulphur on peas and beans was at most 5% of the area of these crops, compared with 52% for the total arable crop area; over 60% of the wheat area received a dressing of sulphur. There are a number of reasons why these legumes, and others, have not received the sulphur they need, including no doubt the lack of cost-effective reliable sulphate fertilisers which do not contain nitrogen.

In 2010 ICL Fertilizers Ltd opened two drift roads into the polyhalite seam below the potash horizon in Cleveland Potash's site at Boulby in the North York Moors National Park, creating the first and only polyhalite mine in the world (Figure 2). The new fertiliser Polysulphate™ is produced following the crushing and grading of the ore, creating a unique and fully water-soluble potassium magnesium calcium sulphate product. The chemical formula for the polyhalite mineral is $K_2Ca_2Mg(SO_4)_4.2H_2O$ and the nutrient analysis of Polysulphate is shown in Table 1. The high sulphur content and the lack of nitrogen but with the additional benefit of three other essential macronutrients - potassium, magnesium and calcium - make this a potentially useful fertiliser for legumes. An initial replicated field trial was set up in conjunction with the International Potash Institute (IPI) to examine its effect on a crop of vining peas (*Pisum sativum*).

Figure 2: *Mining machinery accessing the polyhalite seam.*

Table 1: *Nutrient analysis of Polysulphate.*

Nutrient		Content
Sulphate	SO_3	48%
Potash	K_2O	14%
Magnesium	MgO	6%
Calcium	CaO	17%

Vining Peas

The trial field was a sandy clay loam with adequate nutrient levels of phosphorus, potassium and magnesium; no basal fertiliser dressing was considered necessary by the trial operator and indeed none was possible due to the late integration of the Polysulphate treatments within a larger trial. The pea variety was Jubilee, which was drilled on 6th April, two weeks after the application of the granular Polysulphate, which had been raked into the seedbed (Figure 3). Three dose rates of Polysulphate were applied at 50, 75 and 100 kg SO_3/ha equivalent, with the control plots receiving no Polysulphate. No differences in colour or vigour were noted and the crop was harvested on 25th June.

Figure 3: *The vining pea trial.*

There was a considerable difference in yield between the control and the Polysulphate treatments, with the indication that the 75 kg SO_3/ha rate is likely to be the most appropriate for this crop. The average yield response to the Polysulphate from the treatments was +27.5% (Figure 4). Valuing vining peas at £450/t this additional yield would represent an extra income per hectare of about £580, with the probable cost of the fertiliser being about £22.50/ha.

Included in the cost of the Polysulphate is not only the sulphate applied but also some potash, magnesium and calcium. While these nutrients may have marginally influenced the crop yield despite the reasonable soil reserves' it is considered that the available sulphate was the primary driver of the yield improvement.

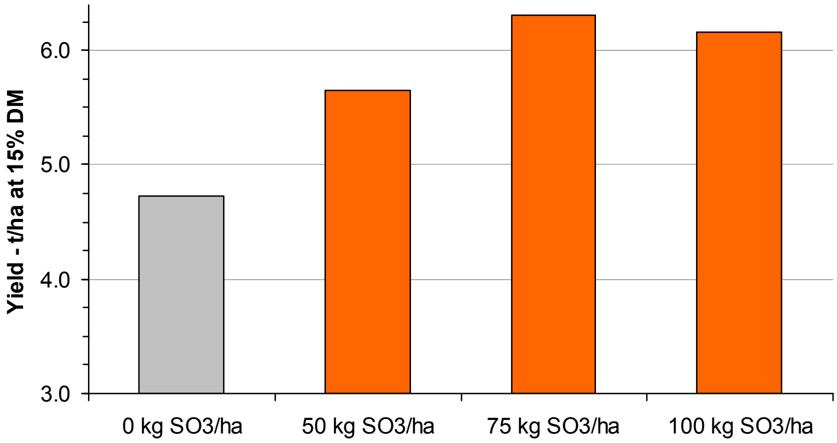

Figure 4: *Yield response of vining peas to different rates of sulphate from Polysulphate.*

Fodder legumes.

The trial on vining peas clearly illustrates the potential importance of sulphur as a nutrient for grain legumes, but it is equally necessary for fodder legumes, including clovers (*Trifolium* spp) and lucerne/alfalfa (*Medicago sativa*). A field trial in Scotland in 2017 examined the effect of the application of Polysulphate on the nutritional value of a crop of lucerne. Two zero nitrogen treatments were applied, one 'control' providing 80 kg/ha of phosphate and 120 kg/ha of potash only, and the other, with Polysulphate, providing the same phosphate and potash rates with in addition 96 kg SO_3/ha plus 34 kg CaO/ha and 12 kg MgO/ha. It was not feasible to measure the yields from the two treatments in this trial, but the crude protein and the nitrogen:sulphur ratios were measured (Figure 5). The N:S ratio in the Polysulphate treatment was improved to the 12:1 target value required for optimal digestibility, while at the same time the crude protein content improved by about 10%.

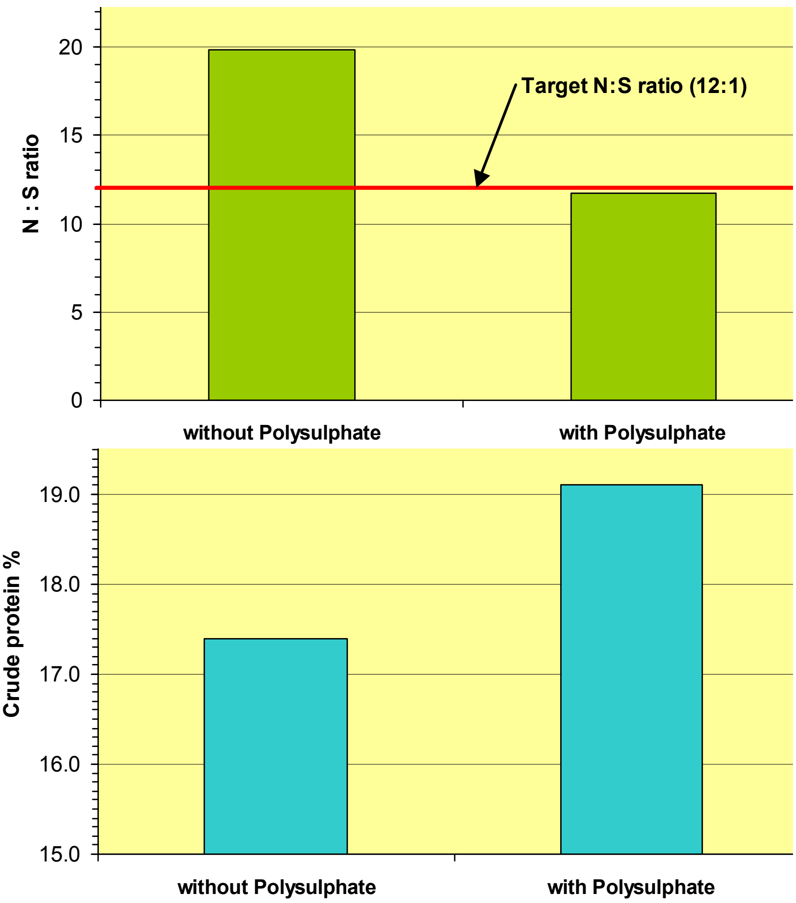

Figure 5: *Beneficial effects of an application of 96 kg SO_3/ha from Polysulphate on the N:S ratio (upper chart) and crude protein (lower chart) of lucerne.*

Conclusions.

The importance of sulphate fertiliser for grain and fodder legumes is clearly demonstrated by the positive yield and quality improvements seen on peas and lucerne, resulting from the application of Polysulphate to these crops. These results, together with other positive results on soya from South America, confirm the value of Polysulphate as an appropriate fertiliser for leguminous crops.