Polysulphate™ - a prolonged release sulphate fertiliser

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Introduction.

Polyhalite is an evaporite mineral which exists in relatively few places on earth. It is an unusual combination of potassium, calcium and magnesium in a single complex sulphate crystal, with the formula $K_2Ca_2Mg(SO_4)_4.2H_2O$ and is suitable for direct application without processing, unlike most fertiliser products. This mineral is present in quantities probably in excess of 1 billion tonnes at an exceptional 90+% purity below the existing potash seam in the Cleveland Potash Boulby Mine of ICL Fertilizers Ltd. Glasshouse and field trials to establish the full solubility and crop availability of the mineral were commenced in 1999 using product from core samples; the sulphur, potassium, magnesium and calcium were confirmed to be fully available to crops. The polyhalite seam was accessed for mining in September 2010. This was the first polyhalite ever to be mined, and Boulby still has the only operational polyhalite mine in the world.

The processed polyhalite is now marketed by ICL Fertilizers as Polysulphate™, primarily as a sulphate fertiliser having a significant potassium, magnesium and calcium content. The guaranteed minimum analysis of Polysulphate is shown in Table 1.

Table 1: *Nutrient analysis of Polysulphate™.*

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

As Polysulphate became commercially more widely used by farmers in the UK, France and other countries it was noticed that the granules sometimes took several weeks to dissolve fully and some questioned its solubility. An experiment was therefore set up to investigate the different rates of dissolution of this and other types of sulphate fertiliser. It was known from earlier experiments and field trials that Polysulphate was fully soluble and that its nutrients were able to supply the crop as it required them equally as well as from traditional proven sources (potassium sulphate, magnesium sulphate and di-hydrate calcium sulphate), described as 'equivalent nutrients' in the following example chart for sulphur, taken from a replicated pot trial, without leaching (Figure 1).

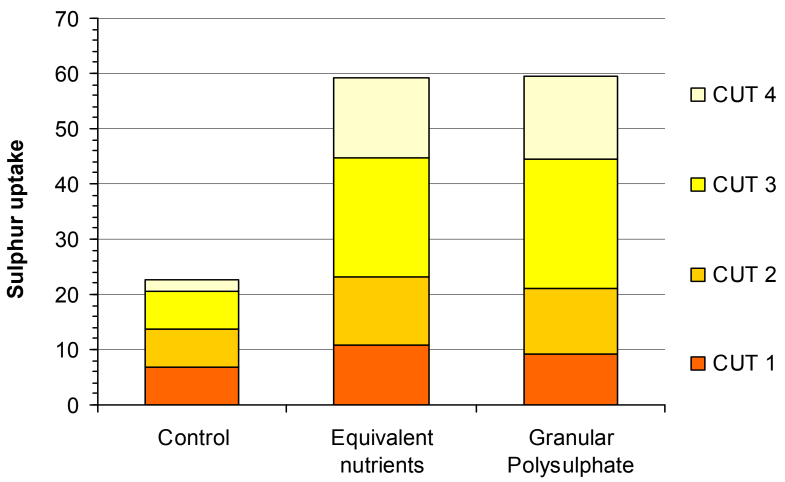

Figure 1: *Uptake of S by each cut of grass. No significant differences were found between the recovery of nutrients supplied from the equivalent nutrient product and from Polysulphate.*

Method.

Knowing that the nutrient recovery from Polysulphate by crops was fully equivalent and complete, an experiment was designed with the University of Nottingham to investigate the rates of dissolution of a number of similarly fully soluble sulphur-containing fertilisers. An apparatus was designed which would permit the daily flushing of columns of soil to which Polysulphate granules and other fertilisers had been added.

Figure 2: *Apparatus for the determination of the relative rates of dissolution of different sulphur-containing fertilisers.*

Triplicate soil columns (200 g sandy loam; arable Wick series) were installed and flushed twice to clean and equilibrate them. They were then fertilised with granular commercial grade Polysulphate, ammonium sulphate $(NH_4)_2SO_4$, potassium sulphate K_2SO_4 or magnesium sulphate $MgSO_4$. The granules were covered with 1 cm of soil. The soil columns were flushed with 1 pore volume of de-ionised water each day and the leachate collected for analysis by inductively coupled plasma mass spectrometry for sulphur and the constituent cations.

Results.

As each of the fertiliser products dissolves the constituent ions are released into the soil solution. The cations tend to become held on the clay and organic matter exchange sites while the sulphate ions move down the profile in the draining water, finally reaching the receiving cup below each column together with some balancing cations. This daily flushing of the columns removes the sulphate which has dissolved from the fertiliser product over the previous 24 hours.

Thus the relative rate at which each fertiliser product dissolves, the rate of dissolution, can be determined by the quantity of sulphate which is measured in each cup each day. The results of the first 30 days of daily washing of the columns, measured as the percentages of the total available sulphate which accumulates in the successive cups, is shown in Table 2. There are clear differences between the rates of dissolution between these fertiliser products, with virtually all of the ammonium sulphate products being dissolved within 4-5 days. The rate of dissolution of sulphate of potash was marginally slower, with kieserite being a little slower again. The rate of dissolution of the Polysulphate is considerably slower than all the other products, with only 84% of the total finally released being dissolved by day 30. The results of the experiment are shown in graphical form in Figure 3.

Table 2: *Accumulating percentages of sulphate flushed from the different products in the first 30 days.*

Days	Ammonium sulphate	Sulphate of potash	Kieserite	Polysulphate
0	0	0	0	0
1	2	1	3	3
2	71	20	10	13
3	91	60	41	21
4	97	83	59	30
5	99	93	69	38
6	100	96	75	45
7	100	97	80	50
8	100	98	84	54
9	100	98	87	57
10	100	98	89	59
11	100	98	91	61
12	100	99	93	63
13	100	100	94	65
14	100	100	95	66
15	100	100	96	68
16	100	100	96	69
17	100	100	97	70
18	100	100	97	71
19	100	100	98	73
20	100	100	98	74
21	100	100	99	75
22	100	100	100	76
23	100	100	100	77
24	100	100	100	78
25	100	100	100	79
26	100	100	100	81
27	100	100	100	82
28	100	100	100	83
29	100	100	100	83
30	100	100	100	84

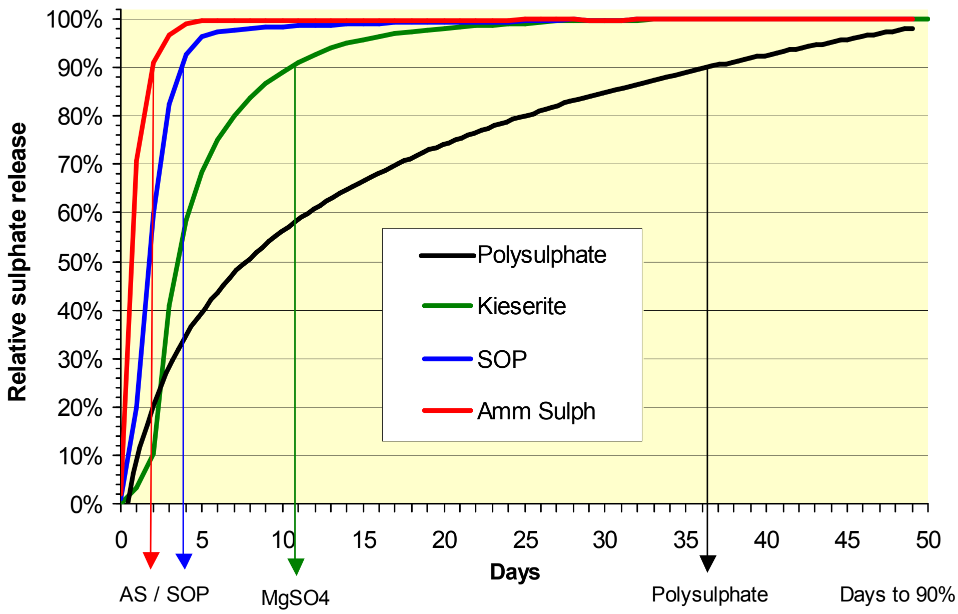

Figure 3: *Relative S release rates, comparing Polysulphate with ammonium sulphate, sulphate of potash and kieserite.*

The days taken to release 90% of the sulphate from each product is also shown in Figure 3, with ammonium sulphate taking about 2 days, sulphate of potash 4 days, kieserite 11 days and Polysulphate 36 days.

Conclusions.

The extended release period of the nutrients in Polysulphate, particularly the sulphate, offers considerable potential advantage in practical farm conditions. The uptake timings of nitrogen and sulphur by wheat and other crops are very similar (Figure 4) and, because most sources of nitrogen have high rates of dissolution, multiple dressings of nitrogen are usually applied in order to minimise the potential loss of nitrogen as leached nitrate. The prolonged release pattern of the sulphate from Polysulphate allows the application of a single dressing of sulphate in the spring without major risk of loss of sulphate by leaching.

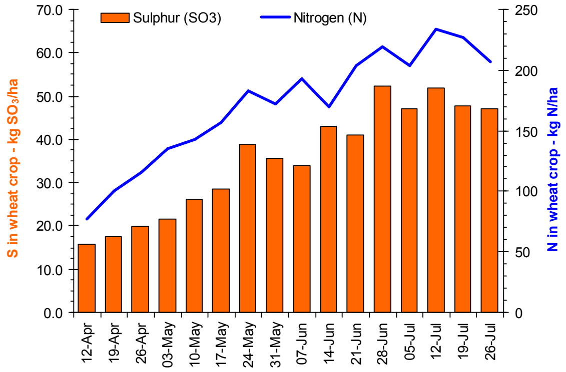

Figure 4: *The extended period of S uptake by wheat, relating to the Polysulphate release curve.*