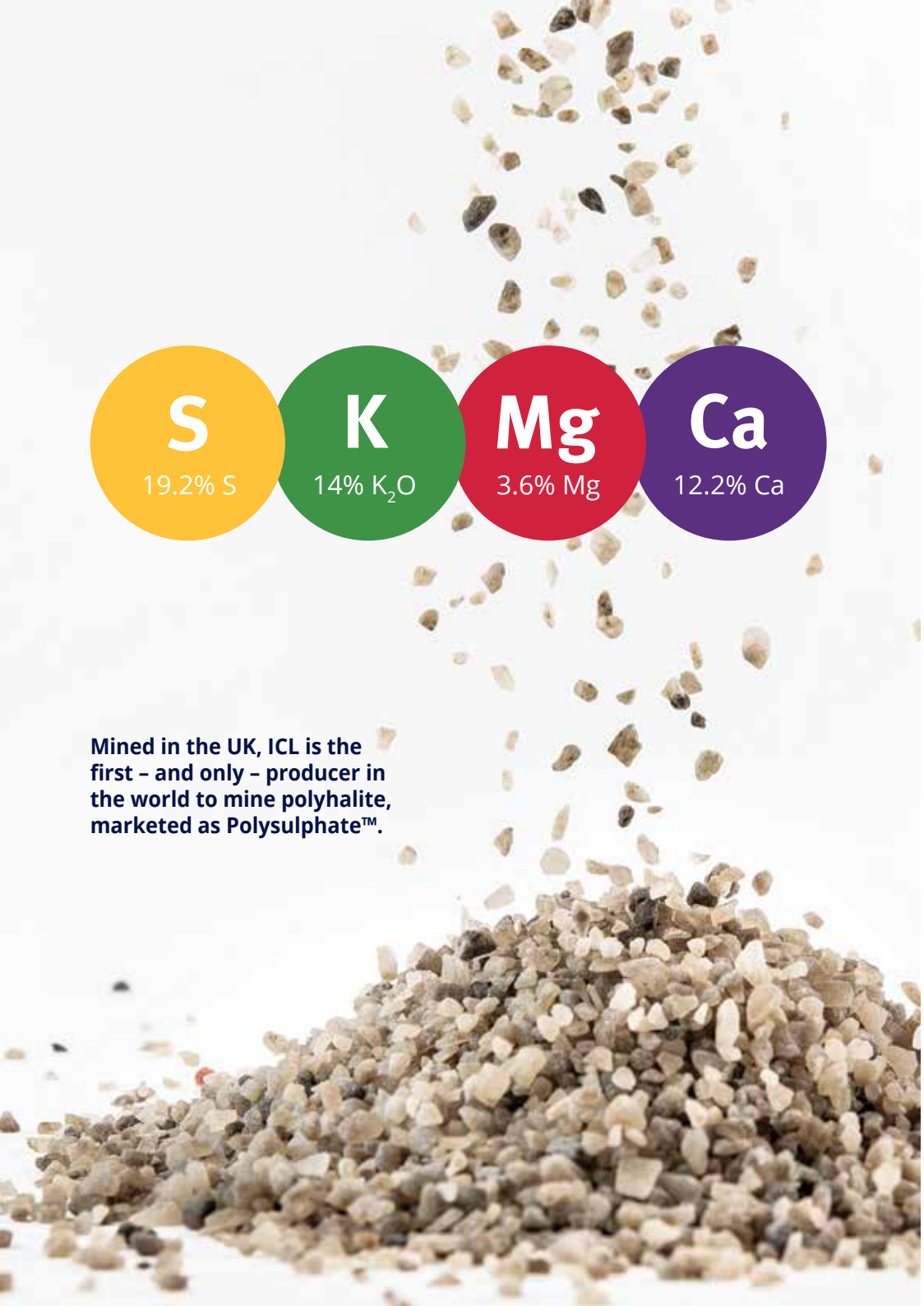
Polysulphate

Readily available sulfur plus potassium, magnesium and calcium for better crops

ICL Fertilizers
Where needs take us

Polysulphate® S K Mg Ca



Mined in the UK, ICL is the first – and only – producer in the world to mine polyhalite, marketed as Polysulphate™.

The need for sulfur application

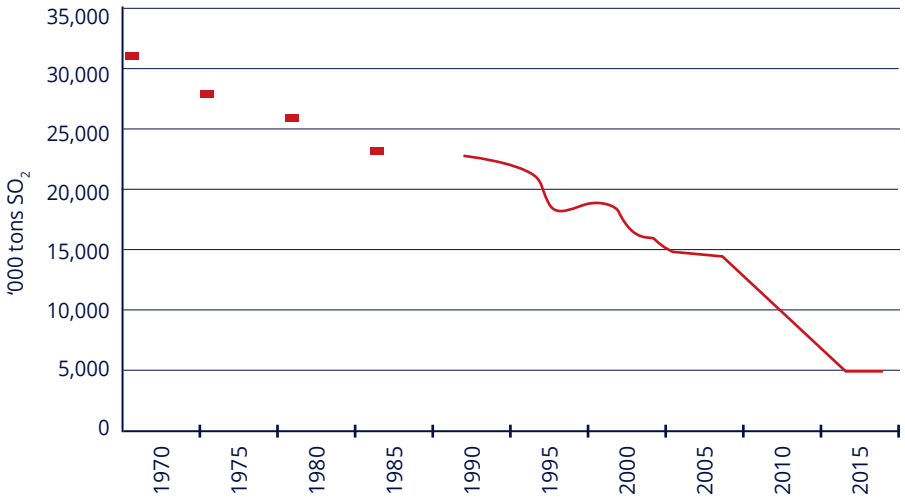
Sulfate is now established as a major fertilizer requirement for arable crops and grassland. Yet most farmland never receives a routine application.

Sulfur fertility has historically not been a major concern for growers on most soils, as soil organic matter, atmospheric deposition, manure application and incidental sulfur contained in fertilizers have typically supplied sufficient sulfur for crop production. However, reductions in the amount of sulfur contributed by these factors combined with increased sulfur removal with greater crop yields have made sulfur deficiencies more common. According to The Sulphur Institute, it is estimated that about 20% of arable lands in North America suffers sulfur deficiency at present.

Historically, in industrialized countries arable crops and grassland had never required sulfate applications. Coal-burning had always ensured plenty of sulphur was supplied via atmospheric deposition.

Regulation has ensured this deposition is now a fraction of what it used to be. As a result, large areas of farmed land are sulphur deficient, particularly those with lighter soils or lower rainfall.

NATIONAL EMISSIONS OF SULFUR DIOXIDE (SO_2) IN USA



Nitrogen (N) and sulfur (S) are both essential constituents of plant and animal protein, so now that sulfur is no longer freely available from the atmosphere, wherever nitrogen fertilizers are applied there is likely to be a need for a balancing sulfate fertilizer to ensure yield and quality.

Legumes such as peas, beans, alfalfa/lucerne and clover, which rely on atmospheric nitrogen but are now deprived of similar sulfur, will now almost certainly respond to a sulfate fertilizer.

This booklet introduces a sulfate fertilizer, Polysulphate™. This new product is mined in the UK, and with 19.2% S, provides a reliable and readily available new source of sulfate.

Livestock requirements

Like arable crops, grassland needs sulfate fertilizer – it's a vital input to ensure a healthy ruminant diet. Even where manure and slurry are returned to the land, extra applications are often needed.

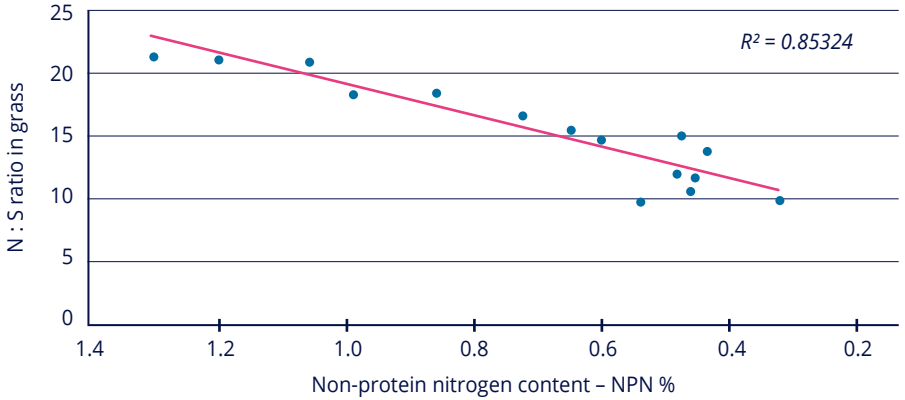
In the UK, only around 10% of grassland currently receives sulfate fertilizer. But a shortage will reduce grass yield and efficient nitrogen utilization, increase nitrate loss and reduce sugar content and digestibility[1]. Grass grown for silage is particularly liable to sulfur deficiency.

[1] G. Fisher, J. Buss *et al.*, 2011, Grassland Report, British Grassland Society, UK

As with arable crops, grass also requires a balance between nitrogen and sulfur for its protein content, and a lack of sulfur will lead to reduced yields and to increased levels of non-protein nitrogen in the feed (see chart).

BENEFICIAL EFFECT OF S-FERTILIZATION ON NON-PROTEIN N CONTENT OF GRASS

Source: Baker A.S. et al. Sulfur Inst J. 9(1), 14-16



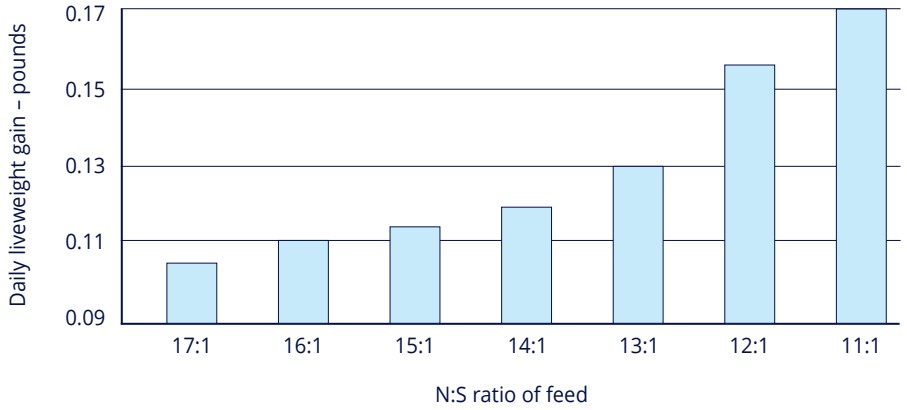
Research on silage carried out by IGER at North Wyke (now part of Rothamsted Research, UK) found dry matter yields increased by 35% over three cuts on sandy loam soil where sulfate was applied[2]. Nitrate losses were cut by up to 82%, while the true protein and soluble sugars content of the silage were boosted by 25% and 30% respectively.

Perhaps even more importantly, the microbes in the rumen also need the correct balance of nitrogen and sulfur. If the grass is short of sulfur they will not be able to use all of its potential feed value. This means that the actual digestibility (D-value) of the feed is reduced and part of the feed value is wasted (see charts).

[2] L. Brown, D. Scholefield *et al.*, 2000, The effect of sulfur application on the efficiency of nitrogen use in two contrasting grassland soils, *Journal of Agricultural Science*, Vol 135

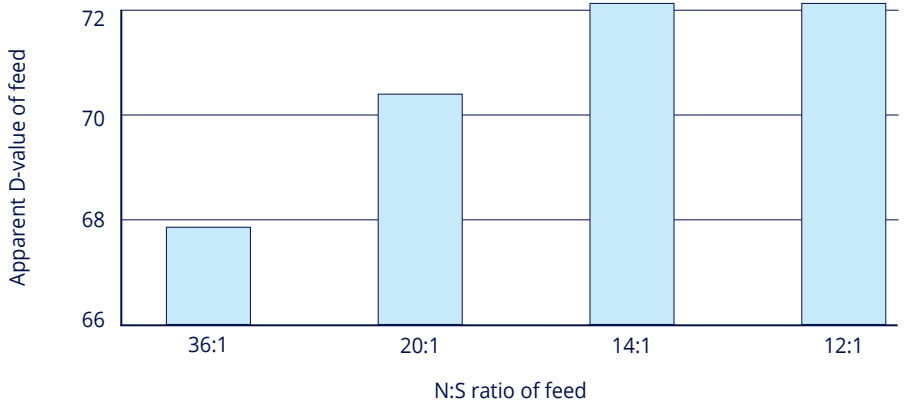
DAILY LIVEWEIGHT GAIN OF LAMBS INCREASES AS FEED N:S RATIO IMPROVES

Source: Rendig and Weir, J. Anim. Sci. 16(2)



IMPROVED N:S RATIO INCREASES D-VALUE OF FEED FOR DAIRY COWS

Source: Bouchard and Conrad, J. Dairy Sci. 56



Sulfur from manure and slurry

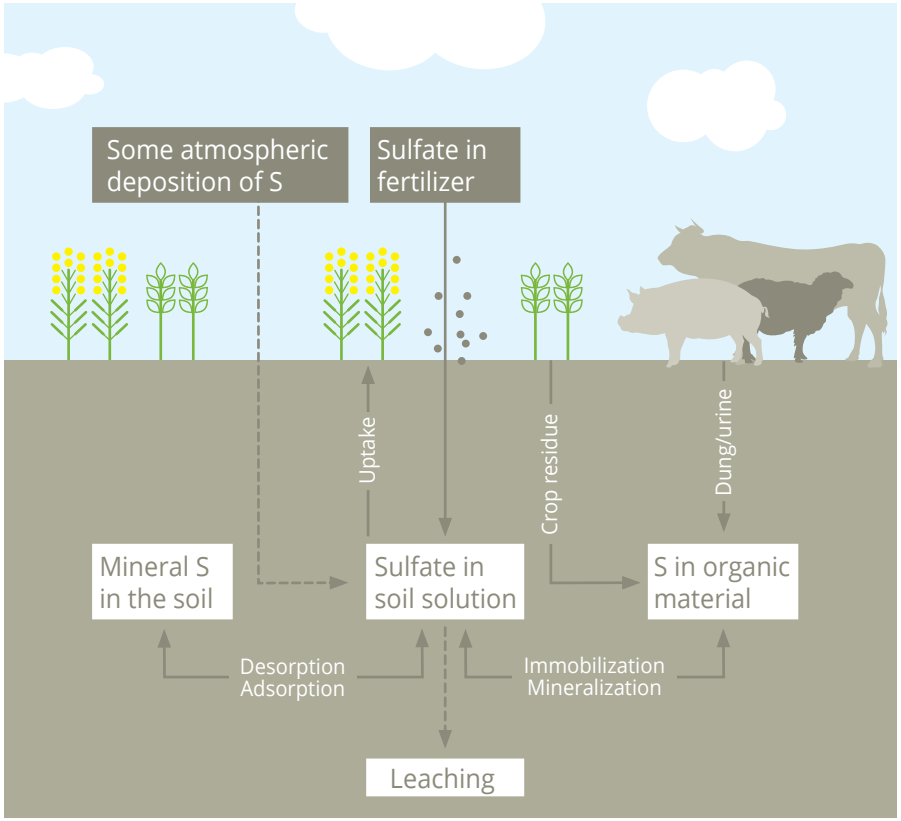
Farmyard manure and slurry contain significant quantities of sulfur. When fresh much of this becomes available to the plant. But in storage the activity of anaerobic bacteria can reduce the sulfate to sulfide and combine it into organic complexes. These cannot be utilized by plants, but gradually oxidize back to sulfate over time.

There is little reliable data on the actual availability of sulfur in stored manures, so it is therefore best to consider it as contributing to overall soil reserves, rather than supplying sufficient nutrient for the current crop.

Sulfur in soil and in the plant

Sulfate behaves like nitrate in the soil. In the plant nitrogen and sulfur are both essential building blocks for proteins. Sulfur deficiency will severely reduce the efficient use of nitrogen and limit protein synthesis.

Sulfur can only be taken up by plants from the soil solution as sulfate. As with readily-available nitrate, it can be liable to loss through leaching. Spring application of sulfate fertilizer is therefore recommended so that the plant can take it up during the period of active growth, as with nitrate. Sulfur is required together with nitrogen for the formation of proteins and uptake timings are similar.



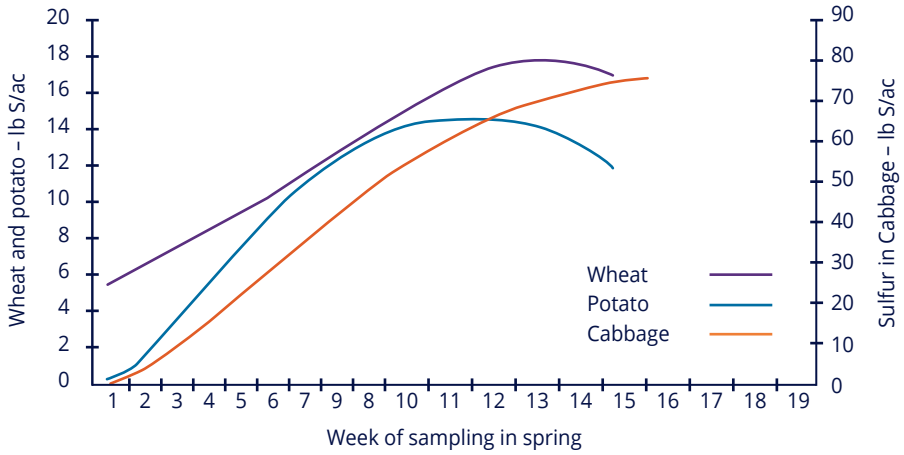
Elemental sulfur

While sulfate fertilizer is immediately available to the crop, applications of elemental sulfur must be converted to sulfate by bacterial activity in the soil before it becomes available. The time taken for this oxidation is unpredictable and may take many months, so the sulfate required by the crop may not be available when needed.

Protein synthesis

Sulfur is required for many growth functions in plants – like nitrogen it is principally an essential constituent of protein. There is therefore a close relationship between the quantities of nitrogen and sulfur in crops, with most taking up about 1 pound of sulfur for every 12 pounds of nitrogen.

SULFUR UPTAKES BY WHEAT, POTATO AND CABBAGE



Brassica crops, such as oilseed rape, cabbage and kale, require much more sulfate. They need extra sulfur for the production of glucosinolates, which are used within the plants as a defense mechanism.

Once taken up, unlike nitrogen, sulfur does not move against the transpiration stream and cannot be taken from older leaves, for example, to support new growth. So a sufficient and continuous supply is needed in the soil to satisfy all the needs of the growing crop.

Signs of deficiency include the yellowing of young leaves or new growth. By contrast, yellowing from nitrogen deficiency affects the older leaves first.

Sulfur-deficient oilseed rape can also have purpling and upward cupping of young leaves, delayed and prolonged flowering, pale-colored flowers, and fewer, smaller pods.

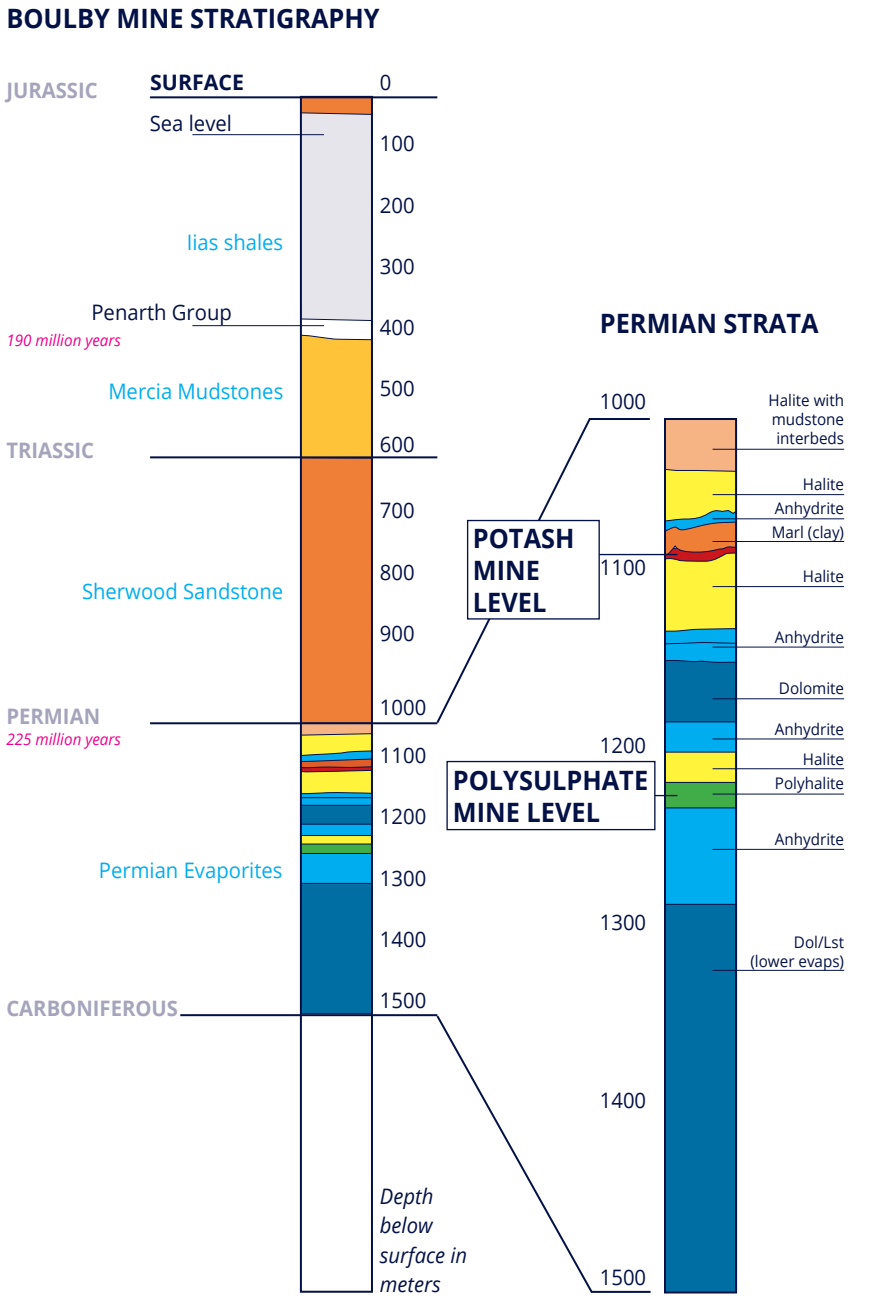
Introducing Polysulphate

Polysulphate is a new fertilizer, high in sulfate, available in its natural state, and mined in the UK. A unique benefit is its additional natural content of other macronutrients.

Polysulphate comes from the polyhalite layer of rock, over 3,300 ft below the North Sea off the North Yorkshire coast in the UK. Deposited 260 million years ago, it lies 490-560 ft below the potash seam at the Cleveland Potash Boulby Mine.

The main Polysulphate seam was reached in September 2010, bringing the first samples up to the surface. It is estimated there are one billion tons available from this one source.

Polysulphate is available as both a granular and powder product. The 2-4mm granular product has excellent spreading characteristics and is an ideal fertilizer to apply alongside straight nitrogen.



Polysulphate contains

- 19.2% S as sulfate
- 14% K_2O as from sulfate of potash
- 3.6% Mg as from magnesium sulfate
- 12.2% Ca as from calcium sulfate

Benefits of potassium, magnesium and calcium

In addition to sulfate, Polysulphate has the added bonus of valuable levels of potassium (K_2O), magnesium (Mg) and calcium (Ca).

Potash is recognized as a necessary regular input, with recommendations based on soil indices and removal at harvest. But surveys have shown reserves are dropping. Most of the potassium in a harvested crop of cereals is in the straw. So when selling straw makes commercial sense, it's important to boost potassium inputs to compensate. The potassium in Polysulphate complements routine fertilizer applications.

Magnesium is often only applied to some cash crops and vegetables. This macronutrient is part of the chlorophyll in all green plants and essential for photosynthesis. It is removed in significant quantities at harvest of all crops, and an application from Polysulphate will provide a useful input of a nutrient that is frequently overlooked.

The fourth constituent of Polysulphate is calcium, which means that it has effectively no non-nutrient constituents. Calcium is responsible for proper plant cell division and for strengthening cell walls. Polysulphate helps to maintain essential calcium reserves in the soil.

Polysulphate is particularly suitable for crops which prefer low levels of chloride in the soil, such as tobacco, grapes and other fruits, and where higher dry-matters are desired in potatoes.

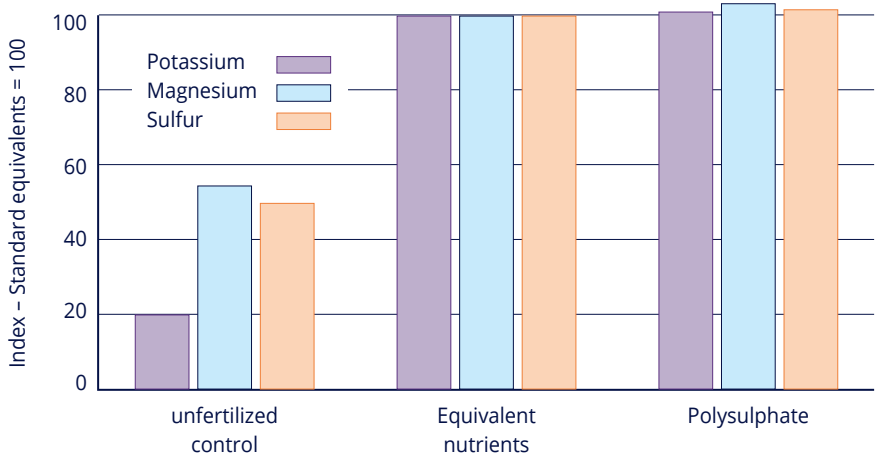
How Polysulphate performs

Proprietary and independent trials work have shown Polysulphate to be as good as the best sources available of the principal nutrients it contains. It also spreads well at 79 ft and above.

Polysulphate trials have focused on establishing that its principal nutrients – sulfate, potassium, and magnesium – are readily available to the plant. Crop samples were grown in pots and given standard sources of pure potassium and magnesium sulfates, or Polysulphate.

Uptake of the Polysulphate nutrients by the plants was found to be as good if not better than the standard already used in the field. The results confirm Polysulphate's effectiveness as a multi-nutrient fertilizer.

RELATIVE NUTRIENT UPTAKE FROM POLYSULPHATE COMPARED WITH EQUIVALENT STANDARD NUTRIENT SOURCES AND UNFERTILIZED CONTROL

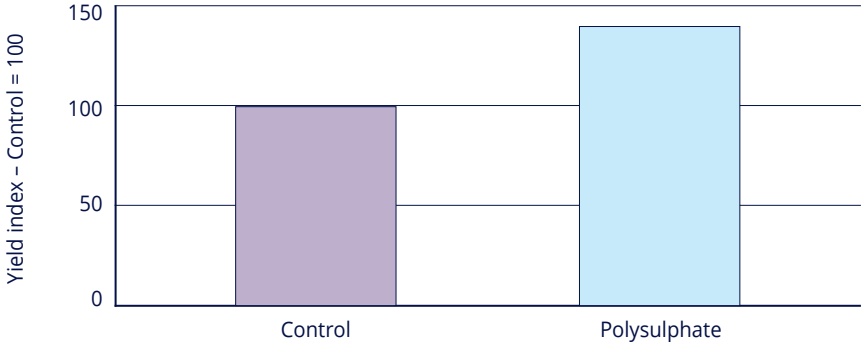


These trials have been repeated many times over the last ten years, both in pots and in the field. In every case Polysulphate has performed equally well or better than the best standard alternatives.

Field trials in the UK have also investigated the response of cabbage to sulfate fertilizer. The results showed a 40% yield improvement from an application of Polysulphate.

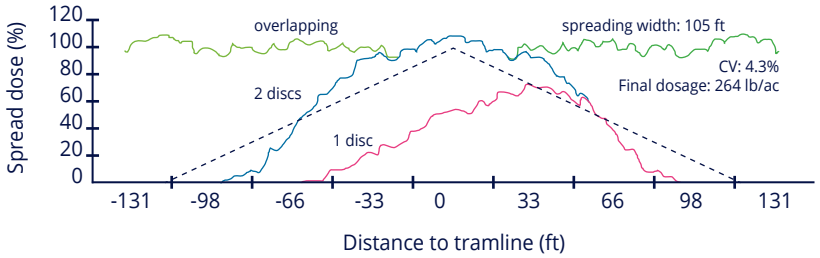
WHITE CABBAGE YIELD RESPONSE TO POLYSULPHATE

(2009 trial on S-deficient site)



Spreadability trials have been undertaken. Polysulphate is a dry, granular product that is available in its natural state. The trials, carried out in France, Denmark and Germany, confirmed an excellent overlapped spread pattern at a 105-feet bout width, with a coefficient of variation of 4.3, and good spreadability up to 118 ft.

SPREADING STRAIGHT POLYSULPHATE



Independent research

"The apparent recovery of potassium indicates that all of the applied potassium [from the Polysulphate] had been taken up by the grass. Significant effects were also seen with magnesium uptake from the applied fertilizers. Sulfur content in the grass was significantly increased over the control."
Grass pot trial #1, Levington, 1999

"Potassium levels in the grass were significantly lower in the untreated control. There was a rate effect from the Polysulphate, with the full rate being equivalent to the standard treatment. Polysulphate was a good source of sulfur for the grass." Grass pot trial #2, Levington, 1999

"The results indicate that Polysulphate provides sulfur in an available form immediately after application." HDRA organic trial, 2001

"The results show that Polysulphate provides an immediately available source of sulfur to spring peas, whereas the S from elemental (90%) sulfur was not being taken up by spring peas over the two-month period following its application to the soil." Rothamsted trial on spring peas, 2001

"The visual vigor scores at harvest averaged 92 for the Polysulphate treatment compared with 72 for the control without sulfur."
Cabbage field trial, OAT, 2009

Getting the best from Polysulphate

Polysulphate has a number of key benefits, which makes it an ideal choice of sulfate fertilizer for farmers. It offers the chance to fulfil the potential of a range of crops.

Polysulphate is:

- Readily available – already in its soluble, sulfate form for immediate use.
- A new granular form of sulfur, offering flexibility to tailor application to field requirements.
- Concentrated, so has a low storage requirement and is quick to spread.
- A source of potassium, magnesium and calcium – an added bonus.
- Low in chloride, so suitable for chloride-sensitive crops.
- Environmentally benign as it is used in its natural state – no processing or waste product, and non-acidifying.
- UK-sourced and a secure supply of fertilizer with a low carbon footprint.

Advice for arable crops

Polysulphate can be applied in one dressing at the beginning of spring growth. The aim is to match the sulfur requirements to the crop's nitrogen needs.

Where nitrogen rates are varied, in precision farming systems for example, the Polysulphate dressing can be independently varied to best match overall nitrogen applications.

Cereals and oilseeds

- Apply as a straight fertilizer at the start of spring growth.
- Readily available, the crop will take it up with the nitrogen over the spring growing period.
- Apply to oilseed rape to optimise yield, protein and oil synthesis.
- Apply to bread-making wheats for yield and to ensure grain protein quality.
- Apply to malting barley for yield and quality.

Peas

- Apply in the seedbed or soon after emergence.
- A zero-N fertilizer, bringing readily available sulfur to the crop.
- Used by the plant at an early stage to feed the nitrogen-fixation process, which occurs within the root nodules and for protein synthesis in the plant.

Brassica field vegetables

- Brassica crops have been shown to be particularly responsive.
- Apply as a base dressing, especially on high-risk light soils.

Advice for livestock farmers

Applications of manure and slurry cannot be relied on as a source of available sulfate, and are best considered as maintaining soil reserves (see page 8). So Polysulphate should be applied in line with nitrogen requirements as necessary to achieve optimum grass growth throughout the season at the correct N:S ratio.

Conserved leys

- Apply after each cut of silage to complement nitrogen uptake and maintain N:S ratio.
- On lighter soils an application at the start of the spring may also be required.

Grazed leys

- Apply after stock is moved on in rotational systems.
- If set-stocked, and especially on lighter soils, apply early at the start of spring.

Clover leys

- Provides an excellent sulfur boost for later-growing clover.
- Apply as spring growth gets underway – earlier growing ryegrass will have taken up soil sulfur reserves.

Natural, sustainable, dependable

Available in its natural form, Polysulphate is UK-sourced and has a low carbon footprint. It delivers dependable high value, for low environmental impact.

Unlike blended or compound fertiliser, Polysulphate is available in its natural state. It is mined, crushed, screened and bagged, involving no chemical separation or other industrial processes. It is therefore an ideal natural source for all crops, especially brassicas, cereals, pulses, field vegetables, clover-rich grassland leys and silage crops.

The low content of the crop nutrient chloride makes it ideal for use on chloride-sensitive crops. The natural process by which Polysulphate is produced makes it a low carbon footprint fertiliser. This helps growers achieve carbon targets demanded by retailers and some food processors.

There's an estimated 1 billion tonnes available, mined in the UK. As global demand for sulphate fertilisers increases, this provides farmers throughout the world with a dependable source, rather than a by-product material.

Polysulphate is widely accepted as an organic source of the nutrients:

- Licensed as a sulphur fertilizer approved for organic use by the Soil Association in UK
- Licensed as a sulphur fertilizer approved for organic use by the Organic Farmers and Growers in UK
- Registered in the list of production facilities for organic farming in Germany by FiBL (Research Institute of Organic Agriculture)
- Product listed in the BIO fertilizers Italian register as per D. Lgs. 75/2010
- Polysulphate Standard Grade is OMRI listed for organic use in USA
- Polysulphate Standard Grade is listed on the OMRI Canada Products List
- Products are compliant with Regulation (EC) 889/2008 governing organic production
- Polysulphate is registered in the Dutch inputs list for organic farming
- Standard and Granular Polysulphate is approved for use in organic farming by the Plant Protection and Inspection Services (PPIS) of the Ministry of Agriculture and Rural Development, Israel

Polysulphate calculator

Use the chart below to decide how much you need, and how much potassium, magnesium and calcium your application will provide.

Crops	Risk of deficiency	Other nutrients applied (lbs/acre)					Notes
		S	Poly-sulphate™	K_2O	Mg	Ca	
Cereals	higher	18	**90**	13	3.2	11	Apply in early spring before the start of stem extension.
	lower	9	**45**	7	1.6	5.5	
Oilseed rape	higher	27	**135**	19	4.9	16.6	Apply in early spring. Spring crops may be less susceptible to deficiency.
	lower	18	**90**	13	3.2	11	
Peas (for dried, vining and fresh markets)		9	**45**	7	1.6	5.5	Apply where soil is sandy, shallow or medium textured and contains little organic matter.
Brussels sprouts, cabbage, cauliflowers, calabrese		18	**90**	13	3.2	11	Apply where sulfur content of soils is low, e.g. light soils following wet winters where there is no history of organic manures application.
Grassland		14	**72**	10	2.6	8.8	Apply at the start of growth before each cut. May not be required before first cut on medium/heavy soils.

* Generally applications should be made where a deficiency has been recognized or is expected. This can be assessed through tissue analysis, crop observation or whether in a high-risk area. Refer to official recommendations for further details.

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