Polysulphate™

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

ICL Fertilizers
Where needs take us

Poly S K Mg Ca™
sulphate

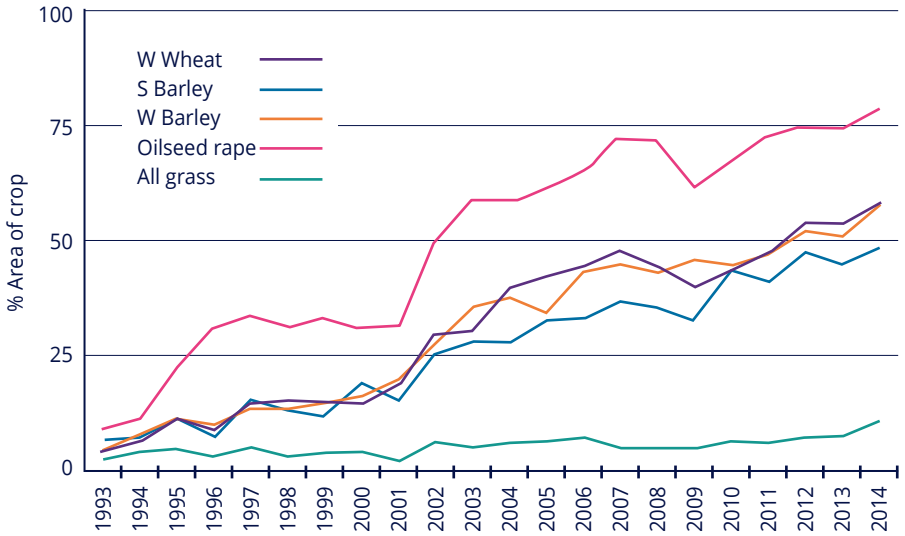
Mined in the UK, ICL is the first – and only producer – in the world to mine polyhalite, marketed as Polysulphate™.

The need for sulphur application

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

Sulphur deficiency is now widespread and in the UK ,for example, yield response to sulphate applications in winter wheat can be up to 30% in some cases, and averages 6%. In brassica crops the benefit is greater, with trials showing winter oilseed rape can give a yield response of as much as 80%. A recent note 'Sulphur for cereals and oilseed rape' has been published in the UK by the HGCA[1].

% AREA OF SOME GB CROPS RECEIVING SULPHUR



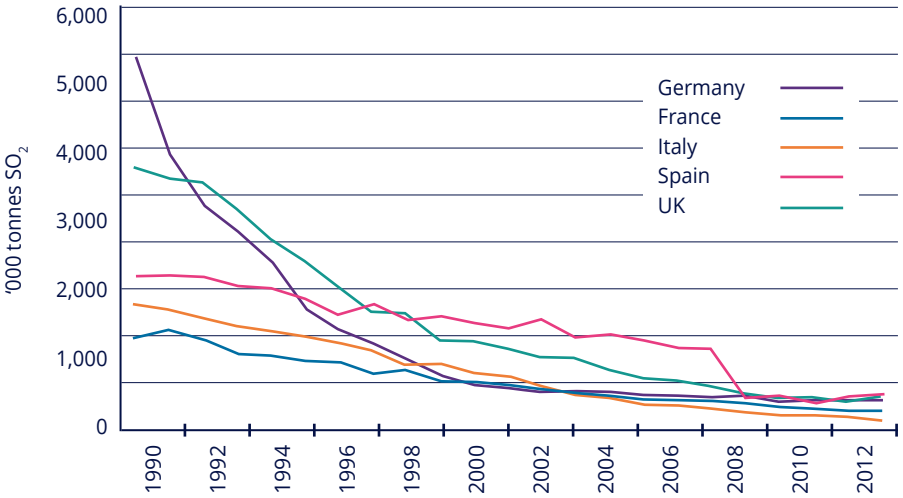
Despite this, sulphate applications to crops remain low, however. Only 42% of cereal crops receive routine applications. In oilseed rape, despite the established benefits, only 65% of crops receive the sulphate they need. Although nearly all crops would benefit, it is possible that applications have been restricted through a lack of cost-effective, easily spread sulphate fertiliser.

[1] http://www.hgca.com/crop-management/nutrient-management.aspx

Historically, in industrialised countries arable crops and grassland had never required sulphate 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.

SULPHUR EMISSIONS (AS SO_2) IN SOME W EUROPEAN COUNTRIES
UNECE/EMEP, 2010



Nitrogen (N) and sulphur (S) are both essential constituents of plant and animal protein, so now that sulphur is no longer freely available from the atmosphere, wherever nitrogen fertilisers are applied there is likely to be a need for a balancing sulphate fertiliser 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 sulphur, will now almost certainly respond to a sulphate fertiliser.

This booklet introduces a sulphate fertiliser, Polysulphate™. This new product is mined in the UK, and with 48% SO_3, provides a reliable and readily available new source of sulphate.

Livestock requirements

Like arable crops, grassland needs sulphate fertiliser – 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.

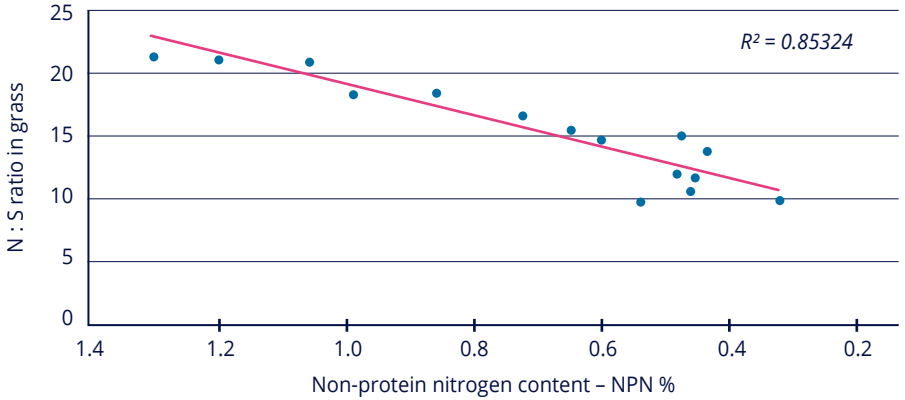
In the UK, only around 10% of grassland currently receives sulphate fertiliser. But a shortage will reduce grass yield and efficient nitrogen utilisation, increase nitrate loss and reduce sugar content and digestibility[2]. Grass grown for silage is particularly liable to sulphur deficiency.

[2] 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 sulphur for its protein content, and a lack of sulphur will lead to reduced yields and to increased levels of non-protein nitrogen in the feed (see chart).

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

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



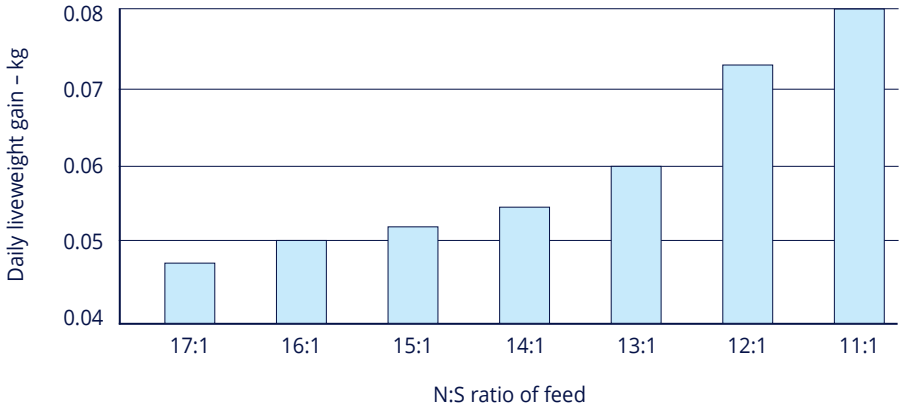
Research on silage carried out by IGER at North Wyke (now part of Rothamsted Research, UK) found dry matter yields increased by 35% over three cuts on sandy loam soil where sulphate was applied[3]. Nitrate losses were cut by up to 82%, while the true protein and soluble sugars content of the silage were boosted by 25% and 30% respectively.

Perhaps even more importantly, the microbes in the rumen also need the correct balance of nitrogen and sulphur. If the grass is short of sulphur 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).

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

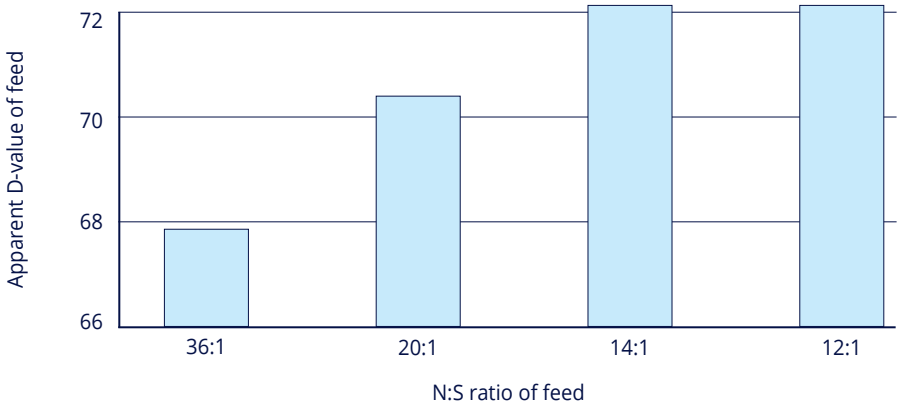
DAILY LIVEWEIGHT GAIN OF LAMBS INCREASES AS FEED N:S RATIO IMPROVES

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



Sulphur from manure and slurry

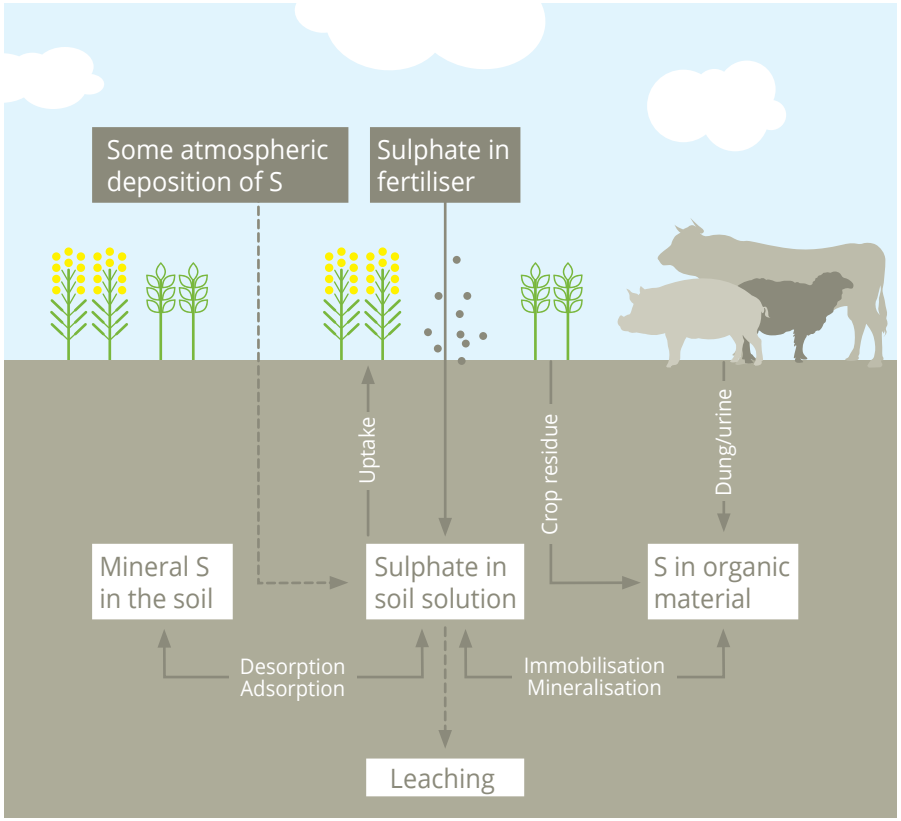
Farmyard manure and slurry contain significant quantities of sulphur. When fresh much of this becomes available to the plant. But in storage the activity of anaerobic bacteria can reduce the sulphate to sulphide and combine it into organic complexes. These cannot be utilised by plants, but gradually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

There is little reliable data on the actual availability of sulphur 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.

Sulphur in soil and in the plant

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

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



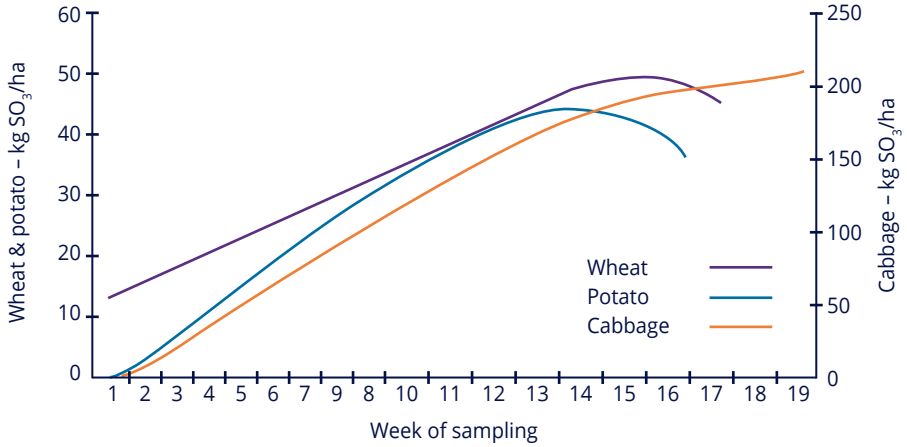
Elemental sulphur

While sulphate fertiliser is immediately available to the crop, applications of elemental sulphur must be converted to sulphate 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 sulphate required by the crop may not be available when needed.

Protein synthesis

Sulphur 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 sulphur in crops, with most taking up about 1kg of sulphur (2.5kg SO_3) for every 12kg of nitrogen.

SO_3 UPTAKES BY WHEAT, POTATO AND CABBAGE DURING THE GROWING SEASON



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

Once taken up, unlike nitrogen, sulphur 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.

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

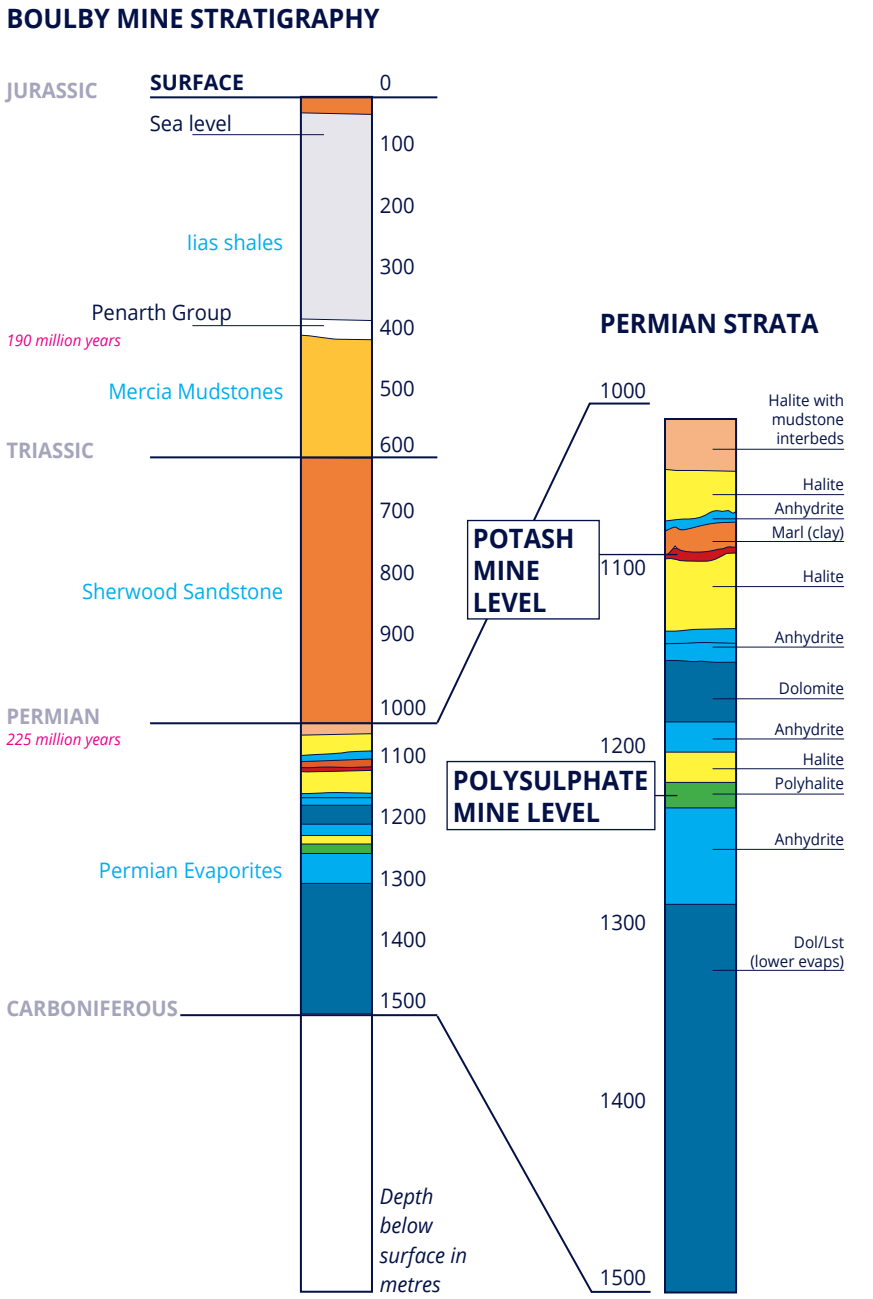
Introducing Polysulphate™

Polysulphate is a new fertiliser, high in sulphate, 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 1000m below the North Sea off the North Yorkshire coast in the UK. Deposited 260 million years ago, it lies 150-170m 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 tonnes 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 fertiliser to apply alongside straight nitrogen.



Polysulphate contains

- 48% SO_3 as sulphate
- 14% K_2O as from sulphate of potash
- 6% MgO as from magnesium sulphate
- 17% CaO as from calcium sulphate

Benefits of potassium, magnesium and calcium

In addition to sulphate, Polysulphate has the added bonus of valuable levels of potassium (K_2O), magnesium (MgO) and calcium (CaO).

Potash is recognised as a necessary regular input, with recommendations based on soil indices and removal at harvest. But surveys have shown reserves are dropping, with more arable soils at index 0 or 1. 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 fertiliser 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.

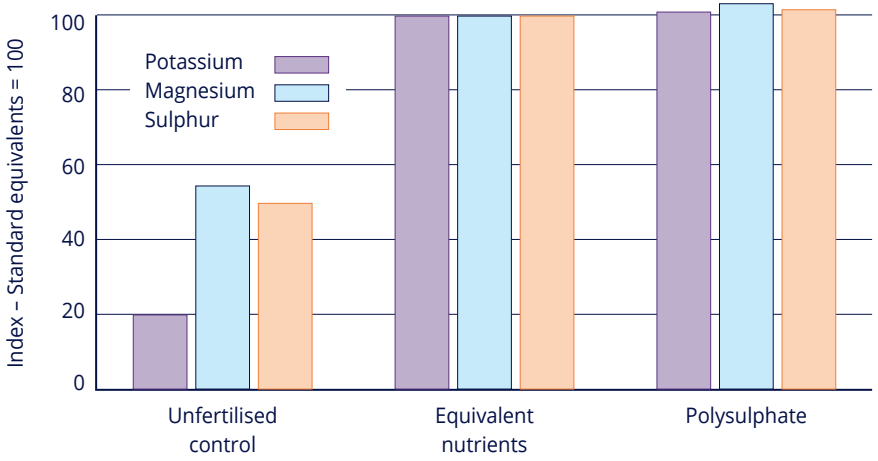
How Polysulphate™ performs

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 24 metres and above.

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

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

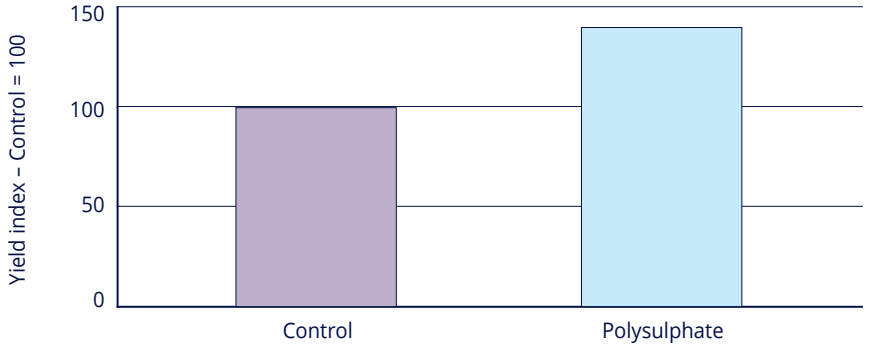


These trials have been repeated many times over the last ten years, both in pots and in the field. In every case Polysulphate has performed equally well or better than the best standard alternatives.

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

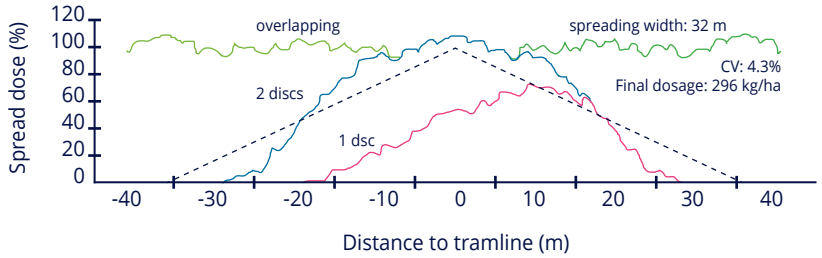
WHITE CABBAGE YIELD RESPONSE TO POLYSULPHATE

(2009 trial on S-deficient site)



Spreadability trials have been undertaken. Polysulphate is a dry, granular 2-4mm 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 32-metre bout width, with a coefficient of variation of 4.3, and good spreadability up to 36 metres.

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 fertilisers. Sulphur 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 sulphur for the grass." Grass pot trial #2, Levington, 1999

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

"The results show that Polysulphate provides an immediately available source of sulphur to spring peas, whereas the S from elemental (90%) sulphur 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 vigour scores at harvest averaged 92 for the Polysulphate treatment compared with 72 for the control without sulphur."
Cabbage field trial, OAT, 2009

Getting the best from Polysulphate™

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

Polysulphate is:

- Readily available – already in its soluble, sulphate form for immediate use.
- A new granular form of sulphur, 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 used in its natural state – no processing or waste product, and non-acidifying.
- UK-sourced and a secure supply of fertiliser 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 sulphur 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 fertiliser 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 fertiliser, bringing readily available sulphur 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 sulphate, 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 sulphur boost for later-growing clover.
- Apply as spring growth gets underway – earlier growing ryegrass will have taken up soil sulphur 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 it contains. In the UK, it is licensed by the Soil Association and Organic Farmers and Growers as a Certified Product for organic use. In Germany it is registered in the list of production facilities for organic farming by FiBL (Research Institute of Organic Agriculture), while in Italy the product is listed in the BIO fertilizers Italian register as per D. Lgs. 75/2010.

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	Advised rate (kg/ha)		Other nutrients applied (kg/ha)							Notes
		SO_3	S	Polysulphate™	K_2O	K	MgO	Mg	CaO	Ca	
Cereals	higher	50	20	**100**	14	11.7	6	3.6	17	12.2	Apply in early spring before the start of stem extension.
	lower	25	10	**50**	7.5	6.2	3	1.8	8.5	6.1	
Oilseed rape	higher	75	30	**150**	21	17.4	9	5.4	25.5	18.4	Apply in early spring. Spring crops may be less susceptible to deficiency.
	lower	50	20	**100**	14	11.6	6	3.6	17	12.2	
Peas (for dried, vining and fresh markets)		25	10	**50**	7.5	6.2	3	1.8	8.5	6.1	Apply where soil is sandy, shallow or medium textured and contains little organic matter.
Brussels sprouts, cabbage, cauliflowers, calabrese		50	20	**100**	14	11.6	6	3.6	17	12.2	Apply where sulphur content of soils is low, e.g. light soils following wet winters where there is no history of organic manures application.
Grassland		40	16	**80**	11.2	9.3	4.8	2.9	13.6	9.8	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 recognised 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.

NORTH AMERICA

UNITED STATES

ICL Fertilizers – North America
622 Emerson Road, Suite 500
St. Louis, Missouri U.S.A. 63141
Tel: +1-314-9837530
Fax: +1-314-9837640
doron.fadlon@icl-group.com

SOUTH AMERICA

BRASIL, CHILE,
ARGENTINA & URUGUAY

ICL Brasil Ltda.
Rua George Ohm, 230 – Torre
B – 21° andar, Brooklin
04576-020 São Paulo, SP, Brasil
Tel: +55-11-21554500
fertilizersbrasil@icl-group.com

AFRICA

ETHIOPIA

Rotem Manufacturing PLC
Bole Cub City,
Bole Medhanealem Mall
Woreda 03\05, Office number 701
Addis Abeba – Ethiopia
Tel: +251-11-6670837/38
Yoseph.Enyew@icl-group.com

ASIA

CHINA

ICL Fertilizers China
Room 908, Shanghai Times Square,
No. 93 Middle Huaihai Road,
Shanghai 200021 China
Tel +8621 23157502
Mobile: 13817365188
He.Ming@icl-group.com

INDIA

ICL India
306, Tower A, Millennium Plaza,
Sector-27, Gurgaon 122 002, India
Tel: +91-124-4044186
Fax: +91-124-4044189
marketing@iclfertindia.com

THAILAND

Ranthai Agro Co.,Ltd.
95/14 Suvintawong Road, Minburi,
Bangkok 10510, Thailand
Tel: +66-81-6222691
ranthai@loxinfo.co.th

EUROPE

FRANCE

ICL Fertilizers Europe C.V.
Succursale Française
1, impasse LUNDY,
51100 Reims, France
Tel: +33-326-478396
thierry.mestrallet@icl-group.com

GERMANY

ICL Fertilizers Deutschland GmbH
Giulinistrasse 2
Gebäude B1/ Marketing & Verkauf
D-67065 Ludwigshafen, Germany
Tel: +49-621-5793-752/753
Fax: +49-621-5793-750
verkauf@icl-group.com

HOLLAND

ICL Fertilizers Europe C.V.
P.O.Box 313, 1000 AH,
Amsterdam, Holland
Tel: +31-20-5815100
Fax: +31-20-6868328
secretary.iclfeip@icl-group.com

ITALY

ICL Italy S.r.l. Milano
Via Monteverdi 11,
20131 Milano, Italy
Tel: +39-02-204871
Fax: +39-02-2049449
luigia.pozzoli@pmchemicals.it

SPAIN

Iberpotash S.A.
Afueras, s/n, 08260,
Suria (Barcelona), Spain
tel: +34 93 255 06 00
fax: +34-93 4739532
icliberia@icl-group.com

UK

ICL UK Sales Limited
Boulby Mine, Loftus,
Saltburn-by-the-Sea,
Cleveland TS13 4UZ, UK
Tel: +44-128-7640140
Fax: +44-128-7640934
CPL.Sales@icl-group.com

ICL Fertilizers

Potash House, P.O.Box 75
Beer-Sheva 8410001, Israel
Tel: +972-8-6465129
Fax: +972-8-6280995
info@iclfertilizers.com
www.iclfertilizers.com

Follow us on
YouTube.com/Polysulphate-fertilizer
Facebook.com/Polysulphate
Twitter.com/Polysulphate

www.polysulphate.com