Sulphur for cereals and oilseed rape

Information Sheet 28
Spring 2014

Sulphur deficiency in winter barley, Woburn, Bedfordshire

Always read product labels, consider your local conditions and consult a professional FACTS Qualified Advisor, if necessary.

Latest information

- Sulphur deficiency continues to become more widespread.
- HGCA trials have shown that correct sulphur fertilisation minimises formation of acrylamide, a processing contaminant, in wheat baked products.
- Livestock manures and biosolids supply readily available sulphur; spring application will make best use of their sulphur content.

Action

Wheat

- Where response is likely, apply 50 kg SO_3/ha in early March to early May.

Barley

- Where response is likely, apply 25–50 kg SO_3/ha in mid-March to mid-April.

Oilseed rape

- Apply 50–75 kg SO_3/ha to all oilseed rape grown on mineral soil in late February to early March.

On S-deficient land

- Applications of S may be necessary year after year.

Sulphur

Sulphur (S) is an essential nutrient required to build yield (Figure 1) and achieve grain and oilseed quality.

Although roots take up S as sulphate (SO_4), recommended rates and the content of fertilisers and organic material are expressed as either SO_3 or S.

S application is currently very cost effective and is not associated with any major environmental problems.

Sulphur is important because:

- yield can be reduced when S is deficient but visual symptoms are absent
- nitrogen (N) fertiliser may not be fully utilised if S is deficient
- correct S fertilisation improves quality of grains and oilseeds

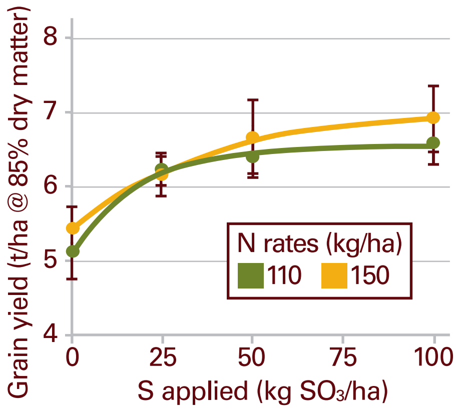

Figure 1. Yield response of winter barley to N and S applications.

Sulphur deficiency

Most soils, especially chalky or sandy soils, store very little sulphate from one year to the next. This is because sulphate is water soluble and easily leached.

In the past, sulphur dioxide (SO_2) emissions from power stations and industry were deposited on farmland and provided an adequate source of S. However, over the past 45 years, emissions have decreased markedly (Figure 2). As a result, S deposition (Figure 3) has also decreased and deficiency has become more widespread.

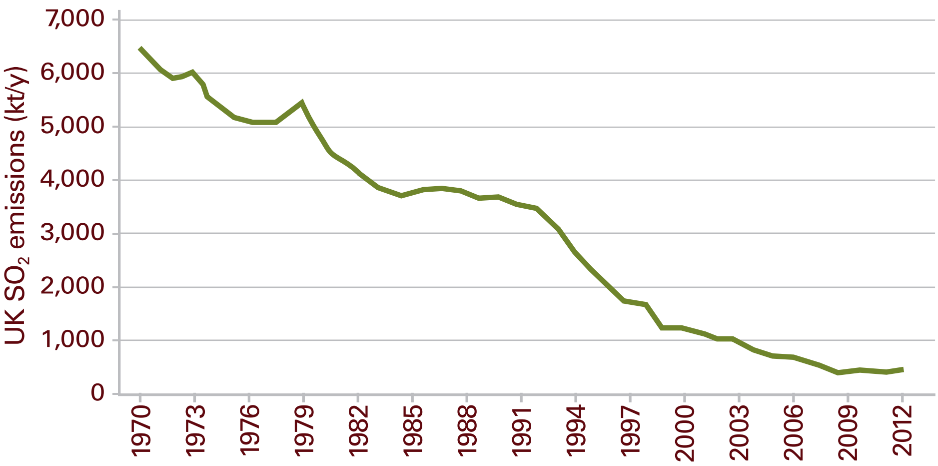

Figure 2. UK SO_2 emissions 1970–2012. Source: RICADO-AEA

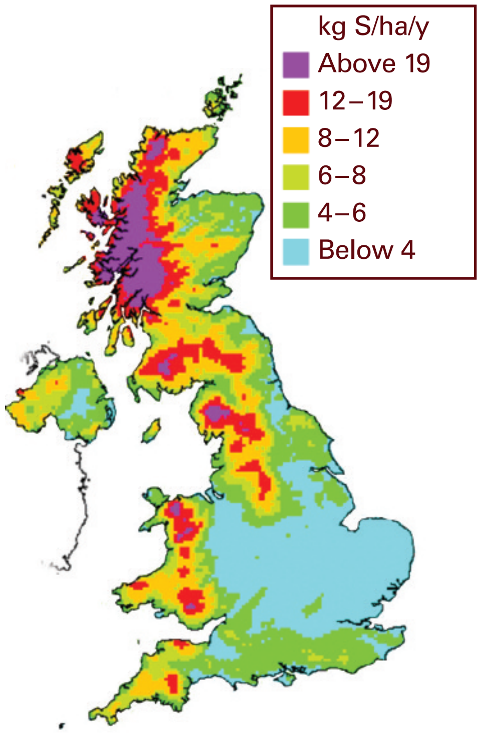

Figure 3. Total S deposition (2011).
Source: Centre for Ecology and Hydrology (CEH)

Sulphur for breadmaking quality

Baking experiments have shown that loaf volume can increase significantly if breadmaking wheat is correctly fertilised with S.

If the N:S ratio in grain exceeds 16:1, breadmaking quality can be reduced.

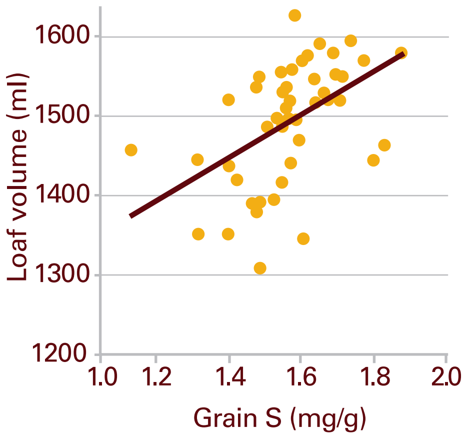

Figure 4. Relationship between loaf volume and grain S concentrations.

Sulphur for malting quality

HGCA trials have shown that when S is applied at deficient sites, malting quality and beer flavour can be improved.

Trials have also indicated that S should be applied to winter barley in mid-March to mid-April.

Minimising the acrylamide-forming potential of wheat

Acrylamide is a processing contaminant that has been found in cooked foods. It can form during high-temperature cooking and processing of wheat. Acrylamide formation in wheat-based products is linked to the levels of the amino acid, asparagine. HGCA trials have shown that asparagine levels, and hence acrylamide formation, can increase if wheat is grown under conditions of S deficiency.

Processors have modified their methods to minimise the formation of acrylamide but growers can also minimise formation by applying S when deficiency is likely. HGCA trials have shown that acrylamide formation can be minimised by applying 50 kg SO_3/ha to wheat (Figure 5), which is the maximum recommended application rate in the Fertiliser Manual (RB209).

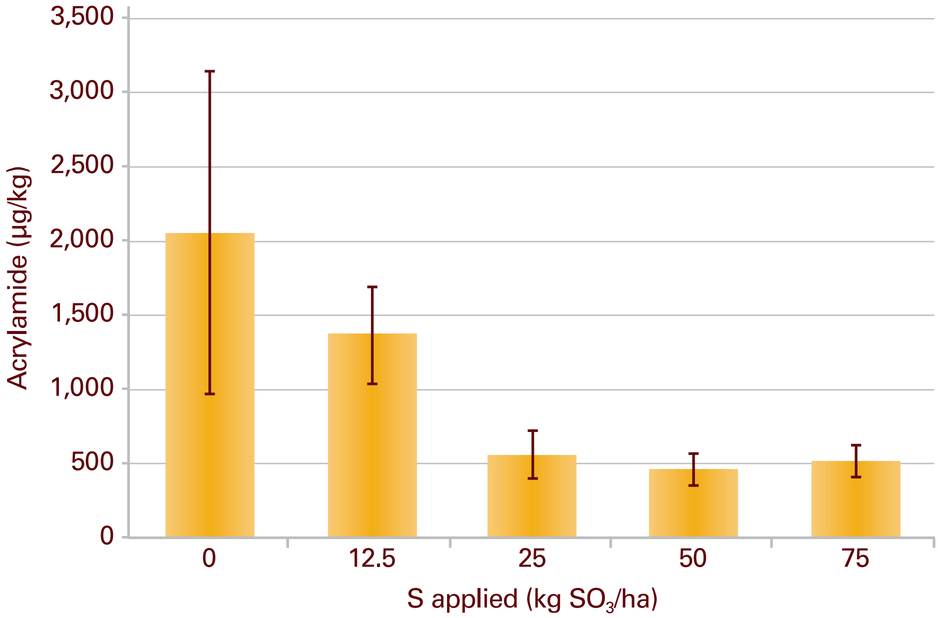

Figure 5. Effect of S on acrylamide formation in heated flour samples. The acrylamide-forming potential of wheat grown at six S-deficient sites was minimised by applying 50 kg SO_3/ha.

Minimising green seeds in oilseed rape

The green plant pigment chlorophyll can remain in the seed at harvest and create problems for rapeseed crushers.

A large proportion of immature seed in a sample, or conditions restricting the natural breakdown of chlorophyll during ripening, can lead to high chlorophyll concentrations.

Extracted with the oil, chlorophyll interferes with subsequent processing. Crushers may be unwilling to accept seed lots with more than 4% immature (green) seed.

While a red seed coat can indicate immaturity, seed coat colour is not a reliable indicator of seed quality.

The best test is to crush the seed and examine the cotyledons inside, which, in a good sample, should be yellow.

HGCA trials have shown that application of S fertiliser at deficient sites reduced seed chlorophyll content (Figure 6). It is also worth noting that application of high rates of nitrogen fertiliser (above the RB209 recommendation) increased chlorophyll content.

Over three sites and three seasons, there was no consistent effect of time of swathing or desiccation on seed chlorophyll content. There was also no difference in chlorophyll content between swathed and desiccated crops.

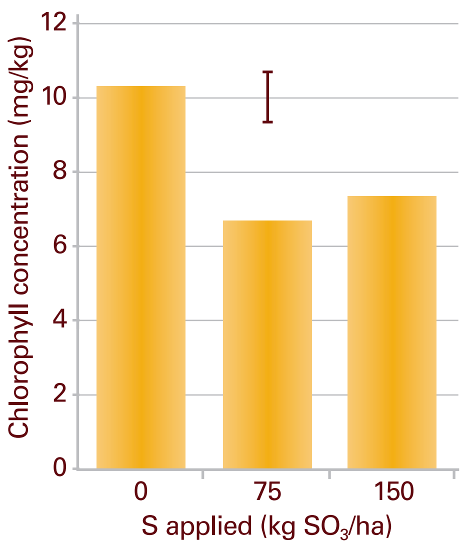

Figure 6. Effect of S on seed chlorophyll content at S-deficient sites. Vertical line represents least significant difference at P = 0.05.

Factors that increase the risk of sulphur deficiencies

S should be applied to all winter oilseed rape crops grown on mineral soil.

Not all winter cereal crops will require S and the responsiveness of a crop to the application of S is dependent on soil texture and winter rainfall (Table 1).

Spring crops are less likely to respond to S. If deficiency is suspected, however, tissue and grain analysis can be used to make a diagnosis and the deficiency should be treated, if necessary.

Table 1. Estimating likely responsiveness of winter wheat and winter barley to S.

	Winter rainfall (Nov–Feb)		
Soil texture	Low (<175mm)	Medium (175–375mm)	High (>375mm)
Sandy	High		
Loamy and coarse silty	Low	High	
Clay, fine silty or peaty	Low		Intermediate

Diagnosing sulphur deficiency

Visual symptoms are usually the first sign of a deficiency, however, they can easily be confused and, by the time they appear, it can be too late to correct the deficiency.

It is also worth noting that, even in the absence of visual symptoms, crops in past HGCA trials have not yielded their full potential when grown on a deficient soil.

S deficiency can be diagnosed using tissue and grain analysis.

Visual symptoms

The youngest leaves of S-deficient cereals (Figure 7) and oilseed rape (Figure 8) are often yellow.

Later, severely S-deficient oilseed rape crops will have pale flowers; however, by this time it will be too late to correct the deficiency.

Figure 7. S-deficient winter wheat.

Figure 8. S-deficient oilseed rape.

Tissue analysis

If a deficiency is suspected, tissue analysis in the spring can be a useful diagnostic tool. There are a number of laboratory tests that can be used to detect S-deficiency but HGCA trials have shown that the malate:sulphate test is the most reliable.

A malate:sulphate ratio of more than 1.5:1 means that the plant is deficient at the time of sampling. A ratio of less than 1.5:1 means that the S supply was sufficient at the time of sampling.

Things to remember when collecting tissue samples:

– collect wheat samples at stem extension but not before early April

– collect oilseed rape samples at stem extension but not before the end of February

– samples should not be taken from crops that have recently been sprayed with an S-containing fertiliser

– avoid collecting and sending samples immediately before a weekend or public holiday

– if areas of fields differ significantly, sample each separately

– ensure there is no soil contamination

– walk a 'W' pattern across the sampling area, stopping at least 25 times

– at each point, collect the youngest 2–3 plants, avoiding dusty or muddy leaves

– dry any wet leaves and immediately send to a laboratory between sheets of paper towel

– use appropriate packaging (normally available from the laboratory) and label samples clearly, providing as much information about the field and crop as possible

Grain analysis

Analysing the N:S ratio of wheat and barley grain at harvest can give a useful indication of the need for S in the future. HGCA trials suggest that a ratio above 17:1 indicates deficiency.

Treating deficiencies

Where S deficiency has been diagnosed or is expected, it can be corrected by applying a manufactured S fertiliser and/or livestock manure or biosolids (Tables 2 and 3).

As most soils store very little S from one year to the next, applications of S will be necessary year after year for the susceptible crop.

Recommended rates and the content of fertilisers and organic material are expressed as either SO_3 or S. To convert units:

1 kg S = 2.5 kg SO_3
1 kg SO_3 = 0.4 kg S

Sulphur fertiliser

S deficiencies are best treated using a water-soluble sulphate which will be immediately available to the crop. Elemental S must be oxidised to sulphate before it is available to the crop and is, therefore, not immediately available.

Manufactured fertiliser should be applied to:

– wheat in early March to early May
– barley in mid-March to mid-April
– oilseed rape in late February to early March

Table 2. Fertiliser requirements.

Crop	kg SO_3/ha
Barley	25–50
Wheat	50
Oilseed rape	50–75

Background

This publication is based on HGCA-funded research conducted over the past 15 years; most recently, HGCA Project Report 522 and Project Report 525. Project partners were ADAS, Anglian Water, Rothamsted Research and Severn Trent Water.

Further information

James Holmes, HGCA
james.holmes@hgca.ahdb.org.uk

Steve McGrath, Rothamsted Research
steve.mcgrath@rothamsted.ac.uk

Lizzie Sagoo, ADAS
lizzie.sagoo@adas.co.uk

The Fertiliser Manual (RB209, 2010) www.defra.gov.uk/rb209

www.hgca.com/nutrientmanagement

Cereal growth stages – a guide for crop treatments (HGCA, 2009)

HGCA Project Report 522: Quantifying the sulphur supply from farm manures to winter wheat crops (HGCA, 2013)

HGCA Project Report 525: Effect of sulphur fertilisation on the acrylamide-forming potential of wheat (HGCA, 2014)

HGCA Publications
T 0845 245 0009
E hgca@cambertown.com
www.hgca.com

Sulphur supply from livestock manures and biosolids

When planning the use of nutrients it is important to make allowance for those contained in organic material but until now it has been unclear how much S they supply to crops. However, recent HGCA trials have shown that livestock manures and biosolids contain useful supplies of S which should be taken into account when calculating how much additional manufactured fertiliser it is necessary to apply.

S in livestock manures and biosolids is available in two main forms:

– readily available S, which can be taken up immediately by the crop
– organic S, which is not immediately available for crop uptake but may be mineralised to readily available S over subsequent months and years

Readily available S + organic S = Total S

HGCA trials have shown that, if organic material is applied to winter wheat in spring, the readily available S varies between around 15% of total S for cattle farmyard manure (FYM) and up to around 60% of total S for broiler litter (Table 3).

If the organic material is applied in autumn, the readily available S may be leached and lost over winter before it is required and taken up by the crop in spring. Losses will depend on the soil type and winter rainfall. HGCA trials with winter wheat on free-draining sandy soils have shown that, for organic material applied in autumn, readily available S in spring will be in the range of 5–10% of total S for cattle and pig FYM and 10–20% of total S for biosolids.

Table 3. Total and readily available S for livestock manures and biosolids applied in spring.

Manure	Total sulphur (kg SO_3/t FW)	Readily available sulphur (% total sulphur)	Readily available sulphur (kg SO_3/t FW)
Cattle FYM	2.4	15%	0.4
Pig FYM	3.4	25%	0.9
Broiler litter	8.0	60%	4.8
Cattle slurry	0.7	35%	0.3
Pig slurry	1.0	35%	0.4
Biosolids	6.0	20%	1.2

Source: Total S – Fertiliser Manual (RB209); Readily available S – HGCA Project Report 522.

Information Sheet 28
Spring 2014

HGCA publications are free to levy payers
To join the mailing list, contact: subscriptions@hgca.ahdb.org.uk