Soaking up the sulphur

In the first of a new series on plant nutrients, *CPM* relays experts' views on the importance of sulphur.

By Andrew Blake

Farming's focus on sulphur intensified in the 1990s when it became clear that previously 'free' supplies from industrial air pollution were disappearing fast, a fact highlighted by Rothamsted Research.

"There's now a widespread need for sulphur in UK fertilisers to ensure good crop yields and quality," says researcher Steve McGrath.

The main driver was the 1993 Clean Air Act, while purer fertilisers are also believed to have led to a drastic decline in the amount of sulphur naturally reaching crops.

Sulphur is essential for all plants and animals. The element must be available to allow them to create the proteins found in all living cells, and the amounts required by crops are quite large.

"Sulphur shouldn't be regarded as a trace element," warns Ecopt's Ian Richards. "Cereals remove nearly as much sulphur (as SO_3) in grain as they do of potash (as K_2O). Root crops remove less and brassicas more," he points out.

Too little sulphur limits nitrogen metabolism, photosynthesis and leaf production, so slowing growth, explains retired soils consultant Neil Fuller. "Low sulphur levels within plants also weaken their ability to withstand high temperatures and drought."

Insufficient sulphur reduces wheat-flour quality and may lower oilseed rape oil content, notes Safagrow's Andrew Low.

Inadequate sulphur in rape can prompt re-flowering in June which can delay ripening, adds Frontier Agriculture's Jim Carswell. Most crops respond to sulphur applications.

Cereals suffering deficiency have had yields raised by up to 2.5t/ha, reports Steve McGrath. "In some severe cases in oilseed rape, which is particularly susceptible to deficiency, output has been lifted by over 400% through sulphur treatment. Sulphur is essential for nodule formation and nitrogen fixation in legumes," he adds.

Other crops, previously thought to be unresponsive to sulphur applications, are now being re-assessed in the light of ever-reducing emissions. The British Beet Research Organisation (BBRO) recently issued new guidance, based on the latest trials, recommending 90kg SO_3/ha for sugar beet grown on sands or sandy loams.

Sulphur's role in plants

A good supply of sulphur is essential for plants to convert amino acids into proteins, explains Neil Fuller.

Sulphur is an important crop nutrient, says Andrew Low. "So it's required in larger quantities than micronutrients, such as copper and manganese.

"It's also found in anti-oxidant compounds. These protect plants from dangers such as oxygen radicals produced during photosynthesis, and help detoxify them of some herbicide actives and heavy metals."

Chris Rigley, of Yorkshire Arable Marketing, is convinced that sulphur

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applications help plants adapt to environmental stresses.

"The increased incidence of light leaf spot in oilseed rape coincided with the introduction of double-low varieties. These have a higher demand for sulphur as a result of their modified glucosinolate metabolism.

"This was also when atmospheric sulphur deposition was declining, so aiding light leaf spot spread. It's well documented that the severity and incidence of the disease in the UK was greatest where depositions were lighter — ie Scotland and northern England."

Higher concentrations of the amino acid methionine, a key product of sulphur assimilation, seem to boost resistance to powdery mildew, he adds.

Sulphur is a crucial component of some essential plant proteins, agrees Jim Carswell. "Our trials have shown very positive and statistically significant responses to co-applications of sulphur with nitrogen compared to where straight nitrogen was applied."

Plants cannot use elemental sulphur — it must first be oxidised by microbes to sulphate which is then taken up by plants, mainly through their roots, although small amounts may also be absorbed by their leaves.

Uptake is influenced by the active root mass, which in turn is driven by both phosphorus and zinc levels, says Neil Fuller. "Sulphur is taken up much like nitrate N, so the conditions that favour plant growth and N uptake also favour sulphur uptake.

"Although sulphur as sulphate is very mobile in the soil, it's not directly affected by antagonism with other soil nutrients."

Soil sulphur

How much sulphur any land contains varies considerably depending on soil texture and rainfall (see HGCA S responsiveness chart) as well as previous cropping and manure applications.

"Sulphate, like nitrate, can be leached out, especially over winter," says Ian Richards. "So the amounts available to crops can change quite rapidly through the growing season."

However, on arable land even repeated sulphur dressings — such as the annual ones applied to Rothamsted's Broadbalk field for 150 years — are unlikely to build reserves, notes Steve McGrath. "Only in grassland, with more organic matter and hence more microbial activity to immobilise the sulphur, is that likely."

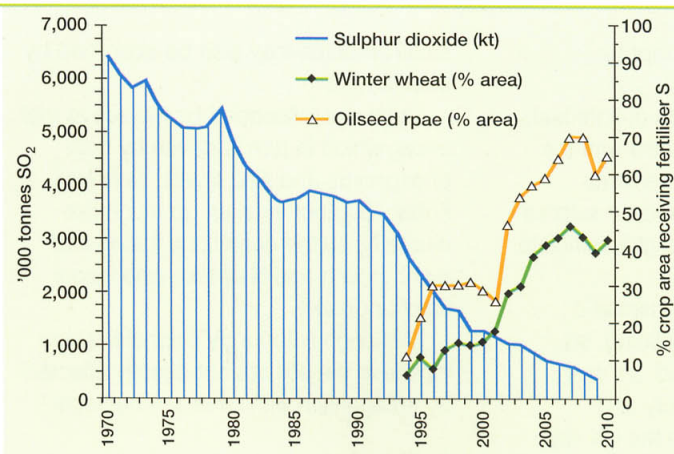
Frontier trials have shown yield responses in milling wheat to sulphur applications, says Jim Carswell.

Three-quarters of a plant's mineral nutrition comes from the top 100mm of soil, says Neil Fuller. "Sulphate can move down the profile at more than 1cm/day, so it can get through this root-feeding zone within 10-12 days.

"So any soils with an open, porous structure or that are considered free draining are likely to become sulphur depleted.

"Conversely soils with high clay content ▸

Chris Rigley reckons sulphur applications help plants adapt to environmental stresses.



Growers' use of sulphur fertilisers took off in the late 1990s as atmospheric sulphur dioxide emissions (blue line) fell away.

Source: National Atmospheric Emissions Inventory & British Survey of Fertiliser Practice

▸ and those which are more moisture retentive are less likely to leach sulphur; and any in which the organic matter levels are building are likely to accumulate it — as well as phosphorus."

Deficiencies in sulphur — shortages which jeopardise crop growth — can be found in most parts of the UK now that the aerial supply is so low, says Jim Carswell. "But they're most likely to occur on light and medium soils and those low in organic matter."

Detecting deficiency

Genuine sulphur deficiency is easy to recognise as entire plants tend to turn pale green, says Neil Fuller. "But it's often confused with water-logging, compaction or lack of nitrogen."

Masstock agronomist David Langton agrees. "The symptoms are easy to spot — often pale patches in fields with the younger leaves being more affected. But that can be mistaken for nitrogen deficiency."

In oilseed rape, severe cases of sulphur deficiency can show as leaf cupping, often with purpling of the margins, notes Chris Rigley.

However the symptoms of slight to moderate shortage are similar to those of nitrogen and so may not be obvious, Andrew Low acknowledges. "Once you see a deficiency symptom it's already too late and yield or quality potential has been affected."

In oilseed rape the pale yellow inter-vein mottling of leaves at the start of rapid stem extension, often in stunted crops, is a sure sign of a lack of sulphur, though it can be confused with nitrogen deficiency, admits Jim Carswell.

The distinguishing clue is that with nitrogen deficiency it is the older leaves that first turn pale green or yellow, says Ian Richards. "And in sulphur-deficient oilseed rape the petals can be almost white, although by then it's usually too late to do anything useful to correct the problem."

Checking for sulphur

Neither soil sampling nor traditional plant-tissue tests are particularly helpful in predicting sulphur deficiency. Several commentators advocate an N:S ratio check at harvest as a more useful approach.

Soil testing may mislead because its sulphate status, like that of nitrate, can change rapidly, says Neil Fuller. "Ideally soil testing should link measures for available

sulphate S with total sulphur and soil organic matter to improve predictability."

Given the mobility of sulphate, samples must be taken to below plough depth, preferably to 90cm, adds Ian Richards. "It's worth thinking about having them done at the same time as nitrate testing in spring, once most leaching is over."

Field sulphur contents may vary greatly, notes Chris Rigley. "So a thorough sampling technique is required for analysis.

"Deficiency indicators differ between crops. Oilseed rape needs at least 15ppm of sulphur in the soil and cereals no less than 10ppm. For future cropping the N:S ratio in seed can be useful."

According to David Langton the malate:sulphate ratio assessment, developed at Rothamsted and commercialised by Hill Court Farm Research, is probably the best diagnostic tissue test. "But it needs to be done when there is active growth, which can be getting late to apply sulphate fertiliser."

HGCA work found the malate test more satisfactory than other methods in detecting sulphur deficiency. But HCFR's Mechteld Blake-Kalff acknowledges that, for fast growing oilseed rape, its in-season value can be limited.

Getting the N:S ratio correct in plants is important to maximise output, says Jim Carswell. "Growers should test harvest produce for nitrogen and sulphur levels to help highlight problems and make plans to rectify any in the following season."

The HGCA's James Holmes agrees. "Growers should take a longer-term view."

HGCA-funded work suggests ratios above 17:1, 16:1 and 15:1 respectively for harvested feed cereals, milling wheat and oilseed rape indicate deficiency.

Rectifying deficiencies and likely responses

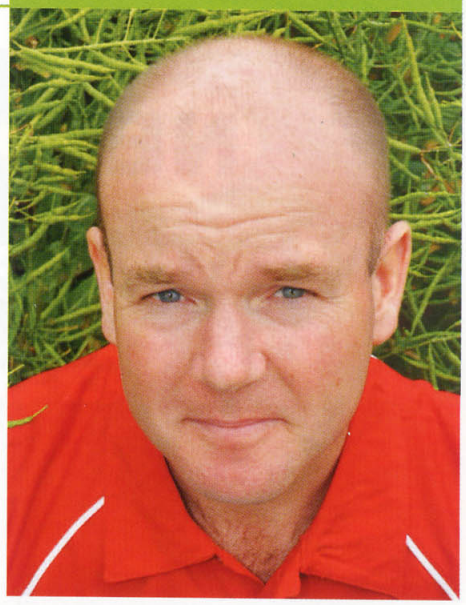
Correcting sulphur deficiency not only optimises crop yields and quality, it helps cut the risk of nitrate losses into the environment, notes Ian Richards.

Other benefits include reduced susceptibility to nitrogen-sensitive pathogens such as mildew, and sap-sucking insects, for example aphids, adds Neil Fuller.

In anticipation of deficiency, early spring applications of 25-50kg SO_3/ha to cereal and 50-75kg SO_3/ha to oilseed rape are advisable, suggests Steve McGrath.

"The optimum timing in wheat is up to early stem extension but in rape it can be applied up to late stem extension." Such treatments are nearly always cost-effective, he believes.

K+S technical manager, Jerry McHoul, suggests that these rates, as revised in the 2010 RB209, should be seen as guidelines and not gospel. ▸



Low sulphur usage could explain why UK OSR yields lag behind those on the continent, believes Jerry McHoul.

appreciated sulphur treatments with yield increases averaging 0.34t/ha between 2004 and 2006 and 0.43t/ha in 2010.

However, Steve McGrath notes that this contrasts with HGCA findings that between 2000 and 2007 winter barley tended to be less responsive to sulphur than wheat.

Sources of sulphur, how and when to apply

There are plenty of sources of sulphur for growers, including organic manures.

The most common and often most cost-effective way to ensure crops get enough sulphur is to apply compounds containing sulphate, says David Langton. "Kieserite (magnesium sulphate) is obviously beneficial where magnesium is also required.

"Sulphate is the most reliable form as it's soluble and immediately available to crops. But because it's soluble, applications shouldn't be too early on shallow soils or to shallow rooted crops because it could leach. Indeed UAP trials suggest that RB209 recommendations aren't high enough for shallow chalk soils."

Given the vagaries of soils and the need for oxidation before crops can absorb elemental sulphur, he advises against relying solely on such products, particularly on oilseed rape where demand is especially heavy in March/April.

In general the finer the particle size in these products the faster the crop response, notes Neil Fuller. "Some elemental sulphurs are taking years to break down."

Jim Carswell advocates little-and-often applications of sulphur-containing compounds. "That can fulfil crop requirements without overloading sulphur and help prevent luxury uptake which can lead to storage of sulphur in the lower leaves. Relocation of this sulphur tends to be poor and can lead to deficiency in the upper parts of the plant."

Trials have shown very positive responses to co-applications of sulphur with nitrogen, says Frontier.

Materials such as potassium thiosulphate can be effective as foliar sulphur treatments, both in feeding crops and suppressing pathogens, says Neil Fuller. "They integrate well with fungicides applied at ear emergence in cereals and post-flowering in oilseed rape."

However, it's worth noting that the sulphur content of such foliar products can range from 300-800g/l, notes Andrew Low.

"Good quality formulated products can usually safely be tank-mixed with most crop protection products." ■