

SSP: Single Superphosphate, a Scenario Slowly Passing

Graeme Blair

Agronomy and Soil Science, School of Environmental and Rural Science, University of New England
(gblair2@une.edu.au)

Abstract

The use of single superphosphate (SSP) has declined in world agriculture, and Australia is following suit. SSP has formed the backbone of pasture fertilisation in Australia since the introduction of topdressing, but, with the imminent closure of another major SSP production facility, what is the way forward?

SSP is a historical accident and for most situations the phosphorus to sulphur ratio (P:S) in SSP of approximately 0.8 is too narrow for optimal plant nutrition. In most situations the P requirement exceeds the S requirement, so a fertiliser with a higher concentration of P and lower concentration of S would be more suitable. Increasing transport costs also mitigate against the use of SSP as the low analysis means that the transport cost from factory to farm, and spreading costs, are an increasing proportion of the overall on-the-ground cost. Many alternatives exist to add S to fertilisers such as triple superphosphate and ammonium phosphates, including coating, inclusion, or as a granular additive to bulk blends. World supplies of elemental S are increasing as S is removed from fuels and gas deposits with high H₂S concentrations are being exploited. Addition of elemental S to fertilisers allows a tailoring of particle size to match plant S requirements. Such fertilisers have been available in Australia for a number of years and more alternatives are on the way. An impediment to the use of elemental S containing fertilisers to date has been the lack of control and difficulty of managing S particle size and misinformation promulgated by some SSP manufactures that elemental S does not oxidize. This is all about to change!

Key words

fertiliser, fertilizer, phosphorus, sulphur, sulphur, ammonium phosphate, triple superphosphate

Introduction

Who would have thought that a fertiliser patented by J.B Lawes in 1843 would still be widely used 165 years later? Such has been the utility of single superphosphate, commonly thought of as a phosphatic fertiliser, but which contains more S than P.

Lawes interest in phosphate was stimulated by the observation that crushed animal bones were not effective in some soils. He experimented with application of sulphuric acid on bones and produced superphosphate, later referred to as single superphosphate (SSP). The addition of approximately 0.3 t H₂SO₄ to 0.7 t rock phosphate produces 1 t of a 50/50 mixture of mono-calcium phosphate and gypsum, which is SSP. This is an extremely simple process which partly accounts for its widespread use. It was first manufactured in Australia in 1876, with the pioneers being James Cumming in Victoria and George Shirley in NSW. This fertiliser has been widely used on crops and pastures in Australia and in the pasture phase in pasture/crop rotations. Application rates have generally been low with 1cwt/ac or 100 kg/ha being widely used. Such low applications, which deliver approximately 0.9 kg P/ha, are generally below the widely recognised maintenance application rate of 1 kg P/DSE, so soil P concentrations, measured by extractants, have generally increased only slowly, or not at all. SSP contains less P than S (0.8:1) and in non-leaching soils extractable S can accumulate at a faster rate than P. Such accumulations of sulphate S can reduce Mo and Se uptake by plants. The widespread occurrence of S deficiencies in pastures and cropping means that in many situations the S in SSP was more valuable than the P. Use of SSP in Australia has gradually declined from 2.1M t in 1974/75, where it made up 82% of total P use, down to 1.2M t in 2005/06, where it made up only 22% of total P use. Over this same time period total P use in Australia increased from 230,000 to 454,000 t, mainly in ammonium phosphates.

Why the change?

There are three major drivers of change in SSP usage. The first is the variation in financial returns from wool and meat in traditional pasture areas. This, together with the observation that responses to SSP are not as noticeable several years of application has lead many producers to believe that SSP was “not what it used to be” or that “I no longer need it”. This resulted from a failure to recognise the residual value of previous applications or that the legume content in the pasture had declined so that N deficiency masked P and S responses. At the other extreme there is a perception amongst some producers that “since I have applied 20 cwt over 30 years my pastures don't need more P”. This fails to recognise that the application rates used, and the infrequency of applications, have generally been below maintenance. In both situations soil testing, which has been poorly adopted, would reveal the true situation.

The second reason is the increased transport and spreading costs. Cartage to the New England region of NSW is currently \$44/t and ground spreading \$40/t so that these costs are higher/unit P than more concentrated P sources. Since the major production costs for both ammonium phosphates and SSP are rock phosphate and sulphur there is likely to be little, or no, reduction in manufacturing cost resulting from a change in fertiliser source. The benefit will come in transport and spreading costs for the high analysis fertiliser.

The third reason is the move from pasture rotations in cropping areas to continuous cropping, with the SSP in the pasture phase being replaced by higher analysis ammonium phosphates in the crops.

Information regarding the S oxidation potential of Australian soils has been clouded by misinterpretation of scientific results and commercial interests. Fertiliser manufacturers who do not have products containing elemental S in their range often tell clients that elemental S will not oxidise in Australian soils but results presented here show that this information is not correct. (see Figures 1 and 2 and Table 1 below).

The future

Incitec Pivot have announced the closure of the Cockle Creek SSP plant in Newcastle in the next few years and this will have a major impact on the supply of SSP to central and northern NSW, and in Queensland. Given the trend in the world fertiliser industry of capital investments being made in DAP and MAP plants, it is unlikely that substantial capital will be put into the current SSP plants in Victoria, Tasmania and Western Australia and they are likely to follow the fate of Cockle Creek.

Triple superphosphate (TSP) could be used to replace SSP but production capacity in Australia is low and it contains little S. Although di-ammonium phosphate (DAP) and mono-ammonium phosphate (MAP) are widely available, both from domestic production and imports, the lack of value placed on the N it contains for pastures, and the lack of S, means that they are unlikely to substitute for SSP, unless S can be added to them. In either case S will need to be added to the fertiliser.

The alternatives

Given the large world capacity to produce ammonium phosphate (AP) and triple superphosphate (TSP) fertilisers it is likely that these will form the basis for an SSP replacement. Amongst the APs it seems likely that MAP will be preferred to DAP because it contains less N and can be made from lower grade phosphate rock. In either scenario it will be necessary to add sulphate or elemental S to the TSP or MAP. Modelling of CNPS cycling in grazed pastures by McCaskill and Blair (1988) indicates that a P:S ratio of 2:1 in pasture fertiliser would meet the P and S needs in most situations. This can be done by coating or incorporation of elemental S and/or gypsum onto, or into, AP or TSP during manufacture, or physically mixing these fertilisers with elemental S/bentonite or granulated gypsum prills.

If sulphate S in a form such as gypsum was added to MAP or TSP to achieve this 2P:1S ratio, the P concentration in the MAPS would be reduced to almost half, thus losing the concentrated nutrient benefits

of the MAP. This leaves elemental S as the most likely candidate material to be added. For the elemental S to become available to the plant soon after application it must be applied in fine particles ($<75\mu$), and preparation of this material is difficult because of the potential explosion risk. This has led to a number of elemental S/bentonite products, commonly containing 10% bentonite, being developed (eg S bentonite 90 in [Figure 1](#)). These are commonly ineffective because the amount and quality of the bentonite used is compromised by the need to avoid it absorbing water and expanding in the bag or pile prior to application.

Another attraction of elemental S is the likely substantial reduction in price for this commodity in the not too distant future. Increased recoveries of S from refineries needing to make cleaner petrol and diesel, together with increased recoveries from new gas fields being opened up in the Middle East and Central Europe, will be likely to increase supply substantially.

Several evaluations of alternative S products have been undertaken and results from one such study, conducted in the 1960's on the Northern Tablelands of NSW, is presented in Table 1. In the first 11 months after application, plant recovery of S was highest from gypsum and second highest from elemental S (S^0) $<150 \mu$. . In the ensuing 11-23 month period the highest recovery was from S^0 with particle size between 150 and 250 μ . . The highest overall S recovery in plants was in the $S^0 <150 \mu$ treatment.

Table 1. Recovery by pasture of S applied as elemental S or gypsum on the Northern Tablelands of NSW (from Weir et al 1963)

S source	S recovery in plants (% of applied)		
	0-11 months	11-23 months	Total over 23 months
S^0 250-600 μ	1.8	4.2	6.0
S^0 150-250 μ	5.5	8.3	13.8
S^0 $<150 \mu$	13.0	7.0	20.0
Gypsum	18.0	0.4	18.4

In a more recent study, also conducted on the Northern Tablelands of NSW (Blair, unpublished), considerable differences were found in white clover yields between sources of S. This most likely relates to the particle size of the elemental S and/or the mechanism of bonding the S to the fertiliser ([Figure 1](#)).

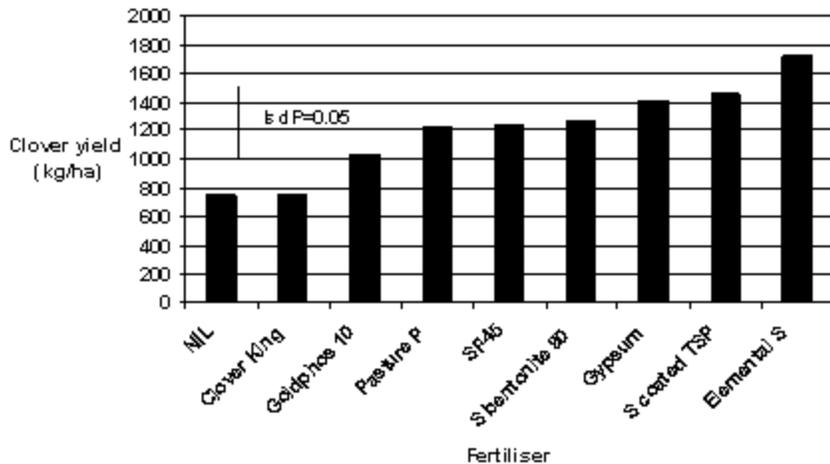


Figure 1. White clover yield (kg/ha) resulting from the application of different S sources applied at 10 kg/ha to a sedimentary soil on the Northern Tablelands of NSW, with N and P balanced between sources.

Coating S onto finished fertiliser such as in Goldphos 10 (Figure 1) has convenience but the difficulty of grinding elemental S to a fine enough particle size adds to the cost and difficulty of preparing an agronomically acceptable product. In addition, abrasion of the coat during transport and handling can create potentially explosive dust problems.

A process has been developed by Shell Canada which incorporates molten elemental S into MAP and DAP during manufacture. This process has been incorporated into the IncitecPivot ammonium phosphate plant at Phosphate Hill, Queensland and products marketed as S8, MAPSZC and DAPSZC, containing approximately 8% S as a mixture of elemental and sulphate S, have been manufactured. A range of experimental products, with up to 20% elemental S, has also been produced in a pilot plant.

Elemental S added into TSP, or MAP are possible alternatives to SSP. One experimental product that could replace SSP is a MAP containing 12% S which has been developed by Shell Sulphur Solutions and made in a pilot plant at the International Fertilizer Development Center (IFDC), Alabama. This is generically known as SEF (Sulphur Enhanced Fertiliser).

One of the SEF products, MAP12 is currently being evaluated in a field trial on the Northern Tablelands of NSW and the results of the three harvests taken to date are presented in Figure 2. A feature of the results is the superiority of SSP over MAP12 in the first harvest, with the reverse being true at the second and third harvests. These results mimic earlier studies that showed that the sulphate S in SSP is immediately available and that it can easily be leached from soil and that the elemental S provides a more sustained release of S to the pasture. Studies with ³⁵S labelled sulphate and elemental S undertaken by Blair et al. (1994) have demonstrated the potential magnitude of S losses from sulphate sources. Losses from gypsum were double that from elemental S over a 1 year period. Manipulation of S particle size can be used to further reduce S losses in extreme leaching situations.

The extremely poor performance of the DAP pastille treatment in Figure 2 highlights the danger of insufficient attention being paid to the S source added. In this instance the pastilles were formed using molten S, which has a negligible surface area for oxidizing organisms to colonise

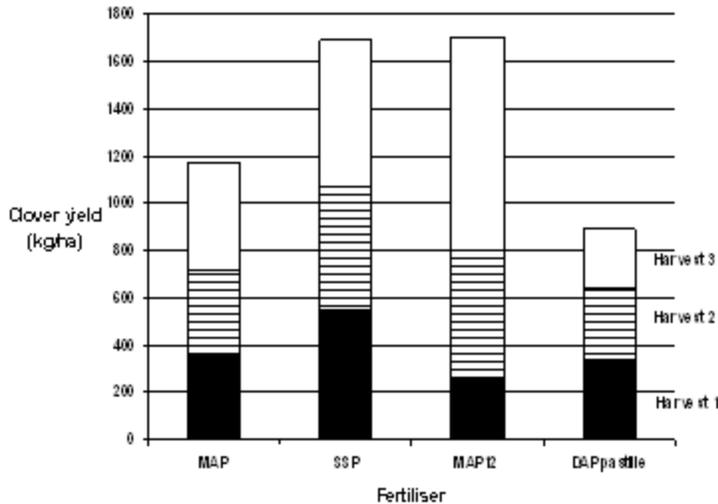


Figure 2. . White clover yield (kg/ha) resulting from the application of different S sources applied at 10 kg/ha to a granitic soil on the Northern Tablelands of NSW, with N and P balanced between sources.

Trials using this family of S enhanced DAP and MAP fertilisers (Sulphur Enhanced Fertilisers, SEF) have been undertaken with crops and pastures in Brazil, Argentina and China and yield responses to the S contained in them have averaged 14% across 84 S responsive sites.

Conclusions

SSP usage in Australia has been in almost continual decline over the past 30 years and with the imminent closure of a significant SSP plant in Newcastle there is a need to find an alternative product to supply P and S. Addition of elemental S to MAP or TSP appears to offer the best potential. Inclusion of the S into the fertiliser granule during manufacture has been shown to be feasible and the resulting NPS fertiliser to be agronomically effective.

References

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