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# Implications of ceasing annual superphosphate topdressing applications on pasture production

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## Abstract

Two field-plot trials were superimposed on irrigated, sheep-grazed pastures on Lismore stony silt loam in Canterbury to investigate residual effects of previous superphosphate applications on dry matter (DM) production and herbage composition. Residual effect of phosphorus (P) in superphosphate was shown to depend upon previous application rate and number of years of superphosphate application. In contrast, residual effect of sulphur (S) in superphosphate was independent of previous application rate if superphosphate had been applied for 25 years at rates at or above the S maintenance rate. Previous applications of superphosphate at the annual rate of 376 kg/ha for 6 years failed to safeguard pasture against yield reduction even in the first year after superphosphate was discontinued. This reduction was attributed equally to both P and S deficiencies. Residual values of both P and S were more substantial in areas where superphosphate had been-applied-at--the-higher rate of 564 kg/ha for 6 years. However, these residual values were also short-lived and DM production declined by 13% in the second year after the cessation of superphosphate application. Different patterns of residual values of superphosphate were recorded on areas where superphosphate had been applied over a longer term of 25 years. Where superphosphate had been applied annually at 188 kg/ha, DM production fell by 10% in the first year after topdressing ceased. This reduction was due entirely to P deficiency affecting clover growth, while S deficiency — in both grass and clover — was not observed until the third year after topdressing ceased. On areas where superphosphate had been applied at a higher rate of 376 kg/ha for a similar period of 25 years, DM production did not decline until the second year. This initial decline was attributed to S deficiency in clover while P deficiency in grass and clover was not apparent until the 4th year after the cessation of superphosphate application. The results were used in a simple model that uses previous topdressing history to predict yield reductions if topdressing is withheld.

**Keywords** residual effects, phosphorus, sulphur, irrigated pasture

## Introduction

The downturn in the agricultural economy in recent years forced many farmers to reduce or withhold superphosphate applications. The effect of these actions on pasture or animal production often depends on the residual values of both phosphorus (P) and sulphur (S) components of superphosphate (Saunders & Cooper 1983; Quinn & Scobie 1985). These residual values under hill country and dairy farm situations have been recently reported by various workers (Gillingham et al. 1989; Lambert et *al.* 1989; O'Connor *et al* 1985).

However, these reported results are likely to be different from those occurring on irrigated pastures in Canterbury because of different levels of pasture or animal production, excretal transfer, and S leaching losses on the different soil types, topography, and management (Cornforth & Sinclair 1984; Sinclair & Saunders 1984).

This paper reports on the residual effect on production of irrigated pasture when topdressing was withheld after both short-term (6 years) and long-term (25 years) applications of superphosphate.

## Methods

The long-term fertiliser trial (Rickard & McBride 1987; Nguyen *et* al. 1989) at Winchmore Research Station on a Lismore stony silt loam (Udic Ustochrept) provided suitable sites for the investigation of the residual effects of superphosphate. This trial was conducted on a grazed, irrigated perennial ryegrass-white clover pasture.

Two trials were carried out to provide information on the effects of ceasing topdressing of either P or S or both P and S on pasture production. Both trials were mown with clippings returned. The effects on botanical composition were also assessed in pastures where superphosphate had been applied for 25 years.

### Trial A

A small plot trial (4.5 x 0.76 m per plot) was established in 1958 on pasture that had received superphosphate for 6 years at two annual rates: 376 and 564 kg/ha. Average annual DM yields on these areas were 10.9 and 11.4 t/ha respectively (Rickard & McBride 1987). Treatments on the small-plot trial included no fertiliser, applied P only, applied S only, and P plus S. Phosphorus was applied as monocalcium phosphate at 34 kg P/ha and S as gypsum at 41 kg S/ha, equivalent to 376 kg/ha superphosphate. This trial had a split-plot design with 4 reps and ran for 4 years.

### Trial B

A small plot trial (4.5 x 0.76 m per plot) was established in 1977 on pasture that had received superphosphate at 188 and 376 kg/ha each year for 25 years. Average DM yields on these areas were 9.8 and 11.1 t/ha respectively (Rickard & McBride 1987). As in trial A, treatments included no fertiliser, P only, S only, and P plus S, applied as monocalcium phosphate and gypsum. Results reported from this second trial are from treatments that received P and S at annual rates equivalent to their previous superphosphate topdressing history: 188 or 376 kg/ha. This trial had a split-plot design with 4 reps and ran for 6 years.

## Results and discussion

### Residual effects of previous superphosphate applications

Residual value of superphosphate applications was measured by the extent of the decline in DM production with time after superphosphate application was withheld. On areas where superphosphate had been applied for 6 years at 376 kg/ha, the decrease in DM (relative to that of the continuous application) in the first and second year after cessation was 15% and 31% respectively (Figure 1). However, DM reduction was less severe in the area that previously received superphosphate at 564 kg/ha, and did not reach significance until the second year (Figure 1).

On areas where superphosphate had been applied over the longer period, the residual effect of previous superphosphate application was also shown to depend on previous topdressing history. After 25 years of applications of 188 kg/ha superphosphate, the decrease in DM production was 10% in the first year after topdressing ceased (Figure 1). This decrease was due entirely to a reduction in clover growth (Table 1). In the second year. the decline in

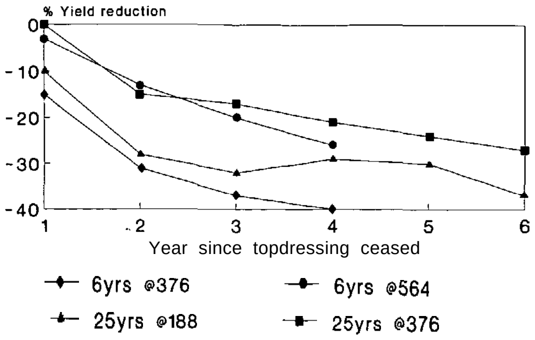


Figure 1 Dry matter yield reduction (%) with time, on plots that received no P or S fertiliser after superphosphate had been applied annually for 6 years at 376 or 564 kg/ha and 25 years at 188 or 376 kg/ha.

DM production had increased to 28% (Figure 1), and this decline was due to an equal decrease in both grass and clover production (Table 1). In contrast, DM production did not decrease in the 1st year on the area that previously received superphosphate at 376 kg/ha; even in year 6 after the cessation of superphosphate application, the decrease was only 27% (Figure 1). The decline in DM production in the second year was due mainly to a reduction of the clover component (Table 1).

These results indicate that there was a substantial residual value of previously applied superphosphate, especially when superphosphate was applied for long periods at rates which were considered to be above superphosphate maintenance requirements (250 kg/ha/year) (Nguyen *et al.* 1989). The residual value of a superphosphate may have been from either P or S, or both P and S.

### Residual value of sulphur from superphosphate

The residual effect of the S component of superphosphate was shown by the extent of the decrease in DM production in areas where only P was applied after the cessation of superphosphate application.

Residual values of S from short-term (6 years) superphosphate applications were shown to depend on previous application rate. On areas that previously received superphosphate at 376 kg/ha, the decrease in DM production in P-applied plots relative to the continuous application was 11% in the first year (Figure 2). DM production continued to decline with time, reaching 37% in the fourth year (Figure 2). In contrast, application of P alone after 6 years of superphosphate topdressing at 564 kg/ha was able to sustain pasture production until the second year (Figure 2).

After 6 years of superphosphate application, the magnitude of yield reduction in plots where there was a continued P application (Figure 2) was similar to that in plots where both P and S were withheld (Figure 1). This suggests that S deficiency is a more limiting factor for pasture growth than P deficiency

Table 1 Dry matter reduction that occurred in subsequent years following the cessation of 25 years of superphosphate (SP) topdressing. (Expressed as a % reduction relative to the continuous treatment).

| Fertiliser input after superphosphate discontinued | Previous application rate | Herbage component | Year after superphosphate withheld | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1 | 2 | 3 | 4 | 5 | 6 |
| No P no S | 188 | grass | 2 | 33 | 38 | 35 | 38 | 53 |
| | | clover | 27 | 35 | 45 | 46 | 49 | 55 |
| | 376 | grass | 0 | 7 | 23 | 27 | 36 | 45 |
| | | clover | 12 | 38 | 27 | 42 | 28 | 34 |
| P only | 188 | grass | 0 | 9 | 21 | 19 | 29 | 28 |
| | | clover | 16 | 15 | 22 | 19 | 27 | 26 |
| | 376 | grass | 0 | 5 | 15 | 17 | 20 | 26 |
| | | clover | 0 | 24 | 25 | 22 | 12 | 8 |
| S only | 188 | grass | 0 | 18 | 31 | 35 | 42 | 50 |
| | | clover | 39 | 42 | 55 | 52 | 45 | 57 |
| | 376 | grass | 0 | 0 | 0 | 9 | 16 | 18 |
| | | clover | 0 | 0 | 0 | 5 | 7 | 23 |

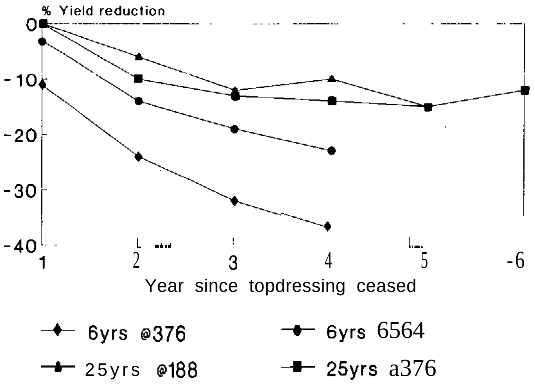


Figure 2 Dry matter yield reduction (%) with time, on plots that received P only as fertiliser after superphosphate had been applied annually for 6 years at 376 or 564 kg/ha and 25 years at 188 or 376 kg/ha.

in areas where superphosphate had been applied for only 6 years at either 376 or 564 kg/ha.

In areas where superphosphate had been applied for over 25 years at 188 or 376 kg/ha, the residual value of S from superphosphate was substantial. When P only was applied, DM yield did not decrease in the first year. In subsequent years, production declined but levelled out at about 12% down, again with no difference between previous application rates (Figure 2). Dry matter reduction in the second year was due entirely to a decrease in clover growth (Table 1). A reduction of over 10% in grass production did not occur until the third year (Table 1).

Residual values of S from superphosphate from both short- and long-term applications may be attributed to the mineralisation-immobilisation of soil organic S (Nguyen & Goh 1990). In areas where superphosphate had been applied for 6 years, the accumulation of soil organic S had not reached a steady state (Nguyen & Goh 1990) and the rate of S mineralisation probably depended on the particular level of organic S reached in the soil (Ghani 1989). However, the rates of S mineralisation in areas where superphosphate had been applied for 25 years at 188 or 376 kg/ha may be similar, since soil organic S in both areas has been reported to attain a similar equilibrium level (Nguyen & Goh 1990). This could explain the similar residual value of S in these areas.

**Residual value of phosphorus from superphosphate**

The residual effect of P from superphosphate was shown by the extent of the decline in DM yield in areas where S only was applied after superphosphate application were discontinued.

Application of S alone after 6 years of superphosphate at 376 kg/ha failed to sustain a pasture against yield reduction even in the first year (Figure 3). However, only a small yield reduction occurred on areas where only S was applied after the application of 564 kg/ha superphosphate was discontinued (Figure 3). This suggests that residual P in the area previously applied with 564 kg/ha was substantial, probably because of the contribution from inorganic and organic P reserves (Goh & Condron 1989; Condron & Goh 1990).

In areas where superphosphate had been applied for 25 years, residual P from 188 kg/ha was unable to sustain pasture production against yeild reduction even in the first year (a 14% decline) after topdressing ceased (Figure 3). There was a substantial (39%) reduction in clover, but grass production was not affected by the absence of P applications until the second year (Table 1).

In contrast, there was a substantial residual of P from superphosphte applied for 25 years at the higher rate of 376 kg/ha. Where no P was applied no significant decrease in DM yield or change in herbage composition occurred until the fifth year after the

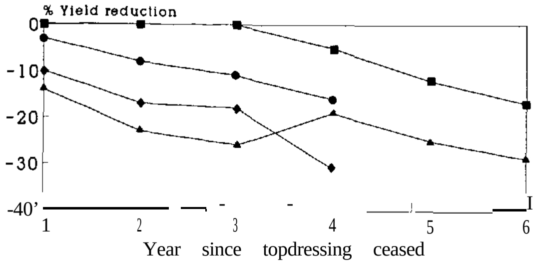


Figure 3 Dry matter yield reduction (%) with time, on plots that received S only as fertiliser after superphosphate had been applied annually for 6 years at 376 or 564 kg/ha and 25 years at 188 or 376 kg/ha.

cessation of superphosphate (Figure 3; Table 1). The higher residual value of P from the 376 kg superphosphate application rate probably reflects the higher soil inorganic P reserve in this treatment (Nguyen et *al* 1989).

### Predictive model for assessing DM reduction after superphosphate cessation

A multiple regression analysis model was constructed to predict yeild reductions due to withholding superphosphate applications on irrigated pasture on Lismore silt loam. This model accounted for previous topdressing history and the number of years topdressing was withheld.

$$DMreduct = 47.7 - 0.08*Prev - 0.92*Nuyr + 14.6*\log(Yr)$$

$$R^2 = 0.923 \ **$$

Where:

DMreduct = % reduction in DM production after the cessation of superphosphate application compared with production from continued application.

Prev = the annual amount (kg/ha) of superphosphate previously applied

Nuyr = number of years at this topdressing rate

Yr = number of years since topdressing ceased

Further work on this model is required, in particular, separation of the residual effects of the P and S components of superphosphate.


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