SULPHUR AND PHOSPHORUS RESPONSES OF RUSSELL LUPIN IN RANGELAND

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ABSTRACT

Russell lupin (*Lupinus polyphyllus*) was established by oversowing into low fertility, depleted tussock rangeland in 1990. The soil was low in phosphorus (P) and sulphur (S). P, (O, 12.5, 25 or 50 kg P /ha) and S (0 or 60 kg S/ha) were applied at sowing. In May 1994, a further 0 or 60 kg S /ha was applied as a sub-plot treatment. Lupin and grass dry matter (DM) was assessed in December 1995. Lupin did not grow in the absence of S. Lupin and grass responded to the additional S giving a maximum of 4.2 and 4.9 t DM/ha respectively compared with a maximum of 1.0 and 2.9 t DM/ha in the absence of the additional S. In the absence of fertiliser P, addition of S increased lupin DM confirming that lupin was able to extract P from soils with low natural P content.

KEYWORDS

Lupin, persistence, sulphur, phosphate, fertiliser, dry matter production

INTRODUCTION

Pasture improvement by oversowing white clover (*Trifolium repens* L.) into unimproved, high country rangeland of New Zealand requires regular inputs of phosphatic and sulphur fertilisers or the clover does not persist for more than a few years on the infertile acid soils found in these regions. (White 1996) Russell lupin (*Lupinus polyphyllus* Lindl.) has been shown to grow well and persist with lower inputs on these tussock grassland sites (Scott and Covacevich 1987).

In a fertiliser trial using Russell lupin, sown in 1990, White *et al.* (1996) showed that lupin did not grow in the absence of sulphur (S) whatever the rate of phosphorus (P) applied. In the presence of S, soluble phosphate (triple superphosphate) gave large, early responses in lupin production in the first and second years after sowing. As well there were associated benefits in grass production from the nitrogen fixed by the lupin. Rock phosphate provided the lupin with a less readily available source of P causing lower production initially but by years 3 and 4, lupin production was greater with rock phosphate than with superphosphate. Initially (years 1, 2 and 3), lupin produced more with high rates of P but by the fourth growing season, lupin supplied with S only produced as well as those with P plus S.

Mean annual production of lupin from all plus S treatments reached a peak in the third year after sowing and decreased during year 4. Chemical analysis indicated that S deficiencies were severely limiting lupin production. The results of an additional application of S at the end of the fourth growing season,in May 1994, are reported.

METHODS

A field experiment was established at Mesopotamia Station, South Canterbury, New Zealand on a yellow brown earth, pH of 5.3, P retention of 44% and deficient in sulphur (S = 2ppm as SO_4), phosphorus (Olsen P = 6), molybdenum and boron. The site is 500m above sea level and rainfall 940mm per annum.

Russell lupin seed was drilled in August 1990 into depleted fescue tussock (*Festuca novae-zealandiae* (Hack) Ckn.) dominated by very low producing browntop (*Agrostis capillaris* L.) and sweet vernal (*Anthoxanthum odoratum* L.) grasses and hieracium (*Hieracium pilosella* L.). Plots were 10m x 2m, arranged in a randomised block design with four replicates. Two forms of P, triple superphosphate (21%P) and North Carolina rock phosphate (13%P) were broadcast at 0, 12.5, 25 and 50 kg P/ha and S (initial S) was applied at 0 or 60 kg S/ha. Molybdenum and boron were applied as basal fertiliser dressings. Full details of the trial and sowing procedure are presented by White *et al* (1996). In May (autumn) 1994, a further 0 or 60 kg S/ha, as gypsum, was applied as a sub-plot treatment to half of each main plot (late S). The trial was grazed by sheep after the early summer (December) sampling and again in winter prior to spring growth.

On 7 December 1995, all subplots were assessed visually for lupin and grass dry matter. Visual scores were calibrated by obtaining dry matter yields of lupin and grasses by cutting twenty 0.2m^2 quadrats to 50mm stubble height. These quadrats were positioned to cover the complete range of visual scores. A regression analysis on score versus dry matter (DM) production of lupin and grass gave a slight curvilinear response with r^2 values of 0.87 and 0.82 respectively.

Leaf samples of lupin were taken for mineral analyses from each sub-plot in two of the replicates.

RESULTS AND DISCUSSION

In the absence of sulphur, lupin plants were still present but were no more than 10 cm tall and producing little dry matter. These plants showed severe chlorosis and some red colouration at the edges of the leaves. Lupin still responded to S applied at sowing but in the absence of late applied S produced a maximum of only 1t/ha (Fig 1)

Lupin DM production increased from an average of 0.5 to 3.4 t/ha when late S was applied (Fig 1). There was also a response in lupin DM with higher rates of establishment P when late S was applied. The large response in 1995 of both lupin (Fig 1) and grass (Fig 2) to the late application of S indicates that these plants had become very sulphur deficient. Mineral analyses of the lupin samples indicate that even after the late application of S the values of tissue S were between 0.08 - 0.14%, P (0.1 - 0.17%) and N (1.5 - 3.0%). These are well below optimum values for leaves of most pasture species (Cornforth and Sinclair, 1982). However the leaves of the plants given the late applied S did not show deficiency symptoms which might have been expected with such low values.

At zero P, applications of S increased lupin DM production. This confirms the response shown by White *et al.* (1996), in earlier years of the trial. The large tap root system of lupin, or the presence of proteoid roots may explain why lupin plants are able to take up soil P from very infertile soils when adequate S is supplied. These proteoid roots, which are known to be present in many species of lupin, are able to secrete citrate which renders soil phosphates more available to plants (Dinkelaker *et al.*, 1989; Gardner *et al.*, 1982). While S was the major factor limiting DM, the response of lupins to increasing rates of P with late applied S indicated that P was also limiting lupin growth after 5 years.

There was no significant difference in lupin DM production in December 1995, the sixth year after sowing, where the different forms of P (triple phosphate or rock phosphate) were applied. This contrasts with earlier results (White *et al.*, 1996), where in the first two years of the trial, lupin DM was greater in plots given the readily available triple superphosphate. By the third year, lupin DM in plots with the relatively insoluble rock P was superior. Presumably P from each source had equilibrated in the environment by the sixth year.

Grass DM was minimal when no S was applied. When S was applied initially together with a late application, grass growth reached a maximum of 4.9 t/ha with the highest rate of P applied. There was no difference between grass DM when S was applied initially or late and was about half that of both initial plus late S (Figure 2). However, in contrast to the lupin, grass DM from the plots given triple superphosphate was superior to those plots given the rock phosphate. This reflects the enhanced nitrogen fixation from the lupins in the early years when supplied with triple superphosphate.

In conclusion, inland mountainous areas of New Zealand are very low in S and lupin will persist and grow moderately well with S fertiliser only, while white clover needs regular applications of both S and P (White, 1996).

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Figure 1
Effect of rate of phosphorus on grass dry matter production when sulphur was applied initially at sowing and late in 1994.
↘ = no S, ↙ = Initial S only,▼ = Late S only,
↔ = Initial and late S.

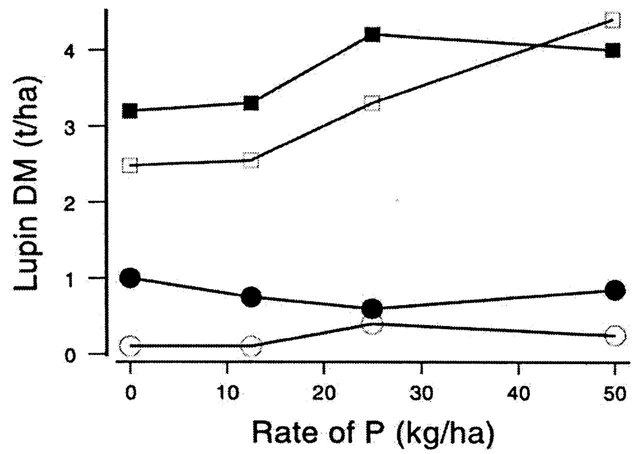

Figure 2
Effect of rate of phosphorus on grass dry matter production when sulphur was applied initially at sowing and late in 1994.
↘ = no S, ↙ = Initial S only,▼ = Late S only, ↔ = Initial and late S.