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WHITE CLOVER CULTIVAR RESPONSESTO PHOSPHATE FERTILISERS OF DIFFERING SOLUBILITY

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Abstract

A glasshouse study Investigated the dry matter response of Grasslands Kopu and Grasslands Tahora white clover, cultivars of differing origins and morphologies, to three phosphate fertilizers, monocalcium phosphate (MCP), partially acidulated phosphate rock (PAPR) and a reactive phosphate rock, North Carolina phosphate rock (NCPR), of differing water solubility.

Kopu responded more rapidly and reached its maximum dry matter yield at a lower phosphorus (P) level than Tahora when MCP and NCPR were the P fertilizers. With PAPR as the P fertilizer, their response was similar. The shoot dry matter response by Kopu to all three P sources was reflected more in leaf weight and size than leaf number or stolon length. In contrast Tahora responded to added P by increasing leaf number and stolon length to a much greater extent than Kopu.

Keywords: *Trifolium repens,* monocalcium phosphate, partially acidulated phosphate rock, reactive phosphate rock.

INTRODUCTION

In recent years, there has been a considerable change in the New Zealand fertilizer industry from the traditional single superphosphate (SSP) to less processed, higher phosphorus (P) analysis materials, such as partially acidulated phosphate rock (PAPR), physical mixtures of SSP and reactive phosphate rock; and reactive phosphate rock materials, namely North Carolina phosphate rock (NCPR) and Sechura phosphate rock (SPR).

Similarly the choice of white clover (*Trifolium repens*) cultivar has increased to include materials of diverse morphology and genetic background. This could be important as Mackay (1987) found Huia white clover and the resident white clover to respond differently to SSP, PAPR and NCPR in hill country. In the same way Grasslands Tahora, a small leaved, stoloniferous white clover selected from New Zealand ecotypes for summer moist hill country of low to moderate P fertility may well respond differently to P fertilizers, compared to the large leaved, erect, sparsely branched Grasslands Kopu selected from crosses of Grasslands Pitau and Ladino clover from the United States of America for summer activity in high P fertility, lowland environments. There is clearly a need to characterise the P response of these new cultivars, particularly in relation to the wide range of P fertilizers with varying degrees of water solubility now available.

The objective of this study was to investigate the dry matter response of Grasslands Tahora and Kopu white clover, cultivars of differing origins and morphologies, to three P fertilizers of differing water solubility.

MATERIALS AND METHODS

The two pot trials reported were conducted in a heated glasshouse at Grasslands Division, DSIR, Palmerston North.

Plant material. Seeds of Grasslands Kopu and Tahora were germinated in petri-dishes at 25°C, transplanted afler 48 h to sand trays and grown for 10 days before planting into pots.

Soil. The Wainui silt loam (YGE/YBE intergrade), with a pH of 5.0 and Olsen P of 6 mg kg^{-1}, used in this study was collected from the field to a depth of 100mm. Soil was passed moist through a 40mm sieve.

Phosphate fertilizer. The three P fertilizers used were: Monocalcium phosphate (MCP), the major P form in SSP, PAPR and NCPR with total P contents of 25, 15 and 13%, respectively, and water soluble P contents of 90, 50 and <0.1 %, respectively. MCP was in a powdered form, PAPR in a granulated form was lightly ground and NCPR had 100% <250mm.

Glasshouse study. The first study was conducted to establish the P additions required for constructing response curves for the two cultivars with the three P fertilizers. Along with the P fertilizers, sulfur as gypsum ($CaSO_4$) and potassium as muriate of potash (KC1) was mixed with the soil and packed into 650ml pots. Each pot was planted with three seedlings of each cultivar and watered daily by weight to field capacity. Inoculation was ensured by watering with several strains of Rhizobia effective on white clover. In the first study P fertilizers was added to soil at rates of 0, 25, 50, 75, 100,500 and 1000 mgP/kg of oven dried soil. In the second study these rates were adjusted and each P fertilizer was added at rates of 0, 37, 75, 150, 300, 450 and 700 mgP/Mg of oven dried soil. In the second study each pot was planted with four seedlings.

Measurements. A single destructive harvest was taken 48 and 65 days after planting seedlings in the first and second studies, respectively. In the first study, leaf, stolon and root weights were recorded. Nodule counts were also made. In the second study leaf number, weight and size (leaf weight/leaf number) and stolon length and weight were measured.

Statlstical analysis. All data was subjected to an analysis of variance. Least significance differences (LSD) were used to compare treatment means. Quadratic functions were fitted to the dry matter response curves. To test differences in the dry matter response of the two cultivars, the fitted curve for each cultivar was compared with a common curve.

RESULTS AND DISCUSSION

Nodule numbers

The general relationship between the P nutrition of legumes and the number and viability of nodules is well established (Graham and Rosas 1979). In the first study nodule numbers of both Kopu and Tahora increased more with MCP than NCPR, at low rates (Fig. 1), reflecting the differing solubility of the two P sources and their initial availability to growing plants (Mackay et *al.* 1984). At the rate of 2000 mgP/kg of soil, MCP and PAPR were toxic to the growth of both Kopu and Tahora, whereas NCPR continued to increase nodule numbers. In addition to checking on nodulation and establishing the P levels for the main study, the first study did identify two interesting differences in the dry matter response of Kopu and Tahora to the three P fertilizers. At 0 and 25 mg of added P Kopu had a greater leaf and lower root to total plant weight ratio than Tahora (Fig. 2). The stolon growth of Tahora expressed as a fraction of total plant growth was significantly less with NCPR (12% of total plant weight) than MCP or PAPR (18% of total plant weight). In contrast the stolon growth of Kopu was not affected by the P fertilizer.

Response of Kopu and Tahora to different P fertilizers

A significant ($P<0.01$) P source x cultivar interaction occurred (Fig. 3). Kopu responded to increasing additions of P as MCP far more rapidly than Tahora, and reached maximum yield at a much lower P level (Fig. 3a). The calculated P level for maximum yield of Kopu was only 612 mg P/kg of soil compared with 1047 mg P kg^{-1} of soil for Tahora. In sharp contrast to the difference found in the response of Kopu and Tahora to MCP (Fig. 3a), no difference was found in the dry matter response of the two cultivars to additions of P as PAPR (Fig. 3b). A PAPR contains, like MCP, a significant fraction of total P in a water soluble form. In contrast to MCP which was appiied as a powder, the granulated PAPR was added to the soil after only light grinding. This may have reduced, by localisation, the availability of P in this P source, sufficient to reduce the potential growth of Kopu. With the third P fertilizer, NCPR, Kopu was again more responsive than Tahora and again reached maximum yield at a much lower P addition (Fig. 3c).

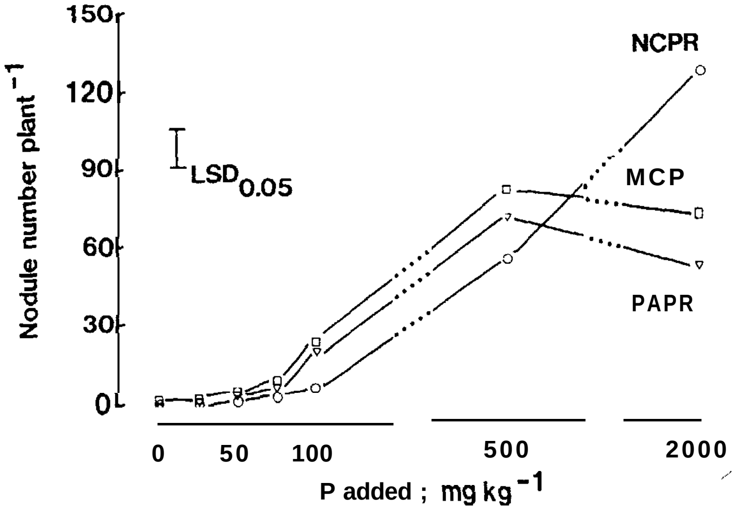

Figure 1: Rhizobium nodule numbers as affected by P level and P source Lines are means for Kopu and Tahora

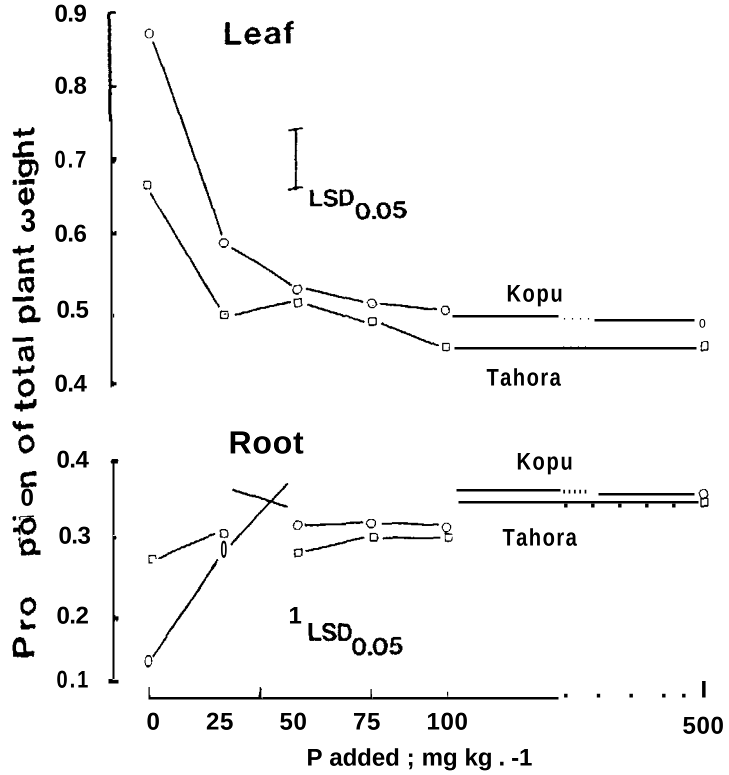

Figure 2: Proportion of leaf and root to total plant weigh for Kopu and Tahora as affected by P level. Lines are means for the three P fertilizers.

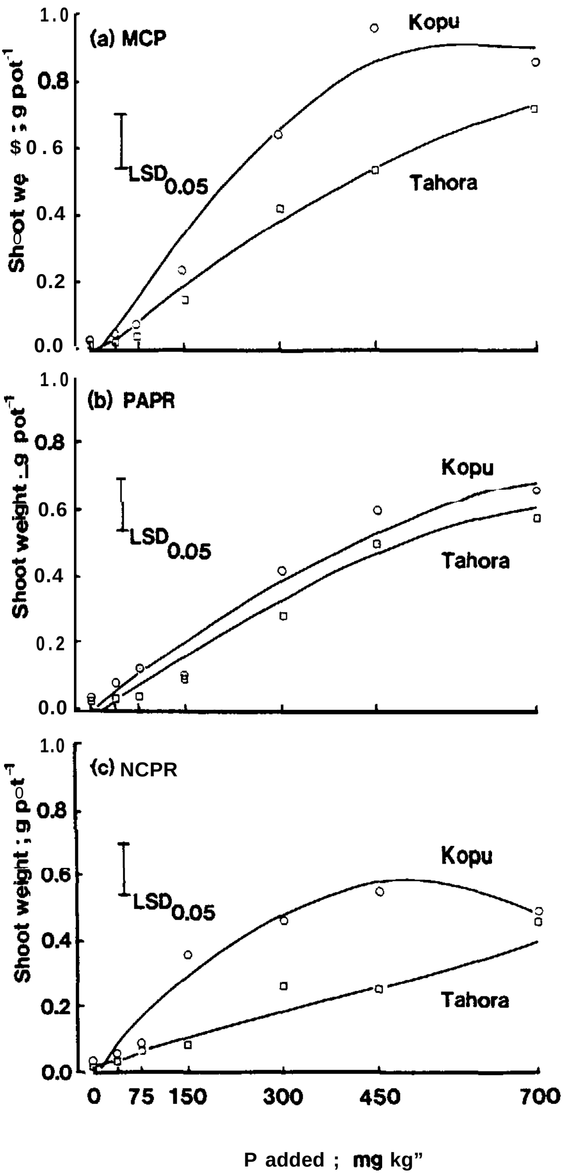

Figure 3: Shoot dry matter response of Kopu and Tahora to (a) MCP. (b) PAPR and (c) NCPR. Fitted curves for Kopu ($Y = 3.27 \times 10^{-3} X - 2.67 \times 10^{-6} X^2 - 0.074$) and Tahora ($Y = 1.65 \times 10^{-3} X - 0.79 \times 10^{-6} X^2 - 0.036$) with MCP are significantly different (F = 5.92'). for Kopu and Tahora with PAPR not significantly different and for Kopu ($Y = 2.30 \times 10^{-3} X - 2.26 \times 10^{-6} X^2$ 0.001) and Tahora ($Y = 0.56 \times 10^{-3} X$ 0.097 $\times 10^{-6} X^2 + 0.023$) with NCPR are significantly different (F = 13.49"). Plotted values at each P level are means for the three replicates.

In both cultivars, the proportion of leaf declined and the proportion of stolon and root increased with increasing additions of P as either MCP, PAPR or NCPR. The shoot dry matter response by Kopu to all three P sources was reflected more in leaf weight and size

(Fig. 4a) than leaf nuniber (Fig. 4b) or stolon length (Fig. 4c). In contrast Tahora responded to added P by increasing leaf number (Fig. 4b) and stolon length (Fig. 4c) to a much greater extent than Kopu.

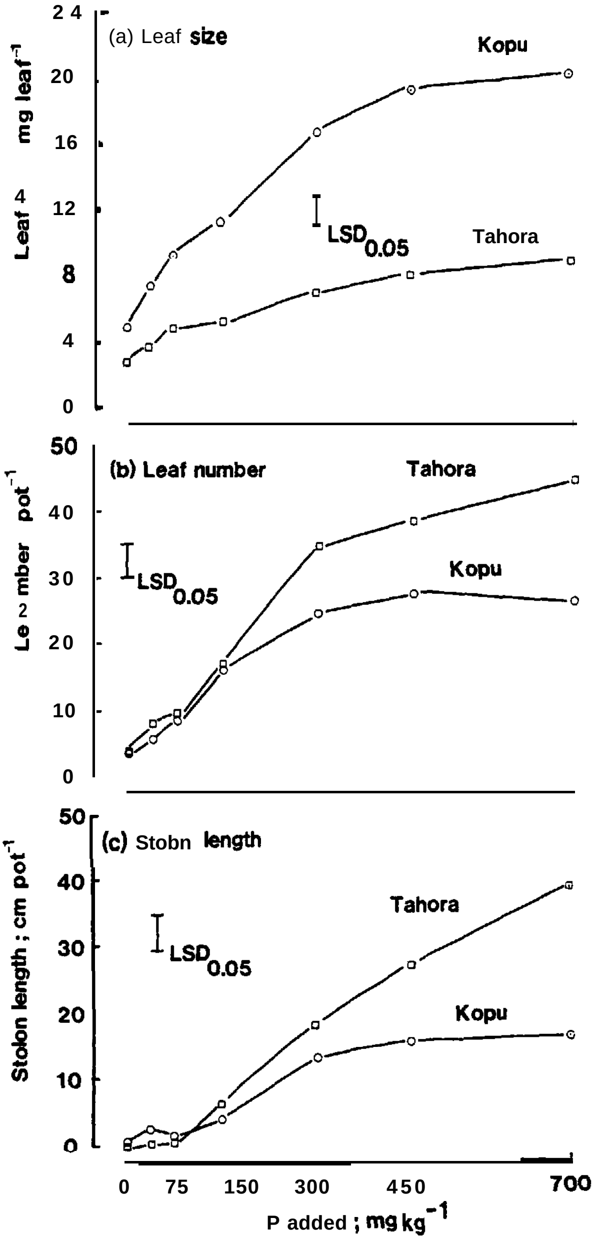

Figure 4: Effect of added P on (a) average leaf size. (b) leaf number and (c) stolon length of Kopu and Tahora. Lines are means for the three P fertilizers. Plotted values at each P level are means for the three replicates of each of the three P sources.

The reason or reasons for the difference in the total dry matter respnse of Kopu and Tahora to added P are not apparent at this stage. The greater leaf to root ratio at very low P levels (Fig. 2), the fewer larger leaves and the shorter, thicker stolons of Kopu (Fig. 4) may simply result in a larger surface area for photosynthesis in this cultivar at lower P levels. This would enable the plant, through an increased supply of carbohydrates to respond more rapidly to added P. This aspect is the subject of further study.

If a major difference between Kopu and Tahora was growth rate, then differences in the response of these two cultivars to the three P fertilizers should have diminished as the water soluble P fraction in the fertilizers decreased. The fact that the dry matter response of Tahora with NCPR was not as rapid as Kopu and the maximum response of Kopu with NCPR was not as great as the response of Kopu with MCP (Fig. 3a), suggests the difference in the response of these two cultivars to added P, reflects a real difference in the ability of Kopu and Tahora to either obtain or utilise added P. The identification of differences in the dry matter response of Kopu and Tahora to added P suggests there may be scope for selecting and breeding a white clover cultivar with improved P nutrition. At no stage in the breeding programme of either Kopu or Tahora was the P response characteristic of parents considered.

While the use of the glasshouse limits the significance and the extent to which the findings of this study can be extrapolated to other environments, the glasshouse did enable a large measure of control over a wide range of parameters. With P fertilizer a major input cost to pastoral farming and P a major factor limiting further increases in pasture productivity, the breeding of a white clover cultivar with improved P nutrition would have a major impact on the viability of pastoral farming systems in N.Z.

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