SEASONALITY IN THE RESPONSE OF PERENNIAL GRASS-CLOVER PASTURES TO PHOSPHORUS FERTILISER

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ABSTRACT

Pasture dry matter yields from individual cuts of multi-year phosphorus (P) fertilizer field trials were analyzed for evidence of consistent seasonal trends in the response to P. The relative response to P was greatest in the late autumn - winter period, with the seasonal variation in relative yield being greater where soil fertility and mean annual relative yields were lowest.

KEYWORDS

Phosphorus, pasture, season, relative yield

INTRODUCTION

Regular applications of phosphorus (P) are required to maintain grass-clover pastures on most soils in New Zealand. P recommendations for grazed pastures (Metherell *et al*., 1995) are usually based on relationships between soil P status, fertilizer inputs and annual dry matter relative yields. However the responsiveness of pasture to P fertilizer and the relationship between the Olsen P soil test and relative yield (RY) varies seasonally with the largest responses being obtained during slow growth periods (Saunders *et al*., 1987). This may have important implications for animal production with greater P response during periods of restricted feed supply. In the present study we sought evidence of consistent seasonal trends in P response in multi-year experiments.

METHODS

Forty four trials on grass-clover pastures with a total of 207 treatments were selected from a national database to cover a spread of regions and soil types. All experiments had soluble P fertilizer (mono calcium phosphate, single superphosphate or triple superphosphate) applied annually and were regularly mown. In most experiments a proportion of clippings were returned to the site and basal sulphur, potassium and sometimes nitrogen fertilizers were applied. Most of the experiments had at least 20 dry matter cuts taken. Relative yields for each treatment for each individual cut were calculated by dividing the measured yield by the highest yielding treatment for that date. Separate analyses of seasonal effects were made for each treatment using Flexi 2.2, a Bayesian curve fitting program (Wheeler and Upsdell, 1994). To account for changes in fertility status over time, the seasonal effect was calculated as the deviation from a long term linear trend. Consecutive years of seasonal deviation data were overlaid on a day of year basis to give a single seasonal dataset covering a period of one year. A cyclic curve with a period of 365 days was fitted using Flexi. The days of the year of the minimum and maximum RYs, and the amplitude $\frac{(maximum-minimum)}{2}$ of the fitted curve was recorded. Relationships between seasonal amplitude and day of maximum R, rate of P, mean Olsen P, mean annual dry matter yield, potential dry matter yield (from the treatment with the highest rate of P applied), geographic regions and season of fertilizer application were investigated.

RESULTS AND DISCUSSION

Seasonal curves for RY could not be fitted to four of the 207 treatments, and another four treatments could not have relative response seasonal curves fitted by Flexi. Closer examination of these treatments indicated that they had very small seasonal effects. Twelve percent of the treatments had a seasonal amplitude greater than 0.08. The frequency distribution for the day of maximum RY (i.e. minimum P response) had a peak in the range 340-365 (5 December to 30 December), while the day of minimum RY (i.e. maximum P response) peaked approximately 183 days out of phase in the range 140 - 160 (19th May - 8th June). 48% of the days of minimum RY were in the range 100- 200 (9th April - 18th July). Treatments outside this range tended to have a smaller seasonal amplitude (Figure 1).

The amplitude of the seasonal effect was moderately correlated with rate of P (r^2 = 0.10), mean Olsen P (r^2 = 0.11), mean annual dry matter (r^2 = 0.09), and mean RY (r^2 = 0.43). The higher the rate of any of these, the less the seasonal amplitude. There was no correlation with potential dry matter yield.

Caution is required in the interpretation of region and season of fertilizer application effects because of limited numbers in some groups. Similar patterns were found for all regions and seasons of fertilizer application, but the greatest amplitudes were observed in the north of the North Island and the south of the South Island, and for fertilizer applied during the winter.

Modeling seasonal relative yields. The seasonal amplitude in RY was found to depend most strongly on the mean RY. A curve was fitted (Figure 2) of the form $A = c\,M\,(1 - M)$, where A is the amplitude, M is the mean annual RY and c is a constant in the range 0 to 1. A curve of this type was used because it gave a good fit to the data, and has the desirable property of predicting zero seasonal amplitude for mean RYs of 0 or 1. In addition the curve lies within the feasible region of the maximum constraint on amplitude (ie. if the mean RY is 0.9 then the amplitude cannot be greater than 0.1). Over all the experiments and treatments the least squares best fit value for c was 0.4065. When the equation was fitted only to the data for control treatments the value of c was 0.34. The seasonal effect throughout the year approximated a cosine curve, thus the RY for any particular day can be found from the equation

$$\textit{Seasonal RY} = 0.4\,M\,(1 - \mathrm{M})\ \mathrm{COS}\ (2þ\ \frac{(day + ø)}{365}) + M$$

where *day* is the day of the year and ø is the phase shift which is approximately equal to 15 days. The mean RY (*M*) can be calculated using the Outlook model (Metherell *et al*., 1995). For example, on a volcanic ash soil with an Olsen P test of 6 and a mean annual RY of 70, the RY is estimated to be 62 and 78 in early winter and summer respectively. However at an Olsen P of 18 the seasonal variation in RY is much less, being from 93 to 97.

The seasonal effects observed are consistent with observed changes in the storage of labile organic P in soil under pasture in New Zealand. There is a tendency for immobilisation of P during the autumn - early winter period and rapid mineralization in the spring (Perrott *et al*., 1990; Perrott *et al*., 1992). The net effect on labile inorganic P is greatest in infertile soils and results in the pasture having a greater reliance on fertilizer P during the autumn to early spring period. Hence the relative response to P is greatest in the winter which is frequently a critical period for animal feed supplies. The impact on animal production is likely to be greater than indicated by the RY of annual pasture dry matter.

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Figure 1
The seasonal relative yield amplitude plotted against the day of year of the minimum relative yield.

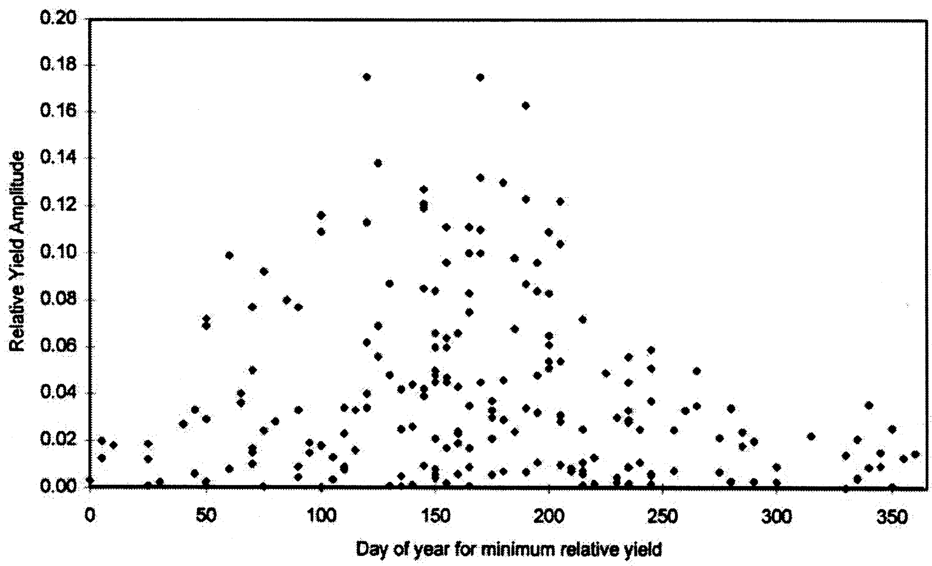

Figure 2
The seasonal amplitude in relative yield versus the treatment mean relative yield and the fitted equation.