

EFFECTS OF FERTILISER RATES AND FORMS ON SOIL PHOSPHORUS FRACTIONS IN A LONG-TERM TRIAL AT WINCHMORE, NEW ZEALAND

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ABSTRACT

In a long-term field trial in mid-Canterbury, New Zealand, on an irrigated pasture fertilised with superphosphate, soil phosphorus (P) has accumulated primarily in the inorganic bicarbonate extractable fraction, and in both organic and inorganic NaOH extractable fractions. With Sechura phosphate rock, inorganic P also accumulated in the HCl extractable fraction. In the control treatment there was little change in the inorganic P fractions, while some accumulation of NaOH extractable organic P occurred.

KEYWORDS

Phosphorus, fertilisers, soil, pasture, New Zealand

INTRODUCTION

The regular application of phosphate (P) fertilisers is necessary for the establishment and maintenance of improved grass-clover pastures in New Zealand ADDIN ENRef (During, 1984). The reactions, fate and availability of fertiliser P in the soil are determined by a combination of factors including the amount, frequency and form of P applied, land use and soil properties such as P retention ADDIN ENRef (Sanyal and De Datta, 1991). Detailed sequential extraction techniques have been developed to examine the nature, distribution and dynamics of P in soil ADDIN ENRef (Tiessen and Moir, 1993). The objective of this study was to determine the long-term effects of applied P on soil P fractions under grazed, irrigated pasture in New Zealand.

MATERIALS AND METHODS

A field trial was established at Winchmore Irrigation Research Station in mid-Canterbury, New Zealand in 1952 on a Lismore stony silt loam soil (Udic Ustochrept) to determine the long-term P fertiliser requirements of irrigated pasture in the region ADDIN ENRef (Nguyen *et al.*, 1989). The trial is ongoing and includes the following 5 treatments:

- Control: no P applied since 1952
- 188SP: 188 kg superphosphate ha⁻¹ yr⁻¹ (18-19 kg P ha⁻¹ yr⁻¹) since 1952
- 376SP: 376 kg superphosphate ha⁻¹ yr⁻¹ (36-38 kg P ha⁻¹ yr⁻¹) since 1952
- 250SP: 376 or 564 kg superphosphate ha⁻¹ yr⁻¹ 1952-57; no P applied 1958-1980; 850 kg superphosphate ha⁻¹ in 1980; 250 kg superphosphate ha⁻¹ yr⁻¹ (23 kg P ha⁻¹ yr⁻¹) since 1981
- Sechura: 376 or 564 kg superphosphate ha⁻¹ yr⁻¹ 1952-57; no P applied 1958-1980; 750 kg Sechura phosphate rock (PR)/gypsum (CaSO₄) pellets ha⁻¹ in 1980; Sechura PR/elemental S @ 23 kg P ha⁻¹ yr⁻¹ since 1981.

Topsoil (0-7.5 cm) sampled from each of the four replicates between 1977 and 1994 was analysed for soil P using sequential fractionation methodology (1M NH₄Cl → 0.5M NaHCO₃ [pH 8.5] → 0.1M NaOH

→ 1M HCl → 0.1M NaOH) (Condrón *et al.*, 1996). P fractionation results from 1958 to 1977 were presented by Condrón and Goh (1989).

RESULTS AND DISCUSSION

Most of the soil inorganic P (Figure 1) and organic P (Figure 2) was extracted in the NaOH I fraction, which is consistent with other similar studies on New Zealand pasture soils (Condrón and Goh, 1989; Perrott *et al.*, 1989). As expected, levels of soil inorganic and organic P were greater in the fertilised treatments compared with the control, and while amounts of organic P were similar in the various fertilised treatments, inorganic P in the bicarbonate and NaOH I fractions was markedly greater in the 376SP treatment compared with the other fertiliser treatments.

In all treatments, including the control, there has been a steady increase in organic P, particularly in the NaOH I fraction, but at a slower rate than in earlier years (Condrón and Goh, 1989). Thus lime application in 1972 caused only a short term reduction in the rate of organic P accumulation (Condrón and Goh, 1989).

In the long-term annual fertiliser treatments (188SP, 376SP), the accumulation of inorganic P in the labile bicarbonate fraction was markedly greater between 1985 and 1994 (9 years) compared with the previous 8 year period (1977 - 1985), particularly in the 376SP treatment (Figure 1). Thus, in the 376SP treatment bicarbonate inorganic P increased from 49.9 µg g⁻¹ in 1977 to 58.4 µg g⁻¹ and 93.0 µg g⁻¹ in 1985 and 1994 respectively (Figure 1). Similar trends have also been observed with Olsen P. This result can be attributed to the decreasing rate of organic P accumulation and possibly to an increase in the concentration of plant available P in the superphosphate applied during the last ten years (Condrón and Goh, 1989; Edmeades *et al.*, 1990).

In all of the fertilised treatments significant quantities of P have accumulated in the NaOH I fractions. For example, in the 376SP treatment NaOH I inorganic P increased from 174 µg g⁻¹ in 1977 to 247 µg g⁻¹ in 1994 (Figure 1), and NaOH I organic P increased from 283 (g g⁻¹ to 322 µg g⁻¹ over the same period (Figure 2). The inorganic NaOH I P fraction, which includes iron and aluminium bound P, contributes to the plant available P pool, although the accumulation of organic NaOH I P effectively represents a loss from the plant available pool in pastoral soils (Perrott, 1992).

The accumulation of residual (undissolved) PR in the Sechura PR treatment is shown by the substantial increase in acid soluble inorganic P (HCl P) from 1977 (59.8 µg P g⁻¹) to 1994 (182.0 µg P g⁻¹) (Figure 1). Nonetheless, dissolution of the "reactive" Sechura PR was sufficient to increase bicarbonate and NaOH I inorganic P to levels only a little less than the equivalent 250SP superphosphate treatment (Figure 1). These findings, together with the corresponding agronomic data for Sechura PR versus superphosphate on this trial (McBride, 1992), confirm that "reactive" PR is an effective maintenance P fertiliser in appropriate environmental conditions (Bolan *et al.*, 1990; Perrott *et al.*, 1992).

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Figure 1
The effect of fertiliser treatments on inorganic P Fractions ($\mu\text{g P g}^{-1}$)

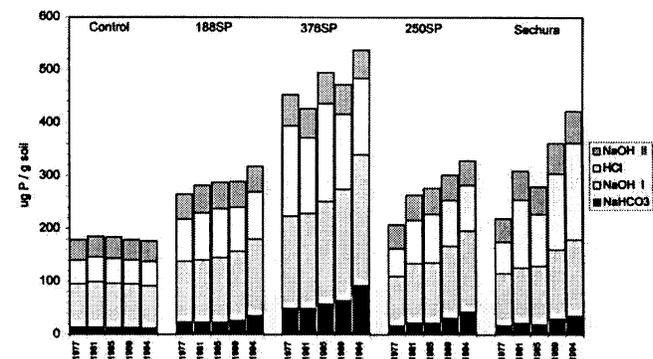


Figure 2
The effect of fertiliser treatments on organic P fractions (g P g^{-1} soil).

