THE FATE OF FERTILISER PHOSPHORUS IN WHAREKOHE PODZOLS

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ABSTRACT

During the 1980's and early 1990's, the then Ministry of Agriculture and Fisheries (MAF) Soil Fertility Service used the mass balance Computer Fertiliser Advisory Service (CFAS) model to make phosphorus (P) fertiliser recommendations where P requirements were calculated to replace losses from the cycling P pool via the soil and animals. In the late 1980's, concerns were raised that higher P application rates than those calculated by the CFAS model were necessary to maintain Olsen P levels on Wharekohe podzols. The soil loss factor (SLF) was identified as the model parameter which most likely led to the inability of the CFAS model to predict P requirements on these podzols. The new Outlook model also uses a mass balance approach incorporating a soil P loss parameter to calculate pasture P requirements. In this study the apparent limitation of the CFAS model to predict the maintenance P requirements of the Wharekohe soils, and the appropriateness of the soil loss parameter used in the New Outlook model, was investigated by (a) determining the fate of applied fertiliser P, (b) examining the possible mechanisms for any soil P retention or loss, (c) quantifying the SLF and (d) modeling the fate of applied fertiliser P.

A chronosequence study found that pasture development resulted in an increase in total soil P to the top of the E horizon with increased P movement down the profile with increasing pasture age. The Wharekohe silt loam appears to have a maximum P storage capacity which is reached by 8 years in the 0-3 cm depth (approx. 166 kg applied P/ha) and by 11 years in the 0-7.5 cm depth (approx. 350 kg applied P/ha). The maximum total P storage capacity can mostly be attributed to a maximum inorganic P (Pi) storage capacity. Sodium hydroxide (NaOH) extractable iron and aluminium-Pi was found to be limited in the Wharekohe soil, due to its low sesquioxide content, in comparison to other New Zealand soils. Once the P storage capacity at each depth is reached there is little further accumulation of applied P and much of the P applied in subsequent application is lost from the topsoil in runoff waters. Up to 65% of the applied P could not be accounted for by animal loss or accumulation in the top 7.5 cm of older sites (>30 years).

A glass house leaching study using intact soil cores confirmed that substantial quantities of applied P can be transported in subsurface water movement through Wharekohe podzols. Forty times more P moved through the Wharekohe soil cores than through cores of the yellow brown earth, Aponga clay (≤45.6 µg/ml in contrast to ≤1.07 µg P/ml). In a field study using suction cups, concentrations of up to 18.65 µg P/ml were obtained in soil water sampled under fertilised Wharekohe silt loam plots in comparison to <2 µg P/ml under unfertilised controls. Movement of dissolved P occurred mostly as DIP after the application of fertiliser P in the glasshouse and field studies. No difference in P movement could be detected in relation to development history in the glasshouse leaching study or in the field study, although the ability of the Wharekohe silt loam to retain added fertiliser P was found to decline with pasture development in a laboratory based P retention study.

Soil loss factors calculated for the Wharekohe podzols from small plot field trials varied enormously (0.04 in the first year to 1.68 over the two year trial period) as a consequence of the large variation in the rate of P required to maintain a steady Olsen P level at each site. Consequently, it was not possible to determine if the SLF of 0.4 used for podzols in the CFAS model was appropriate. The component of the SLF due to non-labile P accumulation, calculated form the chronosequence data, decreased with pasture age. As P applied surplus to animal production requirements and P accumulation is lost from the root zone in runoff, the SLF should be reduced with increasing pasture age or else P runoff losses will increase.

Relationships between pasture age and available Pi, organic P, strongly sorbed/precipitated and residual P, and total P accumulation in the top 7.5 cm of a Wharekohe silt loam were successfully modelled. The annual total soil P accumulation was described in a model which was then incorporated into the Phosphorus in Runoff in High Loss Soils (PRIHLS) model developed to predict potential runoff P losses. Runoff P losses predicted by PRIHLS from the Wharekohe silt loam are nearly 3 times higher from older pasture (>30 years) where the Outlook model is used to calculate P requirements (36 kg P/ha lost in runoff from a calculated P requirement of 44 kg P/ha) compared to the CFAS model (13 kg P/ha lost in runoff from a calculated P requirement of 21 kg P/ha), due to the higher soil loss parameter assigned to the Wharekohe soils in the Outlook model. Such high runoff P losses represent a cost to New Zealand both economically, and environmentally through increased P inputs to water ways leading to possible eutrophication. When runoff P losses have been quantified, through further research, they could be used in the PRIHLS model to predict P requirements and would enable more informed decisions to be made about balanced P fertiliser use on Wharekohe podzols.

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