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Phosphorus

Phosphorus (P) is an essential nutrient, mostly obtained by plants from soil. Unfortunately, few soils are able to continuously meet the P requirements of productive plants, without inputs of phosphatic fertilisers, manures, biosolids and the like. Great progress towards understanding the chemistry and biochemistry of soil and plant P has helped answer questions on the extent of soil P reserves and whether or not a response by plants to P applications might be expected. This chapter draws on that understanding, noting the four key P supply factors are quantity, intensity, rate and capacity.

The most abundant P mineral is apatite [Ca_5(F, Cl, OH)$(PO_4)_3$], which has a structure that tolerates numerous cationic replacements for Ca and several anionic replacements for phosphate. In addition, P often occurs in silicate minerals due to isomorphous replacement of Si^{4+} by P^{5+} in silicate (SiO_4) tetrahedra. The low solubilities of orthophosphates of Ca, Fe, Al and Pb greatly influence the reactivity of P in natural systems and soils. Free PO_4 ions in soils from natural weathering and from fertilisers are rapidly adsorbed onto the surface of most soils via several mechanisms that commonly involve chemical reactions with Fe, Al, Ca and Mg (see Table 9.1; Ure and Berrow 1982). P is non-volatile at normal soil temperatures, while the likelihood of P leaching is low in soils with a capacity to remove it from soil solution by fixation or precipitation.

Total Soil P

Total P (TP) concentrations in Australian soils are low by world standards (Moody and Bolland 1999; Anon 2001). This is supported by Norrish and Rosser (1983), who provided summary data on TP concentrations in a selection of Australian soils. Median concentrations of 0.035 and 0.025% P were obtained from their tabulated data for typical surface and sub-soils, respectively. The concentration range for surface soils was 0.011–0.169% P. Modelled estimates by Anon (2001) found the majority of Australian soils associated with all types of land uses, with the exception of irrigated cropping soils, contained <0.02% of TP. Anon (2001) estimated 16% of horticultural soils contained >0.05% P, with lesser percentages associated with all other

Table 9.1. Effect of pH on important phosphate complexes found in soÕ solutŠns.

SoÕ solutŠn pH	Chemical species/complexes in solutŠn
<1.3	Fe^{3+}- phosphate complexes
1.3–4.3	Al^{3+}- phosphate complexes
4.3–7.2	Hydrolysed phosphate ions
>7.2	Ca and Mg phosphate complexes