13

Extractable iron, aluminium and silicon

Iron, Al and Si are common elements in the earth's crust and in soils. Among the most abundant non-clay minerals found in the clay fractions of soils are the oxides and hydroxy-oxides of Fe (hematite, maghemite, goethite, lepidocrocite), Al hydroxides and oxy-hydroxides (gibbsite, boehmite), Si oxides (quartz, opaline silica), and some disordered forms of Si (Norrish and Pickering 1983). Ure and Berrow (1982) report typical total concentrations in soils of 0.01–21% Fe, 0.07–20.3% Al, and 50–70% SiO_2.

Soil minerals dominated by these elements can be grouped into: (a) those that are easily weathered; (b) those that are moderately resistant to weathering, and (c) those that resist weathering (Ure and Berrow 1982). The first three chemical tests in this chapter help characterise different forms of Fe, Al and Si that affect soil properties. The extractants are acid ammonium oxalate (Tamm 1922; McKeague and Day 1966), sodium pyrophosphate (Blakemore *et al.* 1981; 1987), and citrate-dithionite (Holmgren 1967). For example, the ratio of oxalate-extractable Fe to dithionite-soluble Fe quantifies the proportions of the more and less active fractions, and has been shown to be a useful parameter for characterising soil properties such as P sorption (Schwertmann and Taylor 1989). Sequential extraction of soil involving all three methods in the order pyrophosphate/acid ammonium oxalate/dithionite can be used as a further aid to the type and distribution of Fe in the sample (Taylor 1987). Examples of the levels of Tamm's Oxalate-extractable Fe, Al and Si in New Zealand reference soils are summarised in Table 13.1, derived from data published by Vortman (1980).

The fourth method for extractable Si (13D) is used to assess the likely responsiveness of crops such as sugar cane and rice to applications of silicated products such as Ca silicate, basalt rock dust, diatomaceous earth, and sugarmill muds (Haysom and Chapman 1975; Haysom and Kingston 1999; Berthelsen *et al.* 2001). The method is based on extraction with 0.005 M sulfuric acid, which is the same extractant used for soil P by Method 9G. The test is correlated with relative sugar cane yields as assessed by field experimentation in Queensland (Kingston 1999).

Table 13.2 has summary details on the methods included in this chapter for measuring Fe, Al and Si. Methods 13A1 to 13C1, inclusive, were similarly coded in Rayment and Higginson (1992). More details on all methods are provided in method preambles. No analytical performance data derived from soil interlaboratory proficiency programs of ASPAC are available for these tests.

13A1 Oxalate-extractable iron, aluminium and silicon

Acid ammonium oxalate (acid oxalate) extracts Fe and Al from poorly crystalline minerals such as ferrihydrite, allophane and imogilite; minerals containing Fe^{2+} such as magnetite; and organic matter. Attack on poorly crystalline lepidocrocite has been reported by Childs and Wilson (1983).