Fertility of Soils of Tonga

Interim Report 2

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SOILS EXAMINED IN THIS STUDY

TABLES	SOIL TYPE	ISLAND GROUP	ISLAND	SAMPLE NO.
		Vava'u		
1a+	Hunga clay		Hunga	9153
2, 2a	Longomapu clay loam		Vava'u	TV2/1, 2/2
3a+	Neiafu clay loam		Vava'u	9165
4, 4a	Pangaimotu clay loam		Vava'u	9166
5, 5a	Tu'anekevale clay loam		Vava'u	TV3/1, 3/2
		Ha'apai		
6, 6a	Felemea clay		Uiha	9179
7, 7a	Foa clay		Foa	9175
8, 8a	Foa clay		Ha'ano	9186
9, 9a	Ha'afeva silt loam		Ha'afeva	9176
10*	Ha'apai clay		Nomuka	9172
11,11a	Ha'apai clay		Lifuka	9181
12,12a	Lifuka clay		Lifuka	TH1/1, 1/2
13,13a	Mango clay		Mango	9182
14,14a	Nomuka clay		Nomuka	9171
15,15a	Uiha clay loam		Uiha	9177
16*	Uoleva sandy loam		Ha'ano	9190
		Tongatapu		
17,17a	Lapaha clay		Tongatapu	TT2/1, 2/2
18a+	Lapaha clay, easy rolling phase		Tongatapu	9168
19,19a	Nuku'alofa sandy loam		Tongatapu	TT3/1, 3/2 (9113)
20,20a	Vaini clay		Tongatapu	TT1/1, 1/2
21a+	Vaini shallow clay		Tongatapu	9167
		'Eua		
22a+	Faitoka clay loam		'Eua	9145
23a+	Ha'atua clay loam		'Eua	9148
24,24a	Hango silty clay (H54)		'Eua	9144
25,25a	Hango silty clay (H8)		'Eua	9143
26,26a	Houma silty clay loam		'Eua	9146
27a+	Kallau silty clay loam		'Eua	9149
28a+	Kenani clay		'Eua	9147

* Glasshouse studies only

\+ Chemical and particle size analysis only

PART 1. GLASSHOUSE EXPERIMENTS WITH GREEN PANIC ON SOME REPRESENTATIVE SOILS OF TONGA

INTRODUCTION

This section of the report presents the results of glasshouse experiments designed to assess the plant nutrient status of some representative Tongan soils. In this study the response of Green Panic, *Panicum maximum* var. *trichoglume* to the major nutrients, nitrogen, phosphorus, potassium, sulphur, and to the trace elements, molybdenum, boron, copper, zinc and manganese was examined using a subtractive technique. Green Panic was grown for four months under glasshouse conditions which simulated the climate of Tonga. The grass was harvested four times at intervals of three weeks, to a cutting height 10 cm above the soil surface.

The 6 treatments used on each soil are listed on the data sheets which follow. Grass undergoing the complete fertiliser treatment received all essential nutrients and was largely independent of nutrient supplies from the soil. In each of the 'subtracted' treatments all nutrients were supplied except one and plants were therefore dependent on the soil for this nutrient. The extent to which the growth of Green Panic is limited when a nutrient is left out provides a measure of the adequacy or deficiency of that particular nutrient in the soil.

This technique enables rapid diagnosis of immediate nutrient deficiencies and also determination of those nutrients that would become limiting after a period of intensive cropping. The results obtained from the study, supported by soil chemistry data, provide a sound basis for the planning of fertiliser experiments in the field. It must be emphasised, however, that the results obtained from these glasshouse experiments cannot be extrapolated to such crops as bananas, maize, tomatoes, etc. grown under field conditions. Field experiments will be needed to establish the magnitude of crop response to those nutrients diagnosed as being limiting for plant growth.

The representative soils examined in this study are listed in front of this report. Yields of Green Panic are given for each soil (Tables 1-26) in grams of dry matter per pot and also as a percentage of the yield from the complete fertiliser treatment. A chemical analysis for each of the soils is given in Part 2 of this report.

The technical assistance of H.M. Watts and F.W. Taylor in this study is acknowledged.

Table 2 Longomapu clay loam

TV 2/1, 2/2

Treatment	Yield of Green Panic			
	Topsoil 0-20 cm		Subsoil 20-45 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	10.0	100	3.6	100
" minus nitrogen	2.1	21	0.4	11
" " phosphorus	0.1	1	0.1	3
" " potassium	11.0	110	3.6	100
" " sulphur	8.2	82	3.6	100
" " trace elements	10.7	107	3.4	94

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

Table 4 Pangaimotu clay loam

SB 9166

Treatment	Yield of Green Panic			
	Topsoil 0-26 cm		Subsoil 26-47 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	4.5	100	1.8	100
" minus nitrogen	0.8	18	0.2	11
" " phosphorus	0.2	4	0.2	11
" " potassium	4.1	91	1.0	56
" " sulphur	2.8	62	1.2	67
" " trace elements	4.6	102	1.1	61

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

Table 5 Tu'anekevale clay loam

TV 3/1, 3/2

Treatment	Yield of Green Panic			
	Topsoil 0-20 cm		Subsoil 20-40 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	8.3	100	4.1	100
" minus nitrogen	1.6	19	0.3	7
" " phosphorus	0.1	1	0.1	2
" " potassium	6.7	81	3.9	95
" " sulphur	5.8	70	4.3	105
" " trace elements	7.3	88	5.2	127

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

Table 6 Felemea clay

SB 9179

Treatment	Yield of Green Panic			
	Topsoil 0-35 cm		Subsoil 35-65 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	12.7	100	13.0	100
" minus nitrogen	1.5	12	0.1	1
" " phosphorus	1.0	8	0.4	3
" " potassium	14.1	111	9.2	71
" " sulphur	3.4	27	4.0	31
" " trace elements	n.d.	n.d.	13.6	105

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

n.d. Not determined

Table 7 Foa clay (Foa)

SB 9175

Treatment	Yield of Green Panic			
	Topsoil 0-30 cm		Subsoil 30-65 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	11.9	100	10.7	100
" minus nitrogen	0.9	8	0.2	2
" " phosphorus	0.3	3	0.4	4
" " potassium	10.8	91	6.3	59
" " sulphur	2.0	17	3.0	28
" " trace elements	12.2	103	10.7	100

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

Table 8 Foa clay (Ha'ano)

SB 9186

Treatment	Yield of Green Panic			
	Topsoil 0-29 cm		Subsoil 29-51 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	11.5	100	8.5	100
" minus nitrogen	1.8	16	0.1	1
" " phosphorus	0.2	2	0.2	2
" " potassium	10.0	87	1.3	15
" " sulphur	2.5	22	2.8	33
" " trace elements	11.5	100	8.2	96

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

Table 9 Ha'afeva silt loam

SB 9176

Treatment	Yield of Green Panic			
	Topsoil 0-50 cm		Subsoil 50-80 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	12.2	100	9.8	100
" minus nitrogen	0.2	2	0.1	1
" " phosphorus	0.2	2	0.2	2
" " potassium	6.8	56	3.6	37
" " sulphur	1.0	8	0.6	6
" " trace elements	10.9	89	7.5	77

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

Table 10 Ha'apai clay (Nomuka)

SB 9172

Treatment	Yield of Green Panic			
	Topsoil 0-30 cm		Subsoil 30-60 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	9.6	100	8.2	100
" minus nitrogen	0.2	2	0.1	1
" " phosphorus	0.4	4	0.2	2
" " potassium	6.0	63	1.4	17
" " sulphur	1.4	15	1.8	22
" " trace elements	9.4	98	9.0	110

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

Table 11 Ha'apai clay (Lifuka)

SB 9181

Treatment	Yield of Green Panic			
	Topsoil 0-30 cm		Subsoil 30-60 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	12.9	100	8.1	100
" minus nitrogen	1.0	8	0.2	2
" " phosphorus	0.7	5	0.4	5
" " potassium	8.3	64	1.4	17
" ". sulphur	3.0	23	4.3	53
" " trace elements	13.0	101	6.2	77

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

Table 12 Lifuka clay

TH 1/1, 1/2

Treatment	Yield of Green Panic			
	Topsoil 0-20 cm		Subsoil 20-40 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	8.6	100	7.7	100
" minus nitrogen	1.2	14	0.3	4
" " phosphorus	0.1	1	0.1	1
" " potassium	8.4	98	4.4	57
" " sulphur	1.6	19	0.7	9
" " trace elements	9.3	108	8.2	106

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

Table 13 Mango clay

SB 9182

Treatment	Yield of Green Panic			
	Topsoil 0-15 cm		Subsoil [x]	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	10.4	100		
" minus nitrogen	0.2	2		
" " phosphorus	1.1	11		
" " potassium	9.3	89		
" " sulphur	2.3	22		
" " trace elements	8.3	80		

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

x No sample taken

Table 14 Nomuka clay

SB 9171

Treatment	Yield of Green Panic			
	Topsoil 0-30 cm		Subsoil 30-60 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	11.2	100	8.7	100
" minus nitrogen	0.6	5	0.1	1
" " phosphorus	0.3	3	0.1	1
" " potassium	8.4	75	0.8	9
" " sulphur	2.2	20	5.7	66
" " trace elements	11.7	104	8.4	97

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

Table 15 Uiha clay loam

SB 9177

Treatment	Yield of Green Panic			
	Topsoil 0-30 cm		Subsoil 30-70 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	14.6	100	10.2	100
" minus nitrogen	1.0	7	0.1	1
" " phosphorus	0.3	2	0.2	2
" " potassium	14.1	97	6.1	60
" " sulphur	2.6	18	1.7	17
" " trace elements	13.3	91	11.9	117

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

Table 16 Uoleva sandy loam

SB 9190

Treatment	Yield of Green Panic			
	Topsoil 2-12 cm		Subsoil 20-40 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	16.8	100	8.9	100
" minus nitrogen	2.5	15	0.4	4
" " phosphorus	14.8	88	1.7	19
" " potassium	15.5	92	8.2	92
" " sulphur	3.3	20	1.5	17
" " trace elements	15.1	90	6.8	76

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

Table 17 Lapaha clay

TT 2/1, 2/2

Treatment	Yield of Green Panic			
	Topsoil 0-20 cm		Subsoil 24-50 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	8.3	100	4.4	100
" minus nitrogen	0.6	7	0.3	7
" " phosphorus	3.9	47	0.1	2
" " potassium	6.4	77	3.2	73
" " sulphur	1.4	17	4.2	95
" " trace elements	8.6	104	4.0	91

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

Table 19 Nuku'alofa sandy loam

TT 3/1, 3/2

Treatment	Yield of Green Panic			
	Topsoil 0-30 cm		Subsoil 40-60 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	7.9	100	8.1	100
" minus nitrogen	0.7	9	0.3	4
" " phosphorus	0.7	9	0.1	1
" " potassium	6.1	77	5.0	62
" " sulphur	1.1	14	0.7	9
" " trace elements	5.6‡	71‡	2.5‡	31‡

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

‡ Minus zinc and molybdenum only

Table 20 Vaini clay

TT 1/1, 1/2

Treatment	Yield of Green Panic			
	Topsoil 0-22 cm		Subsoil 40-60 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	6.2	100	3.8	100
" minus nitrogen	0.4	6	0.2	5
" " phosphorus	2.5	40	0.2	5
" " potassium	6.7	108	4.1	108
" " sulphur	1.0	16	2.2	58
" " trace elements	6.1	98	4.8	126

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

Table 24 Hango silty clay (H54)

SB 9144

Treatment	Yield of Green Panic			
	Topsoil 0-12 cm		Subsoil 20-40 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	9.1	100	2.7	100
" minus nitrogen	1.2	13	0.3	11
" " phosphorus	1.1	12	0.2	7
" " potassium	8.7	96	1.2	44
" " sulphur	3.4	37	2.6	96
" " trace elements	9.2	101	3.0	111

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

Table 25 Hango silty clay (H8)

SB 9143

Treatment	Yield of Green Panic			
	Topsoil 0-20 cm		Subsoil 20-40 cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	14.5	100	2.3	100
" minus nitrogen	1.7	12	0.2	9
" " phosphorus	10.7	74	0.4	17
" " potassium	13.7	94	1.6	70
" " sulphur	3.7	26	2.0	87
" " trace elements	14.5	100	2.9	126

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

Table 26 Houma silty clay loam

SB 9146

Treatment	Yield of Green Panic			
	Topsoil 0-20 cm		Subsoil 20-40cm	
	Yield* (grams)	Yield+ (percent)	Yield* (grams)	Yield+ (percent)
Complete fertiliser	10.1	100	3.4	100
" minus nitrogen	1.0	10	0.3	9
" " phosphorus	0.4	4	0.2	6
" " potassium	10.5	104	3.4	100
" " sulphur	4.3	43	2.8	82
" " trace elements	10.8	107	3.5	103

* Yield of dry matter from 4 harvests (grams/pot)

\+ Yield of dry matter from 4 harvests expressed as a percentage of the yield of the complete fertiliser treatment

PART 2. CHEMICAL AND PARTICLE SIZE ANALYSES OF SOME REPRESENTATIVE SOILS OF TONGA

INTRODUCTION

This section of the report contains results of chemical and particle size analyses of samples collected during the soil survey of the Kingdom of Tonga in 1974 and 1975. In addition, it contains a table of chemical ratings used for New Zealand soils. These ratings are a guide only, and do not necessarily indicate that deficiencies will occur.

The analytical data were obtained by the methods described in Blakemore *et al.* (1972), "Soil Bureau Laboratory Methods" (New Zealand Soil Bureau Scientific Report 10A). Much fuller background information on the methods is contained in "Methods of Chemical Analysis for Soil Survey Samples" by A.J. Metson (Soil Bureau Bulletin 12, 1956).

NOTES ON METHODS AND INTERPRETATION

The following brief notes on the methods used and the significance of the results might be helpful.

pH

pH is measured with a glass electrode in a suspension of soil, with a soil to water ratio of 1 : 2.5. The pH of a soil is, in effect, a measure of the acid groups associated with clay and humus in the soil, and the extent to which they are neutralised by bases. Under conditions of strong leaching the soil becomes more acid (pH decreases) as the content of bases decreases. Conversely, in weakly leached soils and in soils derived from calcareous parent materials, the pH will be near neutral or even alkaline because of an excess of bases. pH is important in controlling the availability of nutrients to plants, and the optimum range for most plants is pH 6 to pH 7. This range also favours maximum soil biological activity, and thus maximum breakdown of organic matter.

Organic matter

Organic carbon (% C), total nitrogen (% N), and carbon/nitrogen ratio (C/N) are used to characterise the organic matter present.

Carbon is measured by a combustion method and nitrogen by a semi-micro Kjeldahl procedure. Both are expressed as a percentage; i.e. grams of carbon or nitrogen per 100 grams of oven-dry soil.

Soil organic matter is important as a reserve of nutrients, in holding soil moisture, and in the maintenance of soil structure. The quantity of organic matter present in a soil depends on the balance between the addition of raw organic matter, as plant or animal tissue, and its breakdown or mineralisation by soil organisms.

The state of decomposition is indicated by the C/N ratio. Raw (not well decomposed) organic matter has a ratio greater than 15 while well decomposed humus has a ratio of about 10 to 12.

Phosphorus

(a) Truog-phosphorus. This value is determined by shaking a sample of soil for 30 minutes with Truog reagent (0.001 M H_2SO_4 at pH 3). It gives a measure of the phosphorus that is immediately available to plants, except for soils which contain apatite (a calcium phosphate mineral which is readily soluble in Truog reagent but not readily available to plants).

(b) 0.5M H_2SO_4 - soluble phosphorus. This value gives an approximate measure of the amount of non-fixed inorganic phosphorus present in the soil, and so provides a measure of the reserve of phosphorus. It also gives an indication of the state of weathering in the soil as the proportion of inorganic phosphorus soluble in 0.5 M H_2SO_4 decreases with increasing weathering.

(c) Bondorff phosphorus. This value is determined by shaking the soil for 16 hours with 0.1 M H_2SO_4. It has been found that this extraction procedure gives results which have a higher correlation with plant yield (in pot experiments) than have most procedures in common use, e.g.Truog (McGaveston & Widdowson, unpublished data).

Truog-soluble, 0.5 M H_2SO_4-soluble, and Bondorff phosphorus are expressed as mg % P; i.e. milligrams (thousandths of a gram) of phosphorus per 100 grams of oven-dry soil.

Phosphate Retention (P ret. %)

This is an empirical measure of the ability of the soil to remove phosphate rapidly from solution, a process considered to be a precursor to the much slower process of phosphate fixation which renders phosphorus unavailable to plants (Blakemore *et al.* 1972). In acid soils (pH less than 6.5) phosphate is retained by amorphous compounds of iron and aluminium while in soils with pH greater than 6.5 the added phosphate can be retained by calcium.

The phosphate retention value gives an indication of the probable response of the soil to phosphatic fertilisers. A soil with high phosphate retention would be expected to give less response to the same amount of fertiliser than would a soil with low phosphate retention. Results are expressed as the percentage of added phosphate which is retained by the soil.

Cation Exchange

Cation exchange is a soil property related to the net negative charges on the surfaces of mineral and organic particles in the soil. These negative charges are balanced by positively charged cations which are exchangeable with other cations from the soil solution or from plant roots.

The properties which are related to cation exchange and which are measured in the analysis include cation-exchange capacity (CEC), total exchangeable bases (TEB), percentage base saturation (% BS) and exchangeable cations - Ca (calcium), Na (sodium), Mg (magnesium), and K (potassium). The exchangeable cations are measured after they have been replaced from the soil by neutral, molar ammonium acetate. CEC is measured by subsequent determination of the ammonium ions held by the soil.

CEC provides a measure of the number of cation-exchange sites available on soil particles. As cation exchange is essentially a surface reaction, it is a function mainly of the amount and type of small particle-size fractions present; i.e. clay and organic matter.

Σ cations (total cations) is the sum of all principal exchangeable cations (except hydrogen and aluminium) present in the soil.

% BS, calculated as $\frac{\Sigma \text{ cations}}{\text{CEC}} \times \frac{100}{1}$, provides a measure of the state of leaching of the soil, and is a useful indicator of fertility in that it gives a measure of the overall fraction of exchangeable cations present which are available to plants.

Individual cations. Exchangeable calcium, sodium, magnesium and potassium values represent the amounts of these elements present in exchangeable form, and this is considered to be the form which is immediately available to plants.

CEC, Σ cations, and individual cation levels are expressed as m.e.%; i.e. thousandths of an equivalent per 100 grams of oven-dry soil.

Mg_r value (Reserve magnesium)

This value represents the acid-soluble 'reserve' magnesium content of the soil and is calculated by determining the amount of magnesium soluble in boiling 1 M hydrochloric acid and subtracting the exchangeable magnesium value. Results are expressed as m.e.%. A level of 30 m.e.% has been tentatively suggested as being sufficient for New Zealand pastoral conditions.

K_c (Reserve potassium)

Reserve potassium is a value proposed by A.J. Metson in 1956 to represent the long-term potassium-supplying power of the soil. The K_c value is obtained by successive extractions with boiling, 1 M nitric acid and represents the nearly constant rate of release of potassium from the lattices of clay minerals (particularly illite) in the soil. Results for K_c are expressed as m.e.%. A value of 0.3 m.e.% is taken as the boundary between adequate and inadequate reserves of potassium under New Zealand pastoral conditions. Results for K_c are expressed as m.e.%.

Adsorbed Sulphur (Ads.S)

This is sulphate which is retained by the soil and which, while not soluble in water, is replaceable by other chemicals. Measurements are expressed as p.p.m. S; i.e. grams of sulphur per million grams of

oven-dry soil. Such sulphate is considered to be available to plants and, in pasture, less than 10 p.p.m. of adsorbed sulphur (as sulphate) in the soil is thought to lead to sulphur-deficiency. The adsorbed sulphur is held mainly by forms of aluminium which adsorb more efficiently under acid conditions. For this reason, acid soils usually have high contents of adsorbed sulphur. Unfortunately, this means that soils of high base status and otherwise high nutrient status are usually sulphur-deficient.

Particle-size Analyses

These were carried out using ultrasonic dispersion with sodium hexametaphosphate, followed by measurement by the "falling drop" technique. Particles less than 0.002 mm (< .002 mm) in size are referred to as *clay*; those between 0.002 and 0.02 mm as *silt*; those between 0.02 and 0.2 mm as *fine sand*; those between 0.2 and 2 mm as *coarse sand* and those greater than 2 mm (> 2 mm) as *stones*.

Results are expressed as % ; i.e. grams per 100 grams of oven-dry soil.

RATINGS FOR CHEMICAL PROPERTIES

The following ratings of chemical properties are used by Soil Bureau for New Zealand soils:

RATING	Phosphorus			P retention (%)	Tamm oxalate		Adsorbed SO_4 (ppm S)
	Truog (mg %)	0.5M H_2SO_4 (mg %)	Bondorff (0.1M H_2SO_4) (mg %)		Al (%)	Fe (%)	
Very high	> 5	> 40	> 10	90-100	> 3.0	> 2.0	> 150
High	3-5	20-40	5-10	60-90	1.0-3.0	1.0-2.0	50-150
Medium	2-3	10-20	2-5	30-60	0.5-1.0	0.5-1.0	15-50
Low	1-2	5-10	1-2	10-30	0.2-0.5	0.2-0.5	5-15
Very low	< 1	< 5	< 1	0-10	< 0.2	< 0.2	< 5

RATING	Organic C (%)	Total N (%)	C/N	pH (1:2.5 soil:water)
Very high	> 20	> 1.0	> 24	) > 9.0 (extremely alkaline)) 8.4-9.0 (strongly ")) 7.6-8.3 (moderately ")
High	10-20	0.6-1.0	16-24	) 7.1-7.5 (slightly ")) 6.6-7.0 (near neutral)
Medium	4-10	0.3-0.6	12-16	) 6.0-6.5 (slightly acid)) 5.3-5.9 (moderately ")
Low	2-4	0.1-0.3	10-12	4.5-5.2 (strongly ")
Very low	< 2	< 0.1	< 10	< 4.5 (extremely ")

RATING	Cation-Exchange Properties							Reserve	
	CEC (me.%)	Σ Cat (me.%)	BS (%)	Ca (me.%)	Mg (me.%)	K (me.%)	Na (me.%)	Mg_r (me.%)	K_c (me.%)
Very high	> 40	> 25	80-100	> 20	> 6	> 1.2	> 2	> 30	> 0.50
High	25-40	15-25	60-80	10-20	3-6	0.8-1.2	0.7-2	15-30	0.35-0.50
Medium	12-25	7-15	40-60	5-10	1-3	0.5-0.8	0.3-0.7	7-15	0.20-0.35
Low	6-12	3-7	20-40	2-5	0.3-1	0.3-0.5	0.1-0.3	3-7	0.10-0.20
Very low	< 6	< 3	< 20	< 2	< 0.3	< 0.3	< 0.1	< 3	< 0.10

Table 1a Hunga clay

SB 9153 A-C

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-20	A_1	6.5	5.6	37.2	27.8	75	18.3	0.26	8.4	0.81	7.6	0.12
30-40	B_1	7.1	6.0	30.7	21.1	69	11.9	1.26	6.3	1.59		0.04
50-70	B_2	6.4	5.6	27.8	19.8	71	9.6	3.1	6.9	0.22	5.3	

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Bondorff	Truog	P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur* (ppm) Ads.
0-20	4.0	0.30	3	0.7		70						5
30-40	0.7	0.09	2	0.1		81						49
50-70	0.4	0.04	2	0.3		74						248

*Results of single analysis.

Analysts: M. Cullinane, D.McGaveston

Table 2a Longomapu clay loam TV 2/1, 2/2

Depth (cm)	Horizon	pH(1:2.5)		Cation Exchange Capacity (me%)							Reserve(me%)	
		H_2O	$CaCl_2$	CEC	Σ Cat	% BS	Ca	Na	Mg	K	Mg_r	K_c
0-20		6.0		38.5	28.0	73	15.6	0.36	9.1	3.00	3.6	0.20
20-45		5.9		27.0	15.7	58	6.2	1.66	5.2	2.68	3.9	0.12

Depth (cm)	Organic Matter		Phosphorus (mg%)				Particle Size Analysis %					Sulphur (ppm)	
	C %	N %	Total	0.5M H_2SO_4	Truog	P Ret%	<0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	>2.0 mm	Ads.	
0-20		0.41		9	0.9							42	
20-45		0.14		8	0.6							330	

Analysts: E.J. Gibson, D. McGaveston

Table 3a Neiafu clay loam SB 9165 A-E

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-30	A_{1p1}	6.0	5.3	26.9	19.8	74	14.3	0.22	4.4	0.83	3.4	0.07
30-55	A_{1p2}	6.4	5.5	22.2	13.2	59	9.7	0.37	3.0	0.11		0.06
65-75	B_{21}	6.4	5.6	23.2	15.4	66	10.7	1.80	2.79	0.07	3.4	
82-93	B_{22}	6.3	5.5	22.1	14.1	64	9.8	1.94	2.36	0.04		
98-112	B_3	6.2	5.5	21.7	12.9	59	8.8	2.00	2.02	0.05		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Bondorff	Truog	P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur* (ppm) Ads.
0-30	3.4	0.31	15	4		62	74	22	3	1	0	0
30-55	1.0	0.13	15	5		68	76	20	4	0	0	23
65-75	0.4	0.05	27	11		71	83	14	3	0	0	118
82-93	0.2	0.03	37	14		72	82	13	5	0	0	185
98-112	0.2	0.04	38	15		69	86	12	2	0	0	188

*Results of single analysis.

Analysts: M. Cullinane, D. McGaveston, J. McCarten

Table 4a Pangaimotu clay loam SB 9166 A-E

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-21	A_1	5.7	5.2	26.5	16.3	62	11.9	0.36	3.8	0.22	3.4	0.06
29-41	B_1	6.1	5.6	22.5	13.5	60	9.7	1.27	2.25	0.26		0.03
49-70	B_{21}	6.5	5.7	23.0	14.7	64	10.2	1.91	2.54	0.06	3.4	
77-88	B_{22}	6.3	5.6	22.2	14.0	63	9.4	2.01	2.44	0.10		
96-120	B_3	6.1	5.4	19.9	12.3	62	8.0	2.04	2.18	0.04		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Bondorff	Truog	P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur* (ppm) Ads.
0-21	3.6	0.34	7	2		66	75	17	6	2	0	3
29-41	0.7	0.09	15	5		75	90	8	2	0	0	45
49-70	0.3	0.05	31	11		74	82	14	4	0	0	114
77-88	0.4	0.04	32	13		72	89	8	3	0	0	145
96-120	0.3	0.03	29	11		72	89	8	3	0	0	278

*Results of single analysis.

Analysts: M. Cullinane, D. McGaveston, J. McCarten

Table 5a Tu'anekavale clay loam TV 3/1, 3/2

Depth (cm)	Horizon	pH (1:2.5)		Cation Exchange Capacity (me%)							Reserve (me%)	
		H_2O	$CaCl_2$	CEC	Σ Cat	% BS	Ca	Na	Mg	K	Mg_r	K_c
0-20		5.9		27.8	18.9	68	12.0	0.85	5.4	0.76	1.5	0.09
20-40		6.4		17.2	11.9	69	7.0	1.24	3.2	0.49	0.3	0.05

Depth (cm)	Organic Matter		Phosphorus (mg%)				Particle Size Analysis %					Sulphur (ppm)	
	C %	N %	Total	0.5M H_2SO_4	Truog	P Ret%	<0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	>2.0 mm	Ads.	
0-20		0.38		3	1							30	
20-40		0.16		2	1							53	

Analysts: E.J. Gibson, D. McGaveston

Table 6a Felemea clay

SB 9179 A-D

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-10	A_{11}	6.7	6.0	42.9	37.6	88	22.8	0.75	12.5	1.51	16	0.41
15-35	A_{12}	7.1	5.8	41.8	35.4	85	20.8	1.18	12.7	0.71		
40-70	B_{2g}	7.0	6.0	60.2	57.5	96	34	3.9	18.9	0.67	16	0.35
75-95	C_{fec}	7.2	6.1	43.0	38.8	90	23.1	4.5	10.9	0.30		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Bondorff	Truog	P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur* (ppm) Ads.
0-10	3.5	0.35	8	4		29						1
15-35	0.8	0.10	6	2		46						0
40-70	0.5	0.07	10	2		49						3
75-95	0.2	0.03	5	2		57						4

*Results of single analysis. Analysts: K. Giddens, D. McGaveston

Table 7a Foa clay (Foa)

SB 9175 A-E

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-10	A_{11}	7.1	6.5	56.4	55.5	98	38	0.42	15.0	2.10	16	0.17
15-30	A_{12}	7.2	6.3	42.6	35.8	84	23.2	0.55	10.9	1.18		
45-70	B_{2cy}	7.4	6.3	49.9	39.1	78	24.0	2.99	11.9	0.16	16	0.06
85-105	B_3	7.2	6.5	46.5	43.6	94	28.4	3.4	11.7	0.12		
110-130	C	7.1	5.9	47.6	42.5	89	31	3.7	7.7	0.12		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Bondorff	Truog	P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur* (ppm) Ads.
0-10	4.8	0.37	20	7		52						1
15-30	1.1	0.14	14	3		60						1
45-70	0.4	0.06	9	2		67						3
85-105	0.2	0.04	10	1		72						5
110-130	0.2	0.04	9	1		70						1

*Results of single analysis. Analysts: K. Giddens, D. McGaveston.

Table 8a Foa clay (Ha'ano) SB 9186 A-F

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-29	A_{11}	6.2	5.5	43.4	36.9	85	24.8	0.86	11.0	0.26	14	0.19
29-51	A_{12}	7.1	5.8	43.3	38.6	89	26.2	1.19	11.0	0.22		0.19
51-65	B_1	7.2	5.9	49.9	40.3	81	26.8	2.64	10.7	0.13	14	
65-116	B_{2cy}	7.2	6.0	53.0	46.3	87	32.9	2.83	10.5	0.10		
116-145	C	7.2	5.9	46.0	38.5	84	29.5	1.28	7.6	0.10		
147-160	IIC	7.0	6.0	47.3	44.0	93	34	2.17	7.7	0.15		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Bondorff	Truog	P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur* (ppm) Ads.
0-29	2.0	0.18	9	1		68						1
29-51	1.1	0.12	8	1		65						0
51-65	0.4	0.07	8	0.9		77						1
65-116	0.2	0.03	7	0.9		78						1
116-145	0.1	0.02	6	0.8		67						3
147-160	0.3	0.04	3	0.3		55						16

*Results of single analysis.

Analysts: M. Cullinane, D. McGaveston

Table 9a Ha'afeva silt loam SB 9176 A-E

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-15	A_1	7.2	6.4	31.9	30.7	96	19.2	0.62	10.4	0.50	13	0.16
20-40	A_{12}	7.4	6.4	27.1	27.4	(100)	18.1	0.66	8.4	0.20		
50-65	A_3	7.7	6.3	45.7	43.6	95	29.9	2.83	10.7	0.16		
65-80	(B)	7.7	6.4	41.5	39.7	96	27.2	3.2	9.2	0.14	12	0.09
85-100	C	7.6	6.3	48.3	46.1	96	32	3.8	10.2	0.11		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Bondorff	Truog	P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur* (ppm) Ads.
0-15	1.2	0.11	7	2		51						1
20-40	0.8	0.05	5	2		41						1
50-65	0.3	0.04	5	0.9		55						1
65-80	0.2	0.03	4	0.8		54						1
85-100	0.2	0.02	7	0.9		56						1

* Results of single analysis.

Analysts: A. Hall, V. Vortman, D. McGaveston

Table 11a Ha'apai Clay (Lifuka)

SB 9181 A-E

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-5	A_{11}	6.1	5.5	42.7	34.2	80	22.2	0.70	10.8	0.50	15	0.14
5-30	A_{12}	6.9	5.7	39.7	35.5	89	23.6	0.88	10.8	0.19	14	0.13
36-70	B_{2cy}	7.1	5.9	34.0	27.5	81	16.4	3.2	7.8	0.10		
80-100	B_{3cy}	6.9	5.7	34.4	28.8	84	19.3	3.2	6.2	0.08		
105-120	C_{cy}	6.9	5.8	36.6	31.5	86	22.5	3.2	5.7	0.08		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Bondorff	Truog	P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur (ppm) Ads.
0-5	2.9	0.27	10	2		66						1
5-30	1.8	0.16	8	1		63						1
36-70	0.7	0.07	3	0.6		63						13
80-100	0.4	0.04	3	0.4		65						32
105-120	0.4	0.04	3	0.4		64						13

*Results of single analysis.

Analysts: A. Hall, V. Vortman, D. McGaveston

Table 12a Lifuka clay

TH 1/1, 1/2

Depth (cm)	Horizon	pH(1:2.5)		Cation Exchange Capacity (mc%)							Reserve(me%)	
		H_2O	$CaCl_2$	CEC	Σ Cat	% BS	Ca	Na	Mg	K	Mg_r	K_c
0-20		6.4		41.1	34.2	83	23.1	0.66	10.0	0.57	21	0.34
20-40		7.2		36.4	33.5	92	22.8	0.83	9.6	0.25	23	0.34

Depth (cm)	Organic Matter		Phosphorus (mg%)				Particle Size Analysis %					Sulphur (ppm)	
	C %	N %	Total	0.5M H_2SO_4	Truog	P Ret%	<0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	>2.0 mm	Ads.	
0-20		0.23		11	0.5							4	
20-40		0.11		11	0.4							3	

Analysts: E.J. Gibson, D. McGaveston

Table 13a Mango clay

SB 9182 A-B

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-15	A_1	7.0	5.9	91.0	90.8	100	58	1.16	30.8	0.81	113	0.88
15-38	C_1	7.3	5.9	92.9	91.7	99	58	1.73	31.5	0.50	136	0.78

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Bondorff	Truog	P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur* (ppm) Ads.
0-15	2.9	0.22	7	3		41						10
15-38	0.4	0.03	4	1		43						1

*Results of single analysis.

Analysts: A. Hall, V. Vortman, D. McGaveston

Table 14a Nomuka Clay SB 9171 A-E

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-10	A_{11}	6.5	5.8	54.2	48.1	89	31	0.88	15.3	0.96	15.7	0.19
12-20	A_{12}	6.9	5.8	49.8	40.6	82	28.5	1.28	10.5	0.29		0.16
30-50	B_1	7.1	5.9	50.4	43.0	85	30	2.78	10.1	0.14	15.8	
60-80	B_{2cy}	7.1	5.8	51.0	43.9	86	29.4	3.4	11.0	0.11		
90-110	C	7.0	5.8	45.9	38.3	83	25.8	4.4	8.0	0.07		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Bondorff	Truog	P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	*Sulphur (ppm) Ads.
0-10	4.1	0.35	12	3		64						2
12-20	2.1	0.19	11	2		66						1
30-50	0.5	0.07	7	1		77						1
60-80	0.2	0.04	5	0.9		78						27
90-110	0.2	0.03	7	0.8		69						27

*Results of single analysis.

Analysts: M. Cullinane, D. McGaveston

Table 15a Uina clay loam

SB 9177 A-E

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-10	A_{11}	6.6	5.8	35.5	30.7	87	16.2	0.97	11.8	1.69	14	0.21
15-25	A_{13}	7.1	6.0	33.9	29.7	88	16.1	1.19	11.4	0.97		
30-50	A_3	7.3	6.2	36.3	33.7	93	20.6	1.78	10.9	0.39		
50-70	B_2	7.5	6.3	44.9	41.6	93	25.0	4.8	11.6	0.24	16	0.09
87-107	C	7.5	6.4	44.3	42.3	96	26.4	4.2	11.6	0.12		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Bondorff	Truog	P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur* (ppm) Ads.
0-10	2.7	0.23	12	3		61						1
15-25	1.4	0.12	11	2		54						1
30-50	0.9	0.09	11	2		59						1
50-70	0.5	0.06	11	2		67						1
87-107	0.2	0.03	11	2		60						1

* Results of single analysis. Analysts: A. Hall, V. Vortman, D. McGaveston.

Table 17a Lapaha clay TT 2/1, 2/2

Depth (cm)	Horizon	pH(1:2.5)		Cation Exchange Capacity (me%)							Reserve(me%)	
		H_2O	$CaCl_2$	CEC	Σ Cat	% BS	Ca	Na	Mg	K	Mg_r	K_c
0-20		7.5		46.1	43.8	95	38	0.33	4.7	1.30	8.7	0.14
24-50		7.3		32.3	22.9	71	17.5	1.56	3.7	0.21	3.4	0.04

Depth (cm)	Organic Matter		Phosphorus (mg%)				Particle Size Analysis %					Sulphur (ppm)	
	C %	N %	Total	0.5M H_2SO_4	Truog	P Ret%	<0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	>2.0 mm	Ads.	
0-20		0.23		44	1							7	
24-50		0.07		13	0.7							53	

Analysts: E.J.Gibson, D. McGaveston

Table 18a Lapaha clay, easy rolling phase SB 9168 A-E

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-20	A_p	6.0	5.2	41.2	28.1	68	21.3	0.48	6.0	0.30	7.3	0.10
21-36	A_{12}	6.7	5.4	44.1	31.9	72	24.9	0.64	6.2	0.14		
41-68	B_{21}	7.1	5.9	28.4	22.4	79	16.7	1.88	3.7	0.07	5.7	0.03
70-100	B_{22}	7.2	6.1	28.8	22.3	78	16.9	2.39	3.0	0.05		
109-119	IUA_1	7.6	6.5	37.9	35.9	95	31	1.76	2.96	0.14		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Bondorff	Truog	P Ret.%	Particle Size Analysis ≤0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur* (ppm) Ads.
0-20	3.0	0.25	18	3		69						1
21-36	2.4	0.18	20	3		73						1
41-68	0.4	0.06	9	2		69						22
70-100	0.4	0.05	13	3		70						40
109-119	0.9	0.11	16	3		70						1

*Results of single analysis. Analysts: A. Hall, D. McGaveston.

Table 19a Nuku'alofa sandy loam TT 3/1, 3/2

Depth (cm)	Horizon	pH(1:2.5)		Cation Exchange Capacity (me%)							Reserve (me%)	
		H_2O	$CaCl_2$	CEC	Σ Cat	% BS	Ca	Na	Mg	K	Mg_r	K_c
0-30		7.9		30.7	- Free	lime	-	0.53	1.7	0.71	22	0.06
40-60		8.7		2.0	- Free	lime	-	0.36	2.7	0.17	32	

Depth (cm)	Organic Matter		Phosphorus (mg%)				Particle Size Analysis %					Sulphur (ppm)	
	C %	N %	Total	0.5M H_2SO_4	Truog	P Ret%	<0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	>2.0 mm	Ads.	
0-30		0.32		116	5							9	
40-60		0.05		15	1							20	

Analysts: E.J.Gibson, D. McGaveston

Table 20a Vaini clay

TT 1/1, 1/2

Depth (cm)	Horizon	pH(1:2.5)		Cation Exchange Capacity (me%)							Reserve (me%)	
		H_2O	$CaCl_2$	CEC	Σ Cat	% BS	Ca	Na	Mg	K	Mg_r	K_c
0-30		6.3		45.9	34.2	75	26.1	0.46	5.0	2.44	6.9	0.36
35-65		7.1		44.4	33.5	76	25.6	0.88	4.4	2.64	7.9	0.21

Depth (cm)	Organic Matter		Phosphorus (mg%)				Particle Size Analysis %					Sulphur (ppm)	
	C %	N %	Total	0.5M H_2SO_4	Truog	P Ret%	<0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	>2.0 mm	Ads.	
0-30		0.26		77	1							2	
35-65		0.12		38	0.7							9	

Analysts: E.J.Gibson, D. McGaveston

Table 21a Vaini shallow clay SB 9167 A-H

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-18	A_p	6.5	5.8	51.3	43.1	84	33	0.48	9.4	0.23	8.9	0.10
22-30	A_{12}	6.7	6.0	45.8	38.6	84	29.3	0.59	8.6	0.14		
37-45	B_{21}	7.1	6.2	41.5	33.7	81	23.0	1.77	8.8	0.08	10.0	0.05
62-80	B_{22}	7.0	6.1	41.4	32.5	79	20.8	2.80	8.8	0.07		
88-96	IUA	6.8	5.8	30.9	23.2	75	15.3	3.4	4.5	0.04		
100-125	IUB_{21}	6.6	5.5	26.6	19.1	72	12.8	3.6	2.71	0.03		
138-151	IUB_{22}	6.5	5.4	27.8	19.9	72	15.1	3.3	1.49	0.04		
160-170	$2UA_1$	7.2	6.4	38.4	34.2	89	30	2.36	1.73	0.08		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Phosphorus (mg.%) Bondorff	Phosphorus (mg.%) Truog	Phosphorus (mg.%) P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur* (ppm) Ads.
0-18	4.5	0.36	32	6		69	64	22	12	2	0	1
22-30	2.6	0.23	23	3		73	60	32	6	2	0	1
37-45	0.6	0.08	17	3		83	74	20	6	0	0	7
62-80	0.4	0.05	24	5		84	66	31	3	0	0	8
88-96	0.3	0.04	17	3		75	77	20	3	0	0	52
100-125	0.2	0.04	12	3		67	82	12	6	0	0	92
138-151	0.3	0.04	18	11		66	81	16	3	0	0	82
160-170				12		76						7

* Results of single analysis. Analysts: A. Hall, D. McGaveston, J. McCarten

Table 22a Faitoka clay loam

SB 9145 A-D

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-20	A_1	6.5	6.1	40.5	37.0	91	26.4	0.25	8.5	1.83	5.8	0.05
24-38	B_1	6.4	5.6	26.3	19.3	73	11.3	2.54	5.4	0.09	3.8	0.04
42-56	B_{21}	6.1	5.3	28.1	19.3	69	12.3	3.6	3.3	0.05		
60-80	B_{22}	7.2	6.3	30.4	25.7	85	20.1	3.3	2.21	0.06		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Bondorff	Truog	P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur* (ppm) Ads.
0-20	4.8	0.44	6	1		59						0
24-38	0.9	0.13	2	0.5		63						82
42-56	0.6	0.09	2	0.5		78						102
60-80	0.7	0.10	2	0.2		80						78

* Results of single analysis. Analysts: K. Giddens, D. McGaveston

Table 23a Ha'atua clay loam SB 9148 A-E

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-16	A_1	6.9	6.5	37.5	38.8	(100)	28.9	0.41	8.4	1.09	8.9	0.07
20-34	B_1	6.4	5.6	23.3	14.9	64	7.4	2.59	4.8	0.09	3.9	0.04
38-58	B_2	5.8	5.0	22.4	14.9	67	6.4	4.2	4.3	0.06		
58-78	B_{22}	5.8	4.9	21.8	13.5	62	5.5	3.9	4.1	0.04		
82-100	B_3	5.8	4.9	21.7	13.5	62	5.8	4.1	3.6	0.04		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Phosphorus (mg.%) Bondorff	Phosphorus (mg.%) Truog	Phosphorus (mg.%) P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur* (ppm) Ads.
0-16	4.6	0.37	10	3		67	78	18	2	2	0	0
20-34	0.8	0.11	6	2		77	86	10	4	0	0	110
38-58	0.6	0.06	10	4		76	94	4	2	0	0	327
58-78	0.4	0.05	15	7		73	96	2	2	0	0	319
82-100	0.4	0.04	21	10		75	95	3	2	0	0	308

*Results of single analysis.

Analysts: K. Giddens, D. McGaveston, J. McCarten

Table 24a Hango silty clay (H54) SB 9144 A-E

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-12	A_1	6.5	5.8	38.1	32.3	85	22.0	0.40	9.6	0.34	4.7	0.07
17-29	B_1	6.0	5.0	26.7	17.0	64	8.8	1.73	6.2	0.27	4.4	0.05
32-55	B_{21}	5.8	4.7	23.3	14.9	64	7.9	2.89	4.1	0.03		
55-78		6.1	5.2	22.4	15.3	68	8.9	3.4	3.0	0.04		
82-100	B_{22}	6.2	5.5	22.3	15.1	68	9.8	3.2	2.11	0.03		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Bondorff	Truog	P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur* (ppm) Ads.
0-12	4.0	0.38	5	2		60	65	29	4	2	0	1
17-29	1.4	0.20	3	1		75	86	10	4	0	0	100
32-55	0.6	0.10	3	2		73	92	6	2	0	0	302
55-78	0.5	0.08	7	2		77	92	6	2	0	0	152
82-100	0.4	0.08	8	4		74	90	8	2	0	0	102

*Results of single analysis.

Analysts: K. Giddens, D. McGaveston, J. McCarten

Table 25a Hango silty clay (H8) SB 9143 A-D

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-23	A_1	7.0	6.9	61.2	67.0	(100)	58	0.31	7.8	0.88	11	0.16
31-37	B_1	7.7	6.9	34.9	34.3	98	28.7	0.77	4.7	0.14		0.05
39-64	B_{21}	7.7	6.9	32.9	30.1	91	25.4	1.28	3.3	0.10	5.7	
66-100	B_{22}	7.7	6.8	29.2	26.1	89	22.3	1.86	1.91	0.05		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Bondorff	Truog	P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur* (ppm) Ads.
0-23	6.0	0.52	125	72		62	69	19	5	3	4	1
31-37	1.0	0.15	8	2		68	92	8	0	0	0	1
39-64	0.6	0.11	9	2		72	90	8	2	0	0	1
66-100	0.5	0.11	8	3		67	91	6	3	0	0	13

*Results of single analysis.

Analysts: M. Cullinane, D. McGaveston, J. McCarten

Table 26a Houma silty clay loam SB 9146 A-F

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-9	A_1	5.9	5.1	35.6	23.4	66	16.3	0.28	5.8	0.99	5.9	0.19
11-20	A_3	6.3	5.1	27.7	17.4	63	9.2	0.48	6.6	1.09		
22-44	B_1	5.8	5.0	24.9	15.6	63	7.1	1.63	6.1	0.72	3.8	0.09
46-59	B_{21}	5.9	5.2	23.8	15.8	66	7.1	2.70	5.8	0.15		
67-79	B_{22}	5.9	5.4	18.7	13.3	71	6.7	2.45	4.0	0.17		
81-100	B_3	6.0	5.6	16.0	12.2	76	6.0	2.36	3.6	0.21		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Bondorff	Truog	P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur* (ppm) Ads.
0-9	4.6	0.37	4	0.9		62	51	36	10	3	0	2
11-20	1.5	0.16	3	0.6		71	65	28	6	1	0	1
22-40	0.8	0.11	4	0.4		84	86	13	1	0	0	196
46-59	0.6	0.08	3	0.8		88	85	11	4	0	0	224
67-79	0.6	0.07	2	0.8		70	90	5	5	0	0	128
81-100	0.4	0.11	3	2		76	95	4	1	0	0	122

*Results of single analysis.

Analysts: K. Giddens, D. McGaveston, J. McCarten

Table 27a Kallau silty clay loam

SB 9149 A-C

Depth (cm)	Horizon	pH(1:2.5) H_2O	pH(1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-15	A_1	6.2	5.4	36.9	27.2	68	17.0	0.87	8.9	0.43	4.2	0.07
20-35	B_1	5.6	4.9	15.2	9.1	60	2.7	1.72	4.6	0.11	1.8	0.04
45-55	B_2	5.3	4.6	21.2	10.4	49	2.9	3.0	4.3	0.22		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Bondorff	Truog	P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	*Sulphur (ppm) Ads.
0-15	5.0	0.38	16	4		75						10
20-35	0.6	0.06	14	11		71						305
45-55	0.8	0.09	16	6		82						433

*Results of single analysis.

Analysts: K. Giddens, D. McGaveston

Table 28a Kenani clay

SB 9147 A-C

Depth (cm)	Horizon	pH (1:2.5) H_2O	pH (1:2.5) $CaCl_2$	Cation Exchange Capacity (me.%) CEC	Σ Cat	%BS	Ca	Na	Mg	K	Reserve (me.%) Mg_r	Reserve (me.%) K_c
0-10	A	6.9	6.1	74.2	72.7	98	50	0.47	21.1	1.08	32	0.30
12-44	B_2	6.5	5.5	62.7	57.1	91	32	0.85	23.3	0.95	50	0.41
46-60	C	6.4	5.4	62.2	58.1	93	33	0.78	23.9	0.42		

Depth (cm)	Organic Matter C%	Organic Matter N%	Phosphorus (mg.%) 0.5M H_2SO_4	Phosphorus (mg.%) Bondorff	Phosphorus (mg.%) Truog	Phosphorus (mg.%) P Ret.%	Particle Size Analysis <0.002 mm	0.002-0.02	0.02-0.2	0.2-2.0	> 2.0 mm	Sulphur (ppm) Ads.
0-10	7.8	0.51	69	38		48	63	30	6	1	0	1
12-44	0.6	0.07	14	8		54	65	27	8	0	0	3
46-60	0.4	0.05	9	5		54	46	44	10	0	0	36

*Results of single analysis.

Analysts: K. Giddens, D. McGaveston, J. McCarten