Technical Paper 8

LABORATORY METHODS AND DATA EXCHANGE PROGRAM FOR SOIL CHARACTERIZATION

A REPORT ON THE PILOT ROUND

PART II: Exchangeable bases, Base saturation and pH

L.P. van Reeuwijk

1984

INTERNATIONAL SOIL REFERENCE AND INFORMATION CENTRE

Wageningen - The Netherlands

CONTENTS

ABSTRACT 1

1. INTRODUCTION 1

2. MATERIALS AND METHODS 2
   2.1 Soils 2
   2.2 Data processing 2

3. RESULTS AND DISCUSSION 3
   3.1 Soils 3
   3.2 Laboratories 6
   3.3 Classification aspects 8
   3.4 Analytical procedures 9

4. CONCLUSIONS 12

REFERENCES 12

ACKNOWLEDGEMENT 12

ANNEX:

TABLE 1. Description of reference samples A-1
TABLE 2. Analytical results A-2
TABLE 3. Analysis of variance of the DATA per SOIL A-5
TABLE 4. Analysis of variance of % DEVIATIONS vs. SOILS A-8
TABLE 5. Analysis of variance of % DEVIATIONS vs. LABORATORIES A-11

APPENDIX 1a. Methods for Exchangeable bases A-14
APPENDIX 1b. Methods for pH determination A-15

APPENDIX 2. List of participating laboratories A-16

ABSTRACT

In this report, the data of twenty laboratories from all continents, that analyzed ten reference soil samples on exchangeable bases, base saturation and pH, have been examined. As was found in an earlier study on CEC and texture, these parameters showed a large variability in data. This depended only to a limited extent on the soil type but accuracy and precision varied widely between laboratories. This strongly points to the need for standardization of analytical procedures. The results also indicate that such standardization is feasible but that a certain level of variability has to be accepted and accounted for in the application of taxonomic criteria. These estimated levels are: ± 10% relative for base saturation and ± 0.2 unit for pH values.

1. INTRODUCTION

The first report on the pilot round of ISRIC's[1] Laboratory Methods and Data Exchange Program (Techn. Report 6, henceforth referred to as Part I) dealt with data variability of two important parameters used in soil classification: CEC and texture. In addition to these analyses many participating laboratories produced data of other parameters notably exchangeable bases and pH. These data were considered to give a useful additional illustration of the variability of laboratory results.

---

1 International Soil Reference and Information Centre, the new name for the former International Soil Museum.

2. MATERIALS and METHODS

2.1 Soils

The soil samples used are listed in Table 1, a more extensive description was given in Part I.

2.2 Data Processing

Because the values of exchangeable Na and K, with some exceptions, were generally very low, statistical treatment of these data was not considered useful for the present purpose.

Seven laboratories produced exchangeable cation data with one decimal, nine with two decimals and four with a mixture of one and two. Seventeen labs produced pH values with one decimal, only three gave two decimals. For consistency, we used data with one decimal and rounded off those with two. Only in a few cases of very low values of exchangeable Ca and Mg this has led to a somewhat inaccurate calculation of the proportional deviation from the mean (in the computations, the mean was not rounded off). Although the values for exchangeable Na and K were not treated statistically, they were of course included in the calculation of the base saturation values.

One laboratory (9) produced data of exchangeable Mn. For most soils the values were less than 0.1 me/100 g. However, for soils 2 and 3 the values were 0.2 and 0.4 me/100 g respectively which corresponds with 4% and 22% of the respective CEC values indicating that in some soils this cation may be of significance. For consistency these values were excluded here.

As in Part I, statistical treatment of the data consisted of analyses of variance using computer programs from the SPSS (Nie et al, 1975) with the following particulars:

We are dealing with two variables:

1. **Soils** (sample difference)
2. **Laboratories** (different methods of analysis)

of which the "significance" has to be tested for each soil parameter. In other words, are the soils statistically different (this was aimed at by selecting them) and do the laboratories produce statistically different results? (which was suspected and, in fact, reason for the study).

The print-out of the used program gives useful additional information:

- means of the tested variable
- standard deviation of these means (a measure of the variability or "noise" of the set of data from which the mean was calculated)
- standard error = the standard deviation divided by the square root of the number of counts
- minimum and maximum values of the set of data
- 95% confidence interval for the mean. These are the bounds of uncertainty about the mean caused by the variability of data (= mean ± ca. 2x standard error)
- F-ratio, an expression of the significance of the test. The higher the F-ratio, the greater the significance

The data of the soil parameters are presented in Table 2, left-hand side. For convenience of the reader, in Tables 4 and 5 the most important columns of the print-outs have been outlined.

3. RESULTS and DISCUSSION

3.1 Soils

Table 3 gives the analysis of variance of the data per soil. As was found for the CEC and texture in Part I, the set of soils gives significant differences for the present parameters. The columns "mean" give the average values of the parameters as they were determined by all laboratories. These values, also represented in data Table 2, are used as reference values in this study. For the justification of this, the reader is referred to Part I, p. 4.

The standard deviations of these means, giving an indication of the variation of the data (how "difficult" a soil is in the analysis), cannot be compared directly since their magnitude depends on the magnitude of the means and these are all different. A convenient way to eliminate this problem is to use the proportional (%) deviations from the mean instead of the direct data. These allow a direct comparison of the soils and constitute a useful set of data for easy comparison of individual laboratory performances. These data are also presented in Table 2 (right-hand side) except for exchangeable K and Na which are only given as direct values.

The analysis of variance of the % deviation from the mean is given in Table 4. Obviously, this analysis is not a test for significance as the means of the deviations per soil are nil.

The relative degree of "difficulty" of the soils is now expressed by the relative magnitude of the standard deviations (or of the standard errors): the lower the value, the smaller the deviations from the mean.

Exchangeable bases and Base saturation

It appears that the relative variability of exchangeable bases and base saturation increases with decreasing values of the parameter. Soils 2, 3 and 4 have the lowest base saturation and the highest variabilities (Table 3.1 and 4.1.). Since the base saturation is obtained by:

$$BS = \frac{\text{sum bases}}{\text{CEC}} \times 100\%$$

possible errors and variability in the CEC determination are also incorporated. However, the variability of the CEC values appears to be rather uniform (see Table 4.1, Part I) and most of the variability differences in base saturation may, therefore, be ascribed to the variability differences of the exchangeable base values (Table 4.2). As was indicated earlier, the strong "noise" of the low values is somewhat exaggerated by the rounding-off. A strikingly low variability in base saturation is shown by soils 5 and 10, the Solonetz and Calcaric Fluvisol respectively (Table 4.1). This is no surprise since the base saturation of these soils is 100%. In most cases the actually found base saturation exceeds 100% because of solubilization of salts. This is nicely expressed by the standard deviations of exchangeable Ca and Mg of soil 10 (Table 4.2). For soil 5 this variability is contained mainly in the Na and K data (Table 2.3).

It is interesting to see how wide the gap is between the minimum and maximum values found for the base saturation. From Table 3.1 this appears to range from ca. 45 to 65% (absolute) for all soils except 5 and 10 (which have 100% saturation). Even when the performance of all laboratories together are taken into account, then the 95% confidence interval for the mean indicates a variability of ± 5% to ± 9% absolute. This creates strong doubt as to the practical significance of (sharp) boundary values in soil classification (e.g. 35% and 50%) under the present conditions. Classification of certain soils with base saturation values near (and also not so near) 35% or 50% may be compared with playing dice. Similar situations were earlier observed for the clay increase criterion of the argillic horizon and the CEC-of-the-clay criterion of the oxic horizon or ferralic/oxic properties (Part I).

pH

The determination of the pH of a soil is considered one of the most straightforward chemical analyses of a soil laboratory. Therefore, pH values given by a laboratory are seldom questioned.
Table 2.2 and 3.3 show that for pH-H_2O the difference between the highest and lowest value is not less than a whole unit with extremes of 2.5 for the Solonetz and 2.1 for the calcaric Fluvisol, both having a relatively high pH. For pH-KCl these differences are slightly less, but this can be ascribed to the logarithmic nature of the data.

Although pH values are logarithmic units, they are treated here as normal arithmetic units for convenience (cf. Cronce, 1980). It should be realized, however, that a 2% deviation (≈ 0.1 pH unit) from pH 5 involves 10 times more H^+ moles than a 2% deviation from pH 6. For this reason the largest variability in pH measurement would be expected near pH 7. The several buffering mechanisms operating in soil suspensions facilitate "stable" readings provided there is (near) equilibrium or that reactions are very slow.

The variability of the pH measurements at higher values is unfavourably influenced by the CO_2 partial pressure. In addition to this, in the determination of the pH of soil 10 most probably non-equilibrium conditions play a role. Both these effects are influenced by the shaking/stirring technique (including time). The minimum value of 6.8 for soil 10 is evidently in error and then wrong calibration or a defect in the pH meter or electrode must be suspected. This will be further discussed in the next sections.

3.2 Laboratories

Because classification of a soil is usually based on the data of a single laboratory, examination of the performance of the individual laboratories is of great practical importance.

Table 5 gives the results of the analysis of variance of the % deviations (Table 2) per laboratory. Thus, an expression is obtained of the relative performance of each laboratory on all soils. The column "mean" represent the weighted average of the % deviations per soil for each laboratory. These values are also given in Table 2: vertical column "mean" on right-hand side.

As was explained in Part I, for the judgement of the performance of the individual laboratories, two criteria have to be used:

- Accuracy. This is the deviation of the lab mean from the "true" value, which is presently the overall mean of the parameter.
- Precision. This is expressed by the standard deviation, standard error and the 95% confidence interval, all indicating the "noise" of the data.

Accuracy can be improved by standardization of procedures, precision is to a large extent a quality aspect of the individual laboratory.

In Table 5, for easier visual comparison, the "95% confidence interval for the mean" has been converted to "half-width values" of this range and are presented directly after the means, so that the performance of each lab is expressed by accuracy and precision side-by-side together constituting the **total variability** of the data of each laboratory for the parameter.

Exchangeable bases and Base saturation

Rather "accurate" BS values (less than 10% deviation from the mean)[1] were obtained by ten of the twenty laboratories (1,4,5,6,8,11,13,15,16,17) whereas "good" precision was achieved by only six laboratories (4,8,10,11,13,17). With respect to standardization prospects it is encouraging that five of these six laboratories also had a good accuracy indicating that this combination is well possible.

In a number of cases the larger deviations of the BS values may to some extent be ascribed to a deviating CEC (cf. table 5.1., Part I): Labs 10,12,18 and 20 found relatively high CEC values accompanied by low BS values, while for labs 2, 7 and 9 a low CEC was coupled with a high BS.

It would seem that a total variability of ± 10% (relative) for base saturation is a reasonable goal to aim at. This implies that in practice the flexibility of the mentioned classification boundaries would be 35% ± 3.5 and 50% ± 5.0 (absolute).

Exchangeable Ca and Mg appear to behave mutually different (Table 5.2). The variability of the labs is much larger for Ca than for Mg. This may largely be ascribed to the influence of the low-Ca soils on these figures. For soils 3 and 4 many labs reported zero Ca which invariably leads to a relative deviation of 100% (the mean not being zero). Under such conditions the method of employing proportional deviations fails to give useful information.

)[1] It is somewhat confusing that BS is expressed in %. A clear distiction should be made between proportional or relative deviation and absolute deviation, both expressed in %.

pH

The average variability of both the pH-H_2O and pH-KCl given by the twenty laboratories is about ± 5.5% (Table 5.3) corresponding with about ± 0.3 pH unit. The observation that the average accuracy (± 3.1%) is worse than the average precision (± 2.2% and ± 2.5%) indicates that standardization of the procedure is feasible. As regards precision, of interest is the performance of lab 9 which clearly erroneously measured pH-H_2O = 6.8 for the calcaric soil 10. If wrong calibration had been the cause then all values of this lab should have been too low. However, this appears not to be the case as there are other values above the mean. The relatively very high standard deviation of the performance of this lab indicates a "noisy" pH measurement. Such a shortcoming could easily be improved upon, if only it is noticed (see also section 3.4).

Two labs (10,20) give a variability well below ± 2% (≈0.1 pH unit) while eight labs are better than ± 4% (≈0.2 pH unit). Thus, although an individual performance might be better, a variability of ± 0.2 pH unit (which is a range of 0.4 pH unit!) could be a reasonable standard.

3.3. Classification aspects

The data of Table 2 can be used to discuss the classification aspect of the variability of the data. It is stressed that this discussion is not meant to qualify or disqualify participating laboratories, the only purpose is to establish the consequences of the variability.

Ferric Acrisol/Oxic Paleudult (Samples 1 and 2). The base saturation criterion for Acrisol is that it be less than 50% in some part of the B-horizon. Thus, three laboratories (2,7,19) would not call this soil Acrisol but Luvisol. The criterion for Ultisol is that BS be less than 50% at depth (using NH_4OAc for the CEC). In case sample 2 had been deep enough in the profile (which is not likely, see table 1) then the same laboratories would have called this an Alfisol.

Rhodic Ferralsol/Typic Eutrustox (samples 3 and 4). The criterion for Eutrustox is that the oxic horizon has a BS of 50% or more. Assuming sample 4 is from the oxic horizon then seven laboratories, reporting a BS below 50%, would classify this soil as a Haplustox.

Humic Nitosol/Orthoxic Palehumult (samples 6 and 7). The BS requirement for a humic Nitosol is that it be less than 50% in at least part of the argillic B-horizon within 125 cm of the surface. Only three laboratories (12, 18, 20) give BS values of less than 50% for sample 7 (part of the B) while all other would have to classify this soil as a Eutric Nitosol (assuming other parts of the B-horizon have BS values above 50% also). The same three laboratories would classify this soil as an Ultisol while the other have to call it an Alfisol. Possibly this soil was originally classified as an Ultisol on the basis of deeper samples with a lower base saturation.

Mollic Andosol/Udic Eutrandept (samples 8 and 9). All laboratories report BS values higher than 50% for the topsoil, hence this soil can be safely classified as a Mollic Andosol. The criterion for Eutrandept is that the BS be higher than 50% in some subhorizon between 25 and 75 cm. Unfortunately, sample 9 was taken just below this. Three laboratories (3,12,18) give values below 50% and would have to classify this soil as a Dystrandept. In view of the much higher BS values in the A horizon, it is likely that these three laboratories would have found a higher BS value if sample 9 was taken at a shallower depth. They would then have designated this soil as Eutrandept, too.

3.4 Analytical procedures

Exchangeable bases and Base saturation

The procedures are given in Appendix 1. Exchangeable bases are nearly always determined somewhere on the way to the CEC determination. Thus, Appendix 1a is for most labs a copy of the CEC procedures (cf. App. 1a, Part I). Since the determination of exchangeable cations is a total analysis, i.e. all cations are (supposedly) exchanged by an excess of another cation, the procedure should in principle not have a considerable influence. This in contrast to the CEC determination where such factors as pH, index cation, washing of excess salt and hydrolysis may play a disturbing role. Yet a considerable variability is noticed.

Some of the most important factors suspected to lead to variability are: prewashing with water/alcohol to remove soluble salts, volume of exchange solution, concentration and type of exchange cation, time of contact, exchange technique (centrifuge, percolation, etc.: is the solution clear?). The methods of measuring the cations in solution can be very important, especially at low concentrations where insensitivity plays a role. Also, the preparation of calibration solutions may be a source of error, especially when (dried) salts are used rather than commercial standard solutions.

Since the base saturation data are "polluted" by the CEC procedure, the data for exchangeable Ca and Mg are better suited to judge procedures.

The procedure of exchange by NH_4-acetate pH 7 is the most widely used (by 18 labs) be it with various techniques. Examination of the data produced with these techniques gives no clear picture, both extreme positive and negative deviations occur (Table 5.2, App. 1a). Laboratory 2 employs $BaCl_2$ + NH_4Cl and gives a 20% positive deviation for Ca and + 7% for Mg, while K and Na do not seem to deviate much. Considering the low-value noise of Ca, this method seems to give quite "regular" results and the large positive deviation of the BS of lab 2 (Table 2.1) can largely be ascribed to the low CEC of this lab (Table 2.1, Part I). Laboratory 4 employs KCl to exchange Ca and Mg, and an acid solution for K and Na. This resulted in a high positive deviation for Ca but a negative one for Mg and no significant deviations for K and Na. This positive deviation for Ca seems not to be due to increased solubilization of lime as exchangeable Ca in calcaric soil 10 was far below the average (-58%). Here too, the noise obscures the signal.

It is felt that standardization of the procedure with special attention to the factors mentioned above will reduce the variability considerably.

pH

The methods to measure the pH of soils differ widely (Appendix 1b). Some important factors that influence the determination are: shaking procedure, shaking (contact) time, soil:liquid ratio, position of electrode(s), soluble salt content (ionic activity, use of 1N KCl or 0.01 M $CaCl_2$). Considering the differences in techniques it is not surprising that variations in results occur. However, examination of both table 3.3 (soil influence) and table 5.3 (method influence) does not yield much useful information as to specific influences. The clearest effect noticed is that the calcaric and solonetzic soils (high pH) show the highest variability (see p. 5). Also, the 1:1 soil:liquid ratio (labs 9,11,12,14,16,20) tends to yield somewhat lower values than the 1:2.5 ratio, the labs (2,6) using a 1:5 ratio give value above the average. The labs employing 0.01 M $CaCl_2$ rather than 1 N KCl (11,18) give results above the average, in agreement with the salt influence.

It is suspected that a self-evident factor, calibration, has a strong influence on the variability of the data, if not the strongest. It is essential that pH meters are frequently calibrated with reasonably fresh buffer solutions, and obviously the meter should be calibrated for the range in which is measured. Also, the electrodes have to be kept in good condition.

One participant, when requested to produce pH-KCl data in addition to those already given for pH-H_2O, accidentally repeated the pH-H_2O determination. These data were for all soils between 0.4 and 0.6 unit higher! This was almost certainly a calibration effect.

It may be expected that from standardization of the procedure, which can easily be introduced, and elimination of sources of error in the laboratory, the pH determination of soils can become more consistent.

4. CONCLUSIONS

In this second part of the pilot round of a laboratory methods and data exchange program, examination of data for exchangeable bases, base saturation and pH shows that for these parameters, like for CEC and texture reported in Part I, widely varying analytical results are produced. Therefore, the conclusion can be the same as expressed in Part I: if quantitative taxonomic systems for soil classification are to be used globally, the methods of soil analysis have to be standardized in detail. Also for the present parameters such standardization is feasible but a certain minimum level of variability has to be taken into account when taxonomic criteria are set. From this study such minimum levels were estimated at: ± 10% relative for base saturation and ± 0.2 units for the pH value. For two presently much used base saturation boundary values this implies: 35% ± 3.5 and 50% ± 5 (absolute).

REFERENCES

Cronce, R. (1980). Northeast soil characterization study. Mimeographed report, 3 November 1980, the Pennsylvania State University, Soil Characterization Laboratory, Univ. Park. Penn., USA.

Nie, N.H. et al. (1975). Statistical package for the social sciences, 2nd. ed. Mc.Graw-Hill.

ACKNOWLEDGEMENT

The author is greatly indebted to Mr. E.R. Jordens of the Dept. of Soil Science and Geology, Agricultural University, Wageningen, for his help in the statistical treatment of data and running the computer programs.

TABLE 1. Description of the reference samples.

No.	Location	Horizon	Depth (cm)	Classification
1.	Busia, Kenya	Ap	0- 15	Oxic Pale(?)udult/ferric Acrisol, petric phase
2.		Bt2	50- 70	
3.	Magarini, Kenya	A*	0- 22	Typic Eutrustox/rhodic Ferralsol
4.		B*	80-120	
5.	Bura-east, Kenya	A*	0- 20	Typic Natrargid/orthic Solonetz
6.	Nairobi, Kenya	Ap	0- 18	Orthoxic Palehumult/humic Nitosol
7.		Bt2	65-115	
8.	Kijabe, Kenya	Ah	0- 17	Udic Eutrandept/mollic Andosol
9.		B*	75-105	
10.	Randwijk, Netherlands	C*	60-110	Typic Fluvaquent/calcaric Fluvisol

* unspecified

TABLE 2.1 Analytical results and % deviations from the mean per soil.

BASE SATURATION

Results (%)

SOIL / LAB	Acrisol 1	Acrisol 2	Ferralsol 3	Ferralsol 4	Solonetz 5	Nitosol 6	Nitosol 7	Andosol 8	Andosol 9	Fluvisol 10
1	76	34	20	76	100	50	72	100	100	100
2	100	76	45	81	100	100	100	100	100	100
3	64	25	20	40	100	35	52	75	49	100
4	66	41	30	55	100	64	75	100	74	100
5	69	33	15	46	100	64	69	-	83	-
6	74	40	15	63	100	61	71	-	76	100
7	100	50	27	100	100	62	69	81	67	100
8	76	38	19	62	100	60	68	100	69	100
9	92	45	34	75	99	96	98	97	99	99
10	52	25	20	43	100	48	65	85	60	100
11	82	39	22	57	100	60	69	100	75	100
12	72	35	14	33	100	45	42	100	42	-
13	69	34	18	52	100	58	62	100	64	100
14	71	48	58	69	-	59	65	100	60	-
15	74	29	15	80	95	55	74	95	78	100
16	75	36	32	37	100	62	55	100	59	100
17	75	32	28	62	100	69	70	100	80	100
18	67	29	18	38	100	48	41	98	39	100
19	94	52	61	81	100	69	80	57	86	100
20	54	27	22	36	89	54	49	100	60	100
Mean	75	38	27	59	99	61	67	94	71	100

% Deviation

LAB	1	2	3	4	5	6	7	8	9	10	Mean
1	1	-11	-25	28	1	-18	7	7	41	0	3
2	33	98	69	37	1	64	49	7	41	0	40
3	-15	-35	-25	-33	1	-43	-23	-20	-31	0	-22
4	-12	7	13	-7	1	5	11	7	4	0	3
5	-8	-14	-44	-22	1	5	3	-	17	-	-8
6	-1	4	-44	6	1	0	6	-	7	0	-2
7	33	30	1	69	1	2	3	-14	-6	0	12
8	1	-1	-29	5	1	-2	1	7	-3	0	-2
9	23	17	28	26	0	58	46	3	39	-1	24
10	-31	-35	-25	-27	1	-21	-3	-9	-15	0	-17
11	9	2	-17	-4	1	-2	3	7	6	0	0
12	-4	-9	-47	-44	1	-26	-38	7	-41	-	-22
13	-8	-11	-32	-12	1	-5	-8	7	-10	0	-8
14	-5	25	118	16	-	-3	-3	7	-15	-	17
15	-1	-24	-44	35	-4	-10	10	1	10	0	-8
16	0	-6	20	-38	1	2	-18	7	-17	0	-5
17	0	-17	5	5	1	13	4	7	13	0	3
18	-11	-24	-32	-36	1	-21	-39	5	-45	0	-20
19	25	35	129	37	1	13	19	-39	21	0	24
20	-28	-30	-17	-39	-10	-11	-27	7	-15	0	-17

EXCHANGEABLE Ca

me/100g

SOIL / LAB	1	2	3	4	5	6	7	8	9	10
1	2.0	1.3	0.1	0.0	14.2	7.2	6.0	60.2	12.6	68.9
2	2.1	1.3	0.2	0.5	15.4	8.7	6.9	68.4	14.7	17.7
3	0.7	0.9	0.2	0.0	10.1	5.3	3.5	32.7	6.9	17.7
4	2.4	1.8	0.4	0.8	14.2	8.0	7.8	40.8	13.6	12.0
5	1.7	1.0	0.0	0.0	14.0	8.3	6.2	-	16.8	-
6	1.7	1.2	0.0	0.0	13.4	7.5	5.8	50	13.1	46.1
7	1.2	0.8	0.0	0.0	11.6	6.4	5.2	41.2	11.8	19.4
8	1.8	1.1	0.1	0.0	12.5	7.1	5.5	59.1	11.8	22.6
9	0.8	0.8	0.1	0.0	11.5	5.2	4.8	6.2	7.8	24.7
10	1.5	1.3	0.4	0.8	15.0	7.0	6.3	47.5	10.0	22.5
11	1.8	1.2	0.0	0.0	15.5	7.9	6.4	72.2	15.0	42.4
12	1.9	1.3	0.1	0.1	11.5	7.6	6.3	56.9	12.4	-
13	2.5	1.7	0.2	0.2	14.1	8.8	6.6	78.8	14.4	45.6
14	2.8	2.8	1.2	0.8	-	8.6	7.8	56.7	14.8	-
15	2.8	0.4	0.0	0.0	12.6	5.0	4.2	37.8	8.2	19.6
16	1.7	1.1	0.6	0.1	12.7	6.8	6.0	39.9	11.1	15.5
17	2.2	1.4	0.2	0.2	13.1	8.9	7.7	44.9	15.7	6.0
18	1.9	1.2	0.1	0.2	14.5	7.6	6.2	59.9	13.1	52.9
19	2.2	1.4	0.2	0.2	12.3	7.9	6.6	37.4	14.2	12.2
20	1.8	1.2	0.4	0.4	4.3	7.9	6.4	60.8	12.6	35.2
Mean	1.9	1.3	0.2	0.2	12.8	7.4	6.1	50.1	12.5	28.3

% Deviation

LAB	1	2	3	4	5	6	7	8	9	10	Mean
1	6	3	-56	-100	11	-3	-2	20	1	144	3
2	12	3	-11	133	21	18	13	37	17	-37	20
3	-63	-29	-11	-100	-21	-28	-43	-35	-45	-37	-41
4	28	43	78	272	11	8	28	-19	9	-58	40
5	-10	-21	-100	-100	10	12	1	—	34	—	-22
6	-10	-5	-100	-100	5	2	-5	0	5	63	-15
7	-36	-37	-100	-100	-9	-13	-15	-18	-6	-31	-37
8	-4	-13	-56	-100	-2	-4	-10	18	-6	-20	-20
9	-57	-37	-56	-100	-10	-30	-21	-88	-38	-13	-45
10	-20	3	78	272	18	-5	3	-5	-20	-20	30
11	-4	-5	-100	-100	21	7	5	44	20	50	-6
12	1	3	-56	-53	-10	3	3	14	-1	—	-11
13	33	35	-11	-7	10	19	8	57	15	61	22
14	49	122	433	272	—	16	28	13	18	—	119
15	49	-68	-100	-100	-1	-32	-31	-25	-35	-31	-37
16	-10	-13	167	-53	-1	-8	-2	-20	-11	-45	0
17	17	11	-11	-7	3	21	26	-10	25	-79	0
18	1	-5	-56	-7	14	3	1	20	5	87	6
19	17	11	-11	-7	-4	7	8	-25	13	-57	-5
20	-4	-5	78	86	-66	7	5	21	1	24	15

EXCHANGEABLE Mg

me/100g

SOIL / LAB	1	2	3	4	5	6	7	8	9	10
1	1.1	0.9	0.2	1.3	4.9	1.2	2.2	3.7	2.4	1.3
2	1.2	1.0	0.3	1.6	5.4	1.6	2.4	4.3	3.3	0.8
3	0.7	0.6	0.1	0.7	3.8	1.3	2.0	3.3	2.4	0.7
4	0.8	0.7	0.4	0.8	4.7	1.4	1.2	1.7	2.0	0.2
5	1.1	0.9	0.2	1.4	5.8	1.6	2.6	5.0	3.2	2.3
6	1.3	1.1	0.2	1.4	5.9	1.5	2.5	4.1	2.9	1.1
7	1.1	1.1	0.2	1.3	5.7	1.4	2.4	4.0	3.0	1.0
8	1.2	0.9	0.2	1.4	5.4	1.3	2.4	4.0	2.7	1.0
9	1.5	1.1	0.3	1.3	4.9	1.6	2.6	3.2	2.5	1.1
10	1.0	0.3	0.2	0.5	3.8	1.0	1.8	3.8	4.3	2.5
11	1.4	1.1	0.3	1.5	6.5	1.6	2.7	5.0	3.3	1.2
12	1.4	1.1	0.2	1.4	6.1	1.5	2.8	3.9	2.9	-
13	1.1	0.9	0.1	1.5	5.8	1.4	2.6	4.6	3.0	1.4
14	0.8	0.4	0.4	1.6	-	2.2	3.5	2.6	2.9	-
15	0.8	0.6	0.1	1.0	4.0	1.0	1.6	2.4	1.8	0.6
16	1.2	1.0	0.3	1.0	5.7	1.5	2.5	3.8	3.2	1.2
17	1.1	1.0	0.4	1.4	3.7	1.2	2.3	3.5	2.7	0.9
18	1.2	1.0	0.2	1.3	5.9	1.4	2.6	4.5	2.9	1.2
19	1.7	1.6	1.0	1.8	5.5	1.9	2.9	1.9	3.6	0.2
20	1.1	0.9	0.2	1.2	5.5	1.5	2.3	3.7	2.5	1.0
Mean	1.1	0.9	0.3	1.3	5.2	1.5	2.4	3.7	2.9	1.1

% Deviation

LAB	1	2	3	4	5	6	7	8	9	10	Mean
1	-4	-1	-27	2	-6	-18	-8	1	-16	19	-6
2	5	10	9	26	4	10	0	18	16	-27	7
3	-39	-34	-64	-45	-27	-11	-16	-10	-16	-36	-30
4	-30	-23	45	-37	-10	-4	-50	-53	-30	-82	-27
5	-4	-1	-27	10	11	10	9	37	12	110	17
6	14	21	-27	10	13	3	4	12	2	1	5
7	-4	21	-27	2	9	-4	0	10	5	-9	0
8	5	-1	-27	10	4	-11	0	10	-5	-9	-2
9	32	21	9	2	-6	10	9	-12	-12	1	5
10	-12	-67	-27	-61	-27	-32	-25	4	51	128	-7
11	23	21	9	18	25	10	13	37	16	10	18
12	23	21	-27	10	17	3	17	7	2	—	8
13	-4	-1	-64	18	11	-4	9	26	5	28	2
14	-30	-56	45	26	—	51	46	-29	2	—	7
15	-30	-34	-64	-21	-23	-32	-33	-34	-37	-45	-35
16	5	10	9	-21	9	3	4	4	-5	10	3
17	-4	10	45	10	-29	-18	-4	-4	-5	-18	-2
18	5	10	-27	2	13	-4	9	23	2	10	4
19	49	76	264	42	6	30	21	-48	26	82	38
20	-4	-1	-27	-6	5	3	-4	1	-12	-9	-5

TABLE 2.2 Analytical results (cont'd).

pH-H_2O

Results

SOIL / LAB	Acrisol 1	Acrisol 2	Ferralsol 3	Ferralsol 4	Solonetz 5	Nitosol 6	Nitosol 7	Andosol 8	Andosol 9	Fluvisol 10
1	-	-	-	-	-	-	-	-	-	-
2	6.4	5.2	5.5	5.5	8.9	5.8	6.2	7.3	6.7	8.5
3	6.4	5.0	5.4	5.2	8.1	6.0	6.6	7.4	6.6	8.0
4	6.2	5.1	5.2	5.5	8.1	5.7	6.1	7.3	6.7	8.3
5	6.4	5.2	5.2	5.4	8.2	5.7	6.3	7.3	6.8	8.3
6	6.4	5.3	5.5	5.5	8.8	5.9	6.3	7.5	6.9	8.5
7	6.6	5.0	5.2	5.4	8.1	5.7	6.2	7.2	6.6	8.2
8	6.5	5.1	5.9	5.7	8.4	6.2	6.3	7.3	6.6	8.4
9	5.7	5.5	5.0	5.4	6.4	6.8	6.5	6.5	6.8	6.8
10	6.1	5.0	5.1	5.1	7.8	5.9	6.2	7.2	6.7	8.0
11	6.1	4.9	5.0	5.2	7.4	5.5	6.0	7.1	6.5	8.0
12	6.0	5.0	5.0	5.5	7.5	5.4	5.9	7.0	6.7	8.0
13	6.4	5.3	5.3	5.5	8.3	5.8	6.4	7.3	6.7	8.3
14	5.5	4.4	4.6	4.7	7.4	5.2	5.7	6.9	6.2	7.2
15	5.5	4.4	4.5	4.7	7.8	5.0	5.5	6.7	7.2	7.7
16	5.6	4.8	5.0	4.9	7.0	5.0	5.6	7.2	7.0	7.5
17	6.3	5.3	5.1	5.3	7.2	5.5	6.0	7.0	6.7	7.7
18	-	-	-	-	-	-	-	-	-	-
19	6.3	5.1	5.4	5.5	8.3	5.3	6.1	7.5	6.7	8.7
20	6.1	5.0	5.1	5.4	7.8	5.5	6.2	7.2	6.7	8.3
Mean	6.1	5.0	5.2	5.3	7.9	5.7	6.1	7.2	6.7	8.0

% Deviation

LAB	1	2	3	4	5	6	7	8	9	10	Mean
1	-	-	-	-	-	-	-	-	-	-	-
2	4	3	6	4	13	2	1	2	0	6	4
3	4	-1	5	-2	3	6	8	3	-2	0	2
4	1	1	1	4	3	1	0	2	0	3	2
5	4	3	1	2	4	1	3	2	1	3	2
6	4	5	6	4	12	4	3	5	3	6	5
7	8	-1	1	2	3	1	1	1	-2	2	2
8	6	1	14	8	7	10	3	2	-2	5	5
9	-7	9	-3	2	-19	20	6	-9	1	-15	-2
10	-1	-1	-1	-4	-1	4	1	1	0	0	0
11	-1	-3	-3	-2	-6	-3	-2	-1	-3	0	2
12	-2	-1	-3	4	-5	-5	-4	-2	0	0	-2
13	4	5	3	4	6	2	5	2	0	3	3
14	-10	-13	-11	-11	-6	-8	-7	-4	-8	-10	-9
15	-10	-13	-13	-11	-1	-12	-10	-6	7	-4	-7
16	-9	-5	-3	-8	-11	-12	-8	1	4	-7	-6
17	3	5	-1	0	-8	-3	-2	-2	0	-4	-1
18	-	-	-	-	-	-	-	-	-	-	-
19	3	1	5	4	6	-6	0	5	0	8	3
20	-1	-1	-1	2	-1	-3	1	1	0	3	0

pH-KCl

Results

SOIL / LAB	1	2	3	4	5	6	7	8	9	10
1	-	-	-	-	-	-	-	-	-	-
2	5.4	4.2	4.7	5.0	7.1	4.7	5.2	6.9	5.5	7.8
3	5.4	3.9	4.4	4.6	7.3	4.8	5.4	6.8	5.4	7.5
4	4.8	3.8	4.0	4.2	-	4.4	5.0	-	5.3	-
5	5.2	4.0	4.3	4.5	7.2	4.5	5.2	6.8	5.5	7.5
6	5.4	4.2	4.6	4.9	6.7	4.9	5.3	6.5	5.8	7.0
7	5.2	4.0	4.2	4.4	7.1	4.6	5.2	6.8	5.4	7.5
8	5.5	4.1	5.1	5.1	7.2	5.2	5.3	6.9	5.4	7.6
9	5.2	4.0	4.2	4.5	5.5	4.9	5.2	5.4	5.3	5.9
10	5.1	3.8	4.3	4.5	6.3	4.5	5.1	6.2	5.3	6.9
11*	5.5	4.3	4.4	4.7	7.5	5.0	5.7	7.0	6.1	7.6
12	5.1	4.0	4.3	4.6	6.5	4.6	5.2	6.5	5.4	7.0
13	5.1	4.0	4.4	4.6	7.2	4.6	5.2	6.7	5.4	7.4
14	-	-	-	-	-	-	-	-	-	-
15	4.8	3.8	4.2	4.4	6.4	4.4	4.9	6.4	5.2	7.1
16	4.7	3.7	4.2	4.5	6.3	4.5	5.0	6.4	5.5	6.7
17	5.1	3.8	4.3	4.5	6.7	4.7	5.2	6.7	5.5	7.0
18*	5.2	4.1	4.1	4.4	7.2	4.8	5.6	6.8	5.7	7.5
19	5.4	4.0	4.5	4.8	7.0	4.7	5.3	6.9	5.5	7.7
20	5.1	3.9	4.4	4.7	6.8	4.6	5.2	6.6	5.4	7.3
Mean	5.2	4.0	4.4	4.6	6.8	4.7	5.2	6.6	5.5	7.2

% Deviation

LAB	1	2	3	4	5	6	7	8	9	10	Mean
1	-	-	-	-	-	-	-	-	-	-	-
2	4	6	8	9	4	0	-1	4	0	8	4
3	4	-2	1	0	7	2	3	3	-1	4	2
4	-7	-4	-8	-9	0	-6	-4	0	-3	0	-4
5	0	1	-2	-2	6	-4	-1	3	0	4	1
6	4	6	5	6	-2	5	1	-2	6	-3	3
7	0	1	-4	-4	4	-2	-1	3	-1	4	0
8	6	3	17	11	6	11	1	4	-1	5	6
9	0	1	-4	-2	-19	5	-1	-18	-3	-18	-6
10	-2	-4	-2	-2	-8	-4	-3	-6	-3	-5	-4
11*	6	8	1	2	10	7	9	6	11	5	7
12	-2	1	-2	0	-5	-2	-1	-2	-1	-3	-2
13	-2	1	1	0	6	-2	-1	1	-1	2	1
14	-	-	-	-	-	-	-	-	-	-	-
15	-7	-5	-4	-4	-6	-6	-6	-3	-5	-2	-5
16	-9	-7	-4	-2	-8	-4	-4	-3	0	-7	-5
17	-2	-4	-2	-2	-2	0	-1	1	0	-3	-2
18*	0	3	-6	-4	6	2	7	3	4	4	2
19	4	1	3	4	3	0	1	4	0	6	3
20	-2	-2	1	2	0	-2	-1	0	-1	1	0

* pH-$CaCl_2$

TABLE 2.3 Analytical results (cont'd).

EXCHANGEABLE K

SOIL / LAB	Acrisol 1	Acrisol 2	Ferralsol 3	Ferralsol 4	Solonetz 5	Nitosol 6	Nitosol 7	Andosol 8	Andosol 9	Fluvisol 10
1	0.65	0.05	0.14	0.84	0.12	0.20	0.47	1.22	11.81	10.66
2	0.61	0.22	0.09	0.06	0.94	2.20	0.36	1.08	3.74	0.13
3	0.37	0.19	0.06	0.4	0.67	1.26	0.95	0.86	2.87	0.05
4	0.50	0.16	0.09	0.04	0.65	1.73	0.21	0.74	2.73	0.04
5	0.56	0.24	0.09	0.05	0.95	2.42	0.45	1.28	3.83	0.13
6	0.5	0.2	0.1	0.1	0.9	2.2	0.4	1.1	3.4	0.1
7	0.6	0.3	0.1	0.1	1.0	2.2	0.4	1.1	3.3	0.2
8	0.45	0.18	0.08	0.04	1.29	2.13	0.30	1.03	2.82	0.09
9	0.73	0.23	0.12	0.07	1.26	2.30	0.38	1.23	2.95	0.16
10	0.61	0.23	0.08	0.03	1.37	2.70	0.35	1.49	4.02	0.19
11	0.7	0.3	0.1	0.1	1.1	2.6	0.4	1.4	3.9	0.1
12	0.59	0.25	0.10	0.05	1.09	2.28	0.38	1.22	3.37	-
13	0.66	0.26	0.13	0.13	0.05	2.49	0.36	1.18	3.63	0.15
14	0.7	0.4	0.2	0.2	-	2.8	0.5	1.5	4.4	0.2
15	0.6	0.2	0.1	0.1	1.0	0.2	0.3	1.1	3.3	0.1
16	0.86	0.26	0.08	0.08	0.97	4.13	0.50	1.13	4.58	0.27
17	0.6	0.3	0.1	0.1	1.1	3.5	0.4	1.4	5.6	0.1
18	0.52	0.24	0.10	0.06	1.00	2.60	0.40	1.20	3.69	0.12
19	0.6	0.3	0.1	0.1	1.1	2.6	0.4	1.3	4.2	0.1
20	0.55	0.26	0.12	0.08	0.91	2.50	0.50	1.85	2.62	0.14
Mean	0.6	0.24	0.10	0.14	0.92	2.25	0.42	1.22	4.04	0.69

EXCHANGEABLE Na

SOIL / LAB	1	2	3	4	5	6	7	8	9	10
1	0.04	0.06	0.02	0.04	4.78	0.11	0.11	0.36	0.39	0.49
2	0.02	0.03	0.03	0.03	5.84	0.03	0.04	0.05	0.24	0.21
3	0.05	0.45	0.05	0.0	3.46	0.34	0.07	0.35	0.44	0.65
4	0.02	0.03	0.02	0.02	5.70	0.04	0.05	0.13	0.19	0.24
5	0.00	0.00	0.02	0.01	3.33	0.22	0.05	0.09	0.18	0.23
6	0.0	0.0	0.0	0.0	4.1	0.0	0.0	0.1	0.2	0.2
7	0.0	0.0	0.0	0.0	4.8	0.0	0.0	0.0	0.1	0.1
8	0.01	0.03	0.03	0.04	5.42	0.04	0.04	0.07	0.11	0.16
9	0.08	0.07	0.08	0.08	6.78	0.12	0.13	1.14	1.04	0.98
10	0.02	0.03	0.02	0.02	8.10	0.05	0.07	0.17	0.22	0.25
11	0.1	0.1	0.1	0	6.6	0	0	0	0.2	0.2
12	0	0.02	0.01	0.01	4.47	0.01	0.04	0.03	0.17	-
13	0.17	0.09	0.10	0.09	5.92	0	0	0	0.05	0.09
14	0.3	0.3	0.3	0.3	5.3	0.3	0.3	0.3	0.5	0.4
15	0.1	0.1	0.1	0.1	5.2	0.1	0.1	0.2	0.2	0.3
16	0.02	0.03	0.04	0.02	5.79	0.04	0.06	0.06	0.20	0.18
17	0.1	0.1	0.1	0.1	0.6	0.1	0.1	0.3	0.3	0.1
18	0.02	0.04	0.04	0.04	6.15	0.05	0.07	0.09	0.21	0.21
19	0.1	0.1	0.1	0.1	6.6	0.2	0.2	0.5	0.5	0.4
20	0.03	0.05	0.05	0.04	8.7	0.03	0.07	0.10	0.25	0.21
Mean	0.06	0.08	0.06	0.05	5.38	0.09	0.07	0.20	0.28	0.29

TABLE 3. Analysis of variance of the DATA per SOIL.

These tables give the mean values of the parameters of each soil as obtained by all laboratories together.

Thus, these are the reference values characterizing the soils.

TABLE 3.1

- O N E W A Y -

Variable: BSAT
by Variable SOIL

Base Saturation

Analysis of Variance

Source	D.F.	Sum of squares	Mean squares	F-ratio	F-prob.
Between groups	9	103099.7151	11455.5240	62.855	0.0000
Within groups	184	33534.3417	182.2519		
Total	193	136634.0600			

Group	Count	Mean	Standard deviation	Standard error	Minimum	Maximum	95% conf int for mean		
GRP01	20	75.1000	13.1505	2.9406	52.0000	100.0000	68.9454	to	81.2546
GRP02	20	38.4000	11.8562	2.6511	25.0000	76.0000	32.8511	to	43.9489
GRP03	20	26.6500	13.6624	3.0550	14.0000	61.0000	20.2558	to	33.0442
GRP04	20	59.3000	18.8515	4.2153	33.0000	100.0000	50.4772	to	68.1228
GRP05	19	99.1053	2.7059	0.6208	89.0000	100.0000	97.8011	to	100.4094
GRP06	20	60.9500	15.1917	3.3970	35.0000	100.0000	53.8401	to	68.0599
GRP07	20	67.3000	15.2526	3.4106	41.0000	100.0000	60.1616	to	74.4384
GRP08	18	93.7778	11.8845	2.8012	57.0000	100.0000	87.8677	to	99.6878
GRP09	20	71.0000	17.6814	3.9537	39.0000	100.0000	62.7249	to	79.2751
GRP10	17	99.9412	0.2425	0.0588	99.0000	100.0000	99.8165	to	100.0659
Total	194	68.2680	26.6073	1.9103	14.0000	100.0000	64.5003	to	72.0358

TABLE 3.2

- O N E W A Y -

Variable: EXCA
by Variable SOIL

Exchangeable Ca

Analysis of Variance

Source	D.f.	Sum of squares	Mean squares	F-ratio	F-prob.
Between groups	9	43073.0639	4785.8960	88.113	0.0000
Within groups	185	10048.3445	54.3154		
Total	194	53121.4080			

Group	Count	Mean	Standard deviation	Standard error	Minimum	Maximum	95% conf int for mean		
GRP01	20	1.8750	0.5571	0.1246	0.7000	2.8000	1.6143	to	2.1357
GRP02	20	1.2600	0.4773	0.1067	0.4000	2.8000	1.0366	to	1.4834
GRP03	20	0.2250	0.2826	0.0632	0.0000	1.2000	0.0927	to	0.3573
GRP04	20	0.2150	0.2889	0.0646	0.0000	0.8000	0.0798	to	0.3502
GRP05	19	12.7632	2.5167	0.5774	4.3000	15.5000	11.5502	to	13.9761
GRP06	20	7.3850	1.1699	0.2616	5.0000	8.9000	6.8375	to	7.9325
GRP07	20	6.1100	1.1026	0.2465	3.5000	7.8000	5.5940	to	6.6260
GRP08	19	50.0737	16.6273	3.8146	6.2000	78.8000	42.0596	to	58.0878
GRP09	20	12.5300	2.6624	0.5953	6.9000	16.8000	11.2839	to	13.7761
GRP10	17	28.2941	17.2497	4.1837	6.0000	68.9000	19.4252	to	37.1631
Total	195	11.6251	16.5476	1.1850	0.0000	78.8000	9.2880	to	13.9623

- O N E W A Y -

Variable: EXMG
by Variable SOIL

Exchangeable Mg

Analysis of Variance

Source	D.f.	Sum of squares	Mean squares	F-ratio	F-prob.
Between groups	9	397.2224	44.1358	158.379	0.0000
Within groups	187	52.1118	0.2787		
Total	196	449.3342			

Group	Count	Mean	Standard deviation	Standard error	Minimum	Maximum	95% conf int for mean		
GRP01	20	1.1400	0.2501	0.0559	0.7000	1.7000	1.0230	to	1.2570
GRP02	20	0.9100	0.2864	0.0640	0.3000	1.6000	0.7760	to	1.0440
GRP03	20	0.2750	0.1943	0.0435	0.1000	1.0000	0.1841	to	0.3659
GRP04	20	1.2700	0.3230	0.0722	0.5000	1.8000	1.1188	to	1.4212
GRP05	19	5.2105	0.8498	0.1950	3.7000	6.5000	4.8010	to	5.6201
GRP06	20	1.4550	0.2762	0.0618	1.0000	2.2000	1.3257	to	1.5843
GRP07	20	2.3950	0.4893	0.1094	1.2000	3.5000	2.1660	to	2.6240
GRP08	20	3.6500	0.9214	0.2060	1.7000	5.0000	3.2188	to	4.0812
GRP09	20	2.8500	0.5520	0.1234	1.8000	4.3000	2.5916	to	3.1084
GRP10	18	1.0944	0.5816	0.1371	0.2000	2.5000	0.8052	to	1.3836
Total	197	2.0183	1.5141	0.1079	0.1000	6.5000	1.8055	to	2.2310

TABLE 3.3

- - - - - - - - - - - - - - - O N E W A Y - - - - - - - - - - - - - - -

Variable: PHWAT
by Variable SOIL

pH-H_2O

Analysis of Variance

Source	D.f.	Sum of squares	Mean squares	F-ratio	F-prob.
Between groups	9	192.0116	21.3346	150.837	0.0000
Within groups	170	24.0450	0.1414		
Total	179	216.0566			

Group	Count	Mean	Standard deviation	Standard error	Minimum	Maximum	95% conf int for mean		
GRP01	18	6.1389	0.3483	0.0821	5.5000	6.6000	5.9657	to	6.3121
GRP02	18	5.0333	0.2849	0.0672	4.4000	5.5000	4.8916	to	5.1750
GRP03	18	5.1667	0.3236	0.0763	4.5000	5.9000	5.0058	to	5.3276
GRP04	18	5.3000	0.2849	0.0672	4.7000	5.7000	5.1583	to	5.4417
GRP05	18	7.8611	0.6326	0.1491	6.4000	8.9000	7.5465	to	8.1757
GRP06	18	5.6611	0.4354	0.1026	5.0000	6.8000	5.4446	to	5.8776
GRP07	18	6.1167	0.2956	0.0697	5.5000	6.6000	5.9697	to	6.2636
GRP08	18	7.1611	0.2615	0.0616	6.5000	7.5000	7.0311	to	7.2912
GRP09	18	6.7111	0.2055	0.0484	6.2000	7.2000	6.6089	to	6.8133
GRP10	18	8.0222	0.4882	0.1151	6.8000	8.7000	7.7795	to	8.2650
Total	180	6.3172	1.0986	0.0819	4.4000	8.9000	6.1556	to	6.4788

- - - - - - - - - - - - - - - O N E W A Y - - - - - - - - - - - - - - -

Variable: PHKCL
by Variable SOIL

pH-KCl

Analysis of Variance

Source	D.f.	Sum of squares	Mean squares	F-ratio	F-prob.
Between groups	9	194.0149	21.5572	234.388	0.0000
Within groups	167	15.3594	0.0920		
Total	176	209.3743			

Group	Count	Mean	Standard deviation	Standard error	Minimum	Maximum	95% conf int for mean		
GRP01	18	5.1778	0.2365	0.0558	4.7000	5.5000	5.0602	to	5.2954
GRP02	18	3.9778	0.1629	0.0384	3.7000	4.3000	3.8968	to	4.0588
GRP03	18	4.3667	0.2497	0.0589	4.0000	5.1000	4.2425	to	4.4908
GRP04	18	4.6056	0.2287	0.0539	4.2000	5.1000	4.4918	to	4.7193
GRP05	17	6.8235	0.5032	0.1220	5.5000	7.5000	6.5648	to	7.0822
GRP06	18	4.6889	0.2139	0.0504	4.4000	5.2000	4.5825	to	4.7953
GRP07	18	5.2333	0.1940	0.0457	4.9000	5.7000	5.1368	to	5.3298
GRP08	17	6.6059	0.3799	0.0921	5.4000	7.0000	6.4105	to	6.8012
GRP09	18	5.4778	0.2102	0.0495	5.2000	6.1000	5.3732	to	5.5823
GRP10	17	7.2353	0.4663	0.1131	5.9000	7.8000	6.9955	to	7.4750
Total	177	5.3944	1.0907	0.0820	3.7000	7.8000	5.2326	to	5.5561

TABLE 4. Analysis of variance of the proportional (%) DEVIATIONS from the mean per soil versus SOILS.

This analysis gives information on the 'difficulty' of the soils in analysis. This is expressed by the 'noise' of the deviation distribution: the lower the standard deviation (and standard error), the higher the agreement between laboratories, and thus, the 'easier' the soil is for that parameter. Minimum and maximum deviations and the 95% confidence interval for the mean further illustrate this.

TABLE 4.1

- O N E W A Y -

Variable: DEVBSAT
by Variable SOIL

% Deviation of Base Saturation

Analysis of Variance

Source	D.F.	Sum of squares	Mean squares	F-ratio	F-prob.
Between groups	9	0.0006	0.0001	0.000	1.0000
Within groups	184	129287.2058	702.6479		
Total	193	129287.2100			

Group	Count	Mean	Standard deviation	Standard error	Minimum	Maximum	95% conf int for mean		
GRP01	20	-0.0000	17.5107	3.9155	-30.7590	33.1558	-8.1953	to	8.1953
GRP02	20	-0.0000	30.8754	6.9040	-34.8958	97.9167	-14.4501	to	14.4501
GRP03	20	-0.0000	51.2660	11.4634	-47.4672	128.8931	-23.9932	to	23.9932
GRP04	20	-0.0000	31.7900	7.1085	-44.3508	68.6341	-14.8782	to	14.8782
GRP05	19	0.0053	2.7304	0.6264	-10.1917	0.9082	-1.3107	to	1.3213
GRP06	20	0.0000	24.9248	5.5734	-42.5759	64.0689	-11.6652	to	11.6652
GRP07	20	-0.0000	22.6636	5.0677	-39.0788	48.5884	-10.6069	to	10.6069
GRP08	18	-0.0024	12.6728	2.9870	-39.2194	6.6325	-6.3044	to	6.2996
GRP09	20	0.0000	24.9034	5.5686	-45.0704	40.8451	-11.6551	to	11.6551
GRP10	17	0.0012	0.2427	0.0589	-0.9406	0.0600	-0.1236	to	0.1260

TABLE 4.2

O N E W A Y

Variable: DEVEXCA
by Variable SOIL

% Deviation of Exchangeable Ca

Analysis of Variance

Source	D.F.	Sum of squares	Mean squares	F-ratio	F-prob.
Between groups	9	1.2693	0.1410	0.000	1.0000
Within groups	185	792544.8257	4284.0261		
Total	194	792546.0900			

Group	Count	Mean	Standard deviation	Standard error	Minimum	Maximum	95% conf int for mean		
GRP01	20	-0.2660	29.6346	6.6265	-62.7660	48.9362	-14.1354	to	13.6035
GRP02	20	-0.0000	37.8788	8.4700	-68.2540	122.2222	-17.7278	to	17.7278
GRP03	20	-0.0000	125.6045	28.0860	-100.0000	433.3333	-58.7847	to	58.7847
GRP04	20	0.0000	134.3593	30.0437	-100.0000	272.0930	-62.8821	to	62.8821
GRP05	19	-0.0003	19.7181	4.5236	-66.3094	21.4429	-9.5041	to	9.5035
GRP06	20	0.0000	15.8418	3.5423	-32.2952	20.5146	-7.4142	to	7.4142
GRP07	20	-0.0000	18.0455	4.0351	-42.7169	27.6596	-8.4456	to	8.4456
GRP08	19	-0.0000	33.2057	7.6179	-87.6183	57.3680	-16.0047	to	16.0046
GRP09	20	0.0000	21.2484	4.7513	-44.9322	34.0782	-9.9446	to	9.9446
GRP10	17	0.0001	60.9656	14.7863	-78.7942	143.5137	-31.3455	to	31.3457

O N E W A Y

Variable: DEVEXMG
by Variable SOIL

% Deviation of Exchangeable Mg

Analysis of Variance

Source	D.F.	Sum of squares	Mean squares	F-ratio	F-prob.
Between groups	9	2.1135	0.2348	0.000	1.0000
Within groups	187	221878.2264	1186.5146		
Total	196	221880.3400			

Group	Count	Mean	Standard deviation	Standard error	Minimum	Maximum	95% conf int for mean		
GRP01	20	-0.0000	21.9344	4.9047	-38.5965	49.1228	-10.2656	to	10.2656
GRP02	20	-0.0000	31.4677	7.0364	-67.0330	75.8242	-14.7274	to	14.7274
GRP03	20	0.0000	70.6645	15.8011	-63.6364	263.6364	-33.0720	to	33.0720
GRP04	20	0.0000	25.4315	5.6866	-60.6299	41.7323	-11.9023	to	11.9023
GRP05	19	0.0005	16.3088	3.7415	-28.9895	24.7481	-7.8601	to	7.8611
GRP06	20	-0.3425	18.9182	4.2302	-31.5068	50.6849	-9.1964	to	8.5115
GRP07	20	-0.0000	20.4315	4.5686	-49.8956	46.1378	-9.5622	to	9.5622
GRP08	20	0.0000	25.2434	5.6446	-53.4247	36.9863	-11.8143	to	11.8143
GRP09	20	0.0000	19.3695	4.3311	-36.8421	50.8772	-9.0652	to	9.0652
GRP10	18	0.0041	53.1389	12.5250	-81.7251	128.4357	-26.4213	to	26.4294

TABLE 4.3

- O N E W A Y -

Variable: DEVPHWAT
by Variable SOIL

% Deviation of pH-H_2O

Analysis of Variance

Source	D.F.	Sum of squares	Mean squares	F-ratio	F-prob.
Between groups	9	0.0000	0.0000	0.000	1.0000
Within groups	170	5769.1002	33.9359		
Total	179	5769.1002			

Group	Count	Mean	Standard deviation	Standard error	Minimum	Maximum	95% conf int for mean		
GRP01	18	-0.0002	5.6743	1.3374	-10.4074	7.5111	-2.8219	to	2.8216
GRP02	18	0.0007	5.6606	1.3342	-12.5822	9.2722	-2.8143	to	2.8156
GRP03	18	-0.0006	6.2629	1.4762	-12.9038	14.1928	-3.1151	to	3.1138
GRP04	18	-0.0000	5.3758	1.2671	-11.3208	7.5472	-2.6733	to	2.6733
GRP05	18	0.0001	8.0470	1.8967	-18.5865	13.2157	-4.0016	to	4.0018
GRP06	18	0.0002	7.6911	1.8128	-11.6779	20.1180	-3.8245	to	3.8249
GRP07	18	-0.0005	4.8319	1.1389	-10.0822	7.9013	-2.4034	to	2.4023
GRP08	18	0.0002	3.6521	0.8608	-9.2318	4.7325	-1.8160	to	1.8163
GRP09	18	0.0002	3.0618	0.7217	-7.6157	7.2849	-1.5224	to	1.5228
GRP10	18	0.0003	6.0851	1.4343	-15.2352	8.4491	-3.0258	to	3.0263

- O N E W A Y -

Variable: DEVPHKCL
by Variable SOIL

% Deviation of pH-KCl

Analysis of Variance

Source	D.F.	Sum of squares	Mean squares	F-ratio	F-prob.
Between groups	9	0.0000	0.0000	0.000	1.0000
Within groups	167	4516.5824	27.0454		
Total	176	4516.5825			

Group	Count	Mean	Standard deviation	Standard error	Minimum	Maximum	95% conf int for mean		
GRP01	18	-0.0004	4.5682	1.0767	-9.2279	6.2227	-2.2721	to	2.2713
GRP02	18	-0.0006	4.0952	0.9652	-6.9838	8.1000	-2.0371	to	2.0359
GRP03	18	-0.0008	5.7184	1.3478	-8.3976	16.7930	-2.8445	to	2.8429
GRP04	18	-0.0010	4.9665	1.1706	-8.8067	10.7348	-2.4707	to	2.4688
GRP05	17	0.0004	7.3738	1.7884	-19.3962	9.9143	-3.7908	to	3.7917
GRP06	18	-0.0002	4.5618	1.0752	-6.1614	10.9002	-2.2687	to	2.2683
GRP07	18	0.0006	3.7076	0.8739	-6.3688	8.9179	-1.8431	to	1.8444
GRP08	17	-0.0003	5.7512	1.3949	-18.2549	5.9659	-2.9573	to	2.9567
GRP09	18	-0.0004	3.8373	0.9045	-5.0714	11.3586	-1.9086	to	1.9078
GRP10	17	-0.0001	6.4447	1.5631	-18.4554	7.8048	-3.3136	to	3.3135

TABLE 5. Analysis of variance of the proportional (%) DEVIATIONS from the mean of each soil per LABORATORY.

These tables give information on the performance of each laboratory on all soils. The column 'mean' gives the mean % deviation by averaging the % deviations from the mean of each soil. Thus, the difference in weight of the soil values is eliminated.

TABLE 5.1

- O N E W A Y -

Variable: DEVBSAT
by Variable LAB

% Deviation of Base Saturation

Analysis of Variance

Source	D.f.	Sum of squares	Mean squares	F-ratio	F-prob.
Between groups	19	52287.9899	2751.9995	6.219	0.0000 VERY SIGNIF.
Within groups	174	76999.2176	442.5242		
Total	193	129287.2100			

Group	Count	(%) Mean	95% conf int.	Standard deviation	Standard error	Minimum	Maximum	95% conf int for mean		
GRP01	10	3.0	± 14.2	19.8345	6.2722	-24.9531	40.8451	-11.1474	to	17.2300
GRP02	10	39.7	22.8	31.8598	10.0749	0.0600	97.9167	16.9714	to	62.5536
GRP03	10	-22.2	10.3	14.3671	4.5433	-42.5759	0.9082	-32.5305	to	-11.9753
GRP04	10	2.8	5.6	7.7611	2.4543	-12.1172	12.5704	-2.7275	to	8.3764
GRP05	8	-7.8	15.8	18.8971	6.6811	-43.7148	16.9014	-23.6719	to	7.9248
GRP06	9	-2.3	12.2	15.8123	5.2708	-43.7148	7.0423	-14.5080	to	9.8007
GRP07	10	11.9	17.7	24.7866	7.8382	-13.6276	68.6341	-5.8046	to	29.6580
GRP08	10	-1.9	7.0	9.8013	3.0994	-28.7054	6.6325	-8.9845	to	5.0384
GRP09	10	23.8	14.2	19.7808	6.2552	-0.9406	57.5062	9.7194	to	38.0201
GRP10	10	-16.6	9.4	13.1511	4.1587	-34.8958	0.9082	-26.0724	to	-7.2570
GRP11	10	0.3	5.3	7.3817	2.3343	-17.4484	9.1877	-4.9180	to	5.6430
GRP12	9	-22.4	16.3	21.2101	7.0700	-47.4672	6.6325	-38.7331	to	-6.1260
GRP13	10	-7.9	7.5	10.5440	3.3343	-32.4578	6.6325	-15.4750	to	-0.3895
GRP14	8	17.2	35.6	42.5677	15.0500	-15.4930	117.6360	-18.3303	to	52.8445
GRP15	10	-2.7	15.0	20.9916	6.6381	-43.7148	34.9073	-17.7640	to	12.2689
GRP16	10	-4.9	11.4	15.9026	5.0289	-37.6054	20.0750	-16.3528	to	6.3993
GRP17	10	3.0	6.0	8.3555	2.6422	-16.6667	13.2075	-2.9456	to	9.0086
GRP18	10	-20.3	12.9	18.0929	5.7215	-45.0704	4.4999	-33.2999	to	-7.4141
GRP19	10	24.1	30.7	42.8782	13.5593	-39.2194	128.8931	-6.5708	to	54.7755
GRP20	10	-17.2	10.2	14.1975	4.4897	-39.2917	6.6325	-27.3673	to	-7.0547
Total	194	±12.6	±14.0	25.8821	1.8582	-47.4672	128.8931	-3.6646	to	3.6654

TABLE 5.2

- - - - - - - - - - - - O N E W A Y - - - - - - - - - - - -

Variable: DEVEXCA
by Variable LAB

% Deviation of Exchangeable Ca

Analysis of Variance

Source	D.F.	Sum of squares	Mean squares	F-ratio	F-prob.	
Between groups	19	225787.8897	11883.5730	3.669	0.0000	VERY SIGNIF.
Within groups	175	566758.2069	3238.6183			
Total	194	792546.0900				

Group	Count	(%) Mean	95% conf int.	Standard deviation	Standard error	Minimum	Maximum	95% conf int for mean		
GRP01	10	2.5	±44.1	61.6578	19.4979	-100.0000	143.5137	-41.5824	to	46.6322
GRP02	10	20.4	31.7	44.2531	13.9941	-37.4428	132.5581	-11.2374	to	52.0761
GRP03	10	-41.1	17.9	25.0368	7.9173	-100.0000	-11.1111	-59.0438	to	-23.2234
GRP04	10	40.0	63.7	89.0532	28.1611	-57.5883	272.0930	-23.6984	to	103.7111
GRP05	8	-21.5	42.6	50.9979	18.0305	-100.0000	34.0782	-64.2074	to	21.0630
GRP06	10	-14.5	35.4	49.4757	15.6456	-100.0000	62.9315	-49.9458	to	20.8398
GRP07	10	-36.5	25.2	35.1775	11.1241	-100.0000	-5.8260	-61.6650	to	-11.3360
GRP08	10	-19.6	24.2	33.8191	10.6945	-100.0000	18.0260	-43.8266	to	4.5588
GRP09	10	-44.8	21.7	30.3682	9.6033	-100.0000	-9.8972	-66.5746	to	-23.1264
GRP10	10	30.2	64.2	89.7854	28.3926	-20.4781	272.0930	-33.9841	to	94.4731
GRP11	10	-6.2	37.7	52.7180	16.6709	-100.0000	49.8546	-43.9221	to	31.5022
GRP12	9	-10.6	19.7	25.5827	8.5276	-55.5556	13.6325	-30.3409	to	8.9883
GRP13	10	22.0	17.5	24.4826	7.7421	-11.1111	61.1643	4.5784	to	39.6060
GRP14	8	119.0	129.3	154.6357	54.6720	13.2331	433.3333	-10.2726	to	248.2842
GRP15	10	-37.3	31.8	44.5105	14.0755	-100.0000	48.9362	-69.2357	to	-5.5539
GRP16	10	0.3	43.7	61.0503	19.3058	-53.4884	166.6667	-43.2987	to	44.0468
GRP17	10	-0.4	22.2	30.9902	9.8000	-78.7942	26.0229	-22.6296	to	21.7084
GRP18	10	6.2	24.9	34.8453	11.0190	-55.5556	86.9648	-18.6369	to	31.2167
GRP19	10	-4.7	16.1	22.4598	7.1024	-56.8815	17.0213	-20.8122	to	11.3212
GRP20	10	14.6	31.0	43.2921	13.6902	-66.3094	86.0465	-16.3088	to	45.6298
Total	195	±24.6	±37.2	63.9163	4.5771	-100.0000	433.3333	-9.0547	to	9.0000

Variable: DEVEXMG
by Variable LAB

% Deviation of Exchangeable Mg

Analysis of Variance

Source	D.F.	Sum of squares	Mean squares	F-ratio	F-prob.	
Between groups	19	52994.7457	2789.1971	2.923	0.0001	VERY SIGNIF.
Within groups	177	168885.5935	954.1559			
Total	196	221880.3400				

Group	Count	(%) Mean	95% conf int.	Standard deviation	Standard error	Minimum	Maximum	95% conf int for mean		
GRP01	10	-5.7	± 9.1	12.7382	4.0282	-27.2727	18.7865	-14.8184	to	3.4063
GRP02	10	7.0	10.1	14.0775	4.4517	-26.9006	25.9843	-3.0344	to	17.1065
GRP03	10	-29.7	12.3	17.1629	5.4274	-63.6364	-9.5890	-41.9895	to	-17.4343
GRP04	10	-27.3	24.3	34.0218	10.7586	-81.7251	45.4545	-51.6609	to	-2.9855
GRP05	10	16.7	26.1	36.5337	11.5530	-27.2727	110.1608	-9.4100	to	42.8592
GRP06	10	5.2	9.4	13.1639	4.1628	-27.2727	20.8791	-4.1339	to	14.6998
GRP07	10	0.4	9.2	12.8890	4.0758	-27.2727	20.8791	-8.8022	to	9.6382
GRP08	10	-2.4	8.1	11.2839	3.5683	-27.2727	10.2362	-10.5005	to	5.6435
GRP09	10	5.2	10.0	13.9633	4.4156	-12.3288	31.5789	-4.7885	to	15.1890
GRP10	10	-6.7	41.3	57.7889	18.2745	-67.0330	128.4357	-48.0611	to	34.6182
GRP11	10	18.0	6.3	8.7551	2.7686	9.0909	36.9863	11.7754	to	24.3015
GRP12	9	7.9	11.7	15.2642	5.0881	-27.2727	22.8070	-3.7359	to	19.7303
GRP13	10	2.4	18.5	25.8895	8.1870	-63.6364	27.9240	-16.0358	to	21.0046
GRP14	8	6.9	34.5	41.2599	14.5876	-56.0440	50.6849	-27.5715	to	41.4166
GRP15	10	-35.2	8.6	12.0049	3.7963	-63.6364	-21.2598	-43.8861	to	-26.7106
GRP16	10	2.7	6.9	9.6288	3.0449	-21.2598	9.8901	-4.0882	to	9.6879
GRP17	10	-1.5	14.7	20.5192	6.4887	-28.9895	45.4545	-16.2614	to	13.0957
GRP18	10	4.2	9.5	13.3210	4.2125	-27.2727	23.2877	-5.2676	to	13.7909
GRP19	10	38.3	65.6	91.7342	29.0089	-81.7251	263.6364	-27.2487	to	103.9966
GRP20	10	-5.2	6.7	9.3822	2.9669	-27.2727	5.5561	-11.9716	to	1.4517
Total	197	±11.4	±17.1	33.6458	2.3972	-81.7251	263.6364	-4.7619	to	4.6932

TABLE 5.3

- O N E W A Y -

Variable: DEVPHWAT
by Variable LAB

% Deviation of pH-H_2O

Analysis of Variance

Source	D.F.	Sum of squares	Mean squares	F-ratio	F-prob.	
Between groups	17	2830.7380	166.5140	9.180	0.0000	VERY SIGNIF.
Within groups	162	2938.3622	18.1380			
Total	179	5769.1002				

Group	Count	(%) Mean	95% conf int.	Standard deviation	Standard error	Minimum	Maximum	95% conf int for mean		
GRP02	10	4.2	±2.7	3.7364	1.1816	-0.1654	13.2157	1.5822	to	6.9280
GRP03	10	2.4	2.4	3.3937	1.0732	-1.8868	7.9013	0.0274	to	4.8828
GRP04	10	1.5	1.0	1.4591	0.4614	-0.2730	3.7736	0.4991	to	2.5867
GRP05	10	2.4	1.0	1.3737	0.4344	0.6445	4.3111	1.4992	to	3.4646
GRP06	10	5.2	1.9	2.6301	0.8317	2.8147	11.9436	3.3625	to	7.1255
GRP07	10	1.5	1.8	2.4964	0.7894	-1.6555	7.5111	-0.2285	to	3.3431
GRP08	10	5.3	3.3	4.5437	1.4368	-1.6555	14.1928	2.0809	to	8.5816
GRP09	10	-1.4	8.4	11.7303	3.7095	-18.5865	20.1180	-9.8475	to	6.9353
GRP10	10	-0.1	1.5	2.0331	0.6429	-3.7736	4.2200	-1.5998	to	1.3090
GRP11	10	-2.3	1.2	1.6325	0.5162	-5.8656	-0.2767	-3.4968	to	-1.1612
GRP12	10	-1.7	1.8	2.5506	0.8066	-4.6122	3.7736	-3.6063	to	0.0429
GRP13	10	3.3	1.2	1.7375	0.5494	-0.1654	5.5832	2.1382	to	4.6240
GRP14	10	-8.7	2.0	2.8084	0.8881	-12.5822	-3.6461	-10.7703	to	-6.7523
GRP15	10	-7.2	4.6	6.4878	2.0516	-12.9038	7.2849	-11.9333	to	-2.6511
GRP16	10	-5.6	3.6	5.0636	1.6012	-11.6779	4.3048	-9.3150	to	-2.0705
GRP17	10	-1.2	2.6	3.7045	1.1715	-8.4098	5.2987	-3.9463	to	1.3537
GRP19	10	2.4	2.9	4.0895	1.2932	-6.3786	8.4491	-0.5069	to	5.3441
GRP20	10	0.0	1.3	1.7907	0.5663	-2.8457	3.4629	-1.1930	to	1.3690
Total	180	±3.1	±2.5	5.6771	0.4231	-18.5865	20.1180	-0.8350	to	0.8350

- O N E W A Y -

Variable: DEVPHKCL
by Variable LAB

% Deviation of pH-KCl

Analysis of Variance

Source	D.F.	Sum of squares	Mean squares	F-ratio	F-prob.	
Between groups	17	2516.6956	148.0409	11.770	0.0000	VERY SIGNIF.
Within groups	159	1999.8869	12.5779			
Total	176	4516.5825				

Group	Count	(%) Mean	95% conf int.	Standard deviation	Standard error	Minimum	Maximum	95% conf int for mean		
GRP02	10	4.2	±2.4	3.3219	1.0505	-0.6363	8.5635	1.8625	to	6.6152
GRP03	10	2.0	2.0	2.7606	0.8730	-1.9559	6.9832	0.0943	to	4.0439
GRP04	7	-6.1	2.0	2.1424	0.8097	-8.8067	-3.2458	-8.1007	to	-4.1381
GRP05	10	0.5	2.1	2.8834	0.9118	-4.0287	5.5177	-1.5605	to	2.5648
GRP06	10	2.6	2.6	3.6689	1.1602	-3.2521	6.3922	0.0360	to	5.2852
GRP07	10	-0.0	2.1	2.9705	0.9394	-4.4641	4.0522	-2.1848	to	2.0651
GRP08	10	6.2	3.8	5.2895	1.6727	-1.4203	16.7930	2.4748	to	10.0426
GRP09	10	-6.0	6.5	9.0322	2.8562	-19.3962	4.5021	-12.5223	to	0.4003
GRP10	10	-3.8	1.4	2.0077	0.6349	-7.6720	-1.5026	-5.2427	to	-2.3703
GRP11	10	6.4	2.4	3.3150	1.0483	0.7626	11.3586	4.1253	to	8.8681
GRP12	10	-1.6	1.1	1.5092	0.4773	-4.7410	0.5581	-2.6939	to	-0.5346
GRP13	10	0.4	1.6	2.2205	0.7022	-1.8960	5.5177	-1.0922	to	2.0847
GRP15	10	-4.8	1.2	1.6711	0.5284	-7.2965	-1.8700	-6.0797	to	-3.6889
GRP16	10	-4.8	2.1	2.9294	0.9263	-9.2279	0.4053	-6.9546	to	-2.7635
GRP17	10	-1.3	1.3	1.7736	0.5609	-4.4698	1.4245	-2.6112	to	-0.0737
GRP18	10	1.8	3.0	4.1679	1.3180	-6.1076	7.0071	-1.1339	to	4.8292
GRP19	10	2.7	1.5	2.1039	0.6653	0.2367	6.4227	1.2450	to	4.2552
GRP20	10	-0.4	1.0	1.3373	0.4229	-1.9559	2.0497	-1.3705	to	0.5429
Total	177	±3.1	±2.2	5.0658	0.3808	-19.3962	16.7930	-0.7517	to	0.7512

APPENDIX 1[a].

METHODS FOR EXCHANGEABLE BASES

Lab	Method	Sample weight	Exchange technique	Contact time	Procedure
1	NH_4OAc pH7	10 g (or 5 g)	leaching tube	5-6 hrs	2x50ml NH_4OAc pH7. Measure bases.
2	Compulsive exchange	2 g	centrifuge tube	2 hrs	20ml .1M $BaCl_2$ (+ some NH_4Cl). Measure bases.
3	NH_4OAc pH7	2.5 g	leaching tube	1 drop/3sec	(100ml ethanol 75% if $EC_{2.5}$> 0.8mS/cm) 4x25ml 1N NH_4OAc pH7. Measure bases.
4	Mixed	10 g (?)	erlenmeyer	overnight	100ml 1N KCl: measure Ca & Mg by EDTA titration. 0.05N HCl + 0.025N H_2SO_4: K & Na flamephotometrically.
5	NH_4OAc pH7	5 g	leaching tube	> 1 hr	230ml 1M NH_4OAc pH7. Measure bases.
6	NH_4OAc pH7	5 g	filter funnel	2-24 hrs	(100ml ethanol 80% if EC_5>0.5mS/cm) 10x20ml 1N NH_4OAc pH7. Measure bases.
7	NH_4OAc pH7	5 g	leaching tube	1½ hr/100ml	100ml ethanol 1:1, 100ml 1N NH_4OAc pH7 /ethanol 1:1. Measure bases.
8	NH_4OAc pH7	3-8 g	leaching tube (after Schollenberger)	4-24 hrs	100ml 1N NH_4OAc pH7. Measure bases.
9	NH_4OAc pH7	5 g	centrifuge tube	2 hrs	30ml 1N NH_4OAc pH7 (repeat 2x). Measure bases.
10	NH_4OAc pH7	20 g	filter funnel	?	Exchange in 100 ml beaker with ca. 25 ml increments followed by progressive transfer to filter funnel. Percolate to 150 ml. Measure bases.
11	NH_4OAc pH7	2.5 g	automatic extractor	overnight	extract with ca 70ml 1N NH_4OAc pH7. Measure bases.
12	NH_4OAc pH7 & 8.2	?	centrifuge		details unknown.
13	NH_4OAc pH7	5 g	leaching tube	1½ hr/100ml	method virtually the same as lab 7.
14	NH_4OAc pH7	5 g	extraction bottle	overnight	30ml 1N NH_4OAc, filter on büchner funnel, 5x30ml 1N NH_4OAc. Measure bases.
15	NH_4OAc pH7	10 g	extracting bottle	1 hr	100ml 1 N NH_4OAc pH7, filtrate. Measure bases.
16	NH_4OAc pH7	5 g	leaching tube	overnight	2x25ml 1N NH_4OAc pH 7 (overnight with 2nd 25ml). Measure bases.
17	NH_4OAc pH7	5 g	leaching tube	?	5x20ml 1N NH_4OAc pH7. Measure bases.
18	NH_4OAc pH7	5 g	centrifuge tube	shake ½ hr stand 12 hrs	25ml 1N NH_4OAc, 5x25ml of same (shake 10 min.). Measure bases.
19	NH_4OAc pH7	25 g	erlenmeyer	overnight	50ml 1N NH_4OAc pH7, filtrate. Leach with 1N NH_4OAc pH7 until 250ml. Measure bases.
	KCl-TEA pH8.2 (calc. soils)	10 g	filter funnel	>1 hr.	Stir occasionally for 1 hr in beaker with 40 ml buffer (1N KCl + 0.2N TEA pH8.2). Transfer to funnel with Whatman no. 40 filter paper. Leach with small increments of buffer until 100 ml in vol. flask. Measure bases.
20	NH_4OAc pH7	10 g	erlenmeyer	overnight	250ml 1N NH_4OAc pH7, filtrate by büchner funnel (leach further until neg. test for Ca with NH_4oxal.). Measure bases.

APPENDIX 1[b].

METHODS FOR pH DETERMINATION

Lab	Method	Sample size	Ratio	Equilibration procedure	Measurement
1	H_2O; 0.01N KCl	10 g	1:2½	Stand overnight, then shake 1 hr.	While agitating suspension
2	H_2O; 1M KCl	4 g	1:5	1 hr. shaking	With combination electrode
3	H_2O; 1N KCl	20 ml	1:2½	2 hrs. shaking	In agitated suspension
4	H_2O; 1N KCl	10 ml	1:2½	Agitate with glass rod, then stand for 1 hr.	In agitated suspension
5	H_2O; 1N KCl	10 g	1:2½	High speed stirrer, stand overnight	Glass electr. in sedim., calomel in supernatant
6	H_2O; 1N KCl	10 ml	1:5	30 mins. shaking	Measure after settling
7	H_2O; 1N KCl	20 g	1:2½	Overnight shaking	In agitated suspension
8	H_2O; 1N KCl	15 g	1:2½	Stir several times during at least 1 hr.	In agitated suspension
9	H_2O; 1N KCl	20 g	1:1	Stir occasionally during 30 mins.	In partly settled suspension, without stirring
10	H_2O; 1N KCl	20 g	1:2½	Magnetic stirring with cooled-off boiled water	While agitating suspension. Powdered KCl added after pH-H_2O, measure then after ca. 3 mins.
11	H_2O; 0.01M $CaCl_2$	20 g	1:1 (H_2O) 1:2 ($CaCl_2$)	Stir regularly for 1 hr.	In agitated suspension
12	H_2O; 1N KCl	-	1:1	-	-
13	H_2O; 1N KCl	20 g	1:2½	Mechanical shaking for 2 hrs.	In agitated suspension
14	H_2O; -	20 ml	1:1	Stir intermittently for ½hr., then stand for ½ hr.	Glass electr. in sedim., reference in supernatant
15	H_2O; 1N KCl	-	1:2½	-	-
16	H_2O; 1N KCl	20 g	1:1	Stir regularly for 1 hr.	In agitated suspension
17	H_2O; 1N KCl	10 g	1:2½	Mechanical shaking for 2 hrs., then stand overnight	After ½ hr. mechanical shaking
18	- 0.01M $CaCl_2$	10 g	1:2½	Stir regularly for 1 hr.	-
19	H_2O; 1N KCl	-	1:2½	-	-
20	H_2O, 1N KCl	20 g	1:1	Stir several times during 30 mins.	In agitated suspension

LIST OF PARTICIPATING LABORATORIES

AUSTRALIA

CSIRO, Division of Soils, Davies Laboratory
Pte Bag, Aitkenvale, QLD 4810, Australia

Liaison officer: Dr. G.P. Gillman

BELGIUM

Lab. v. Fysische Aardrijkskunde en Bodemstudie
Geologisch Instituut
Krijgslaan 271
B-9000 Gent, Belgium

Liaison officer: Prof. Dr. C. Sys

BRAZIL

SNLS-EMBRAPA
Rua Jardim Botânico, 1024 - Gávea
22460 Rio de Janeiro, RJ, Brazil

Liaison officer: Dr. A.F. de Castro

CAMEROUN

Inst. de la Recherche Agronomique
Centre de Recherche d'Ekona
PMB 25, Buea, Cameroun

Liaison officer: Dr. S.N. Lyonga, Chief of Centre

COLOMBIA

Instituto Geografico "Agustin Codazzi"
Laboratorio de Suelos
Apartado Aereo 6721
Bogota, Colombia

Liaison officer: Dr. C. Luna Zambrano

FRANCE

Services Scientifiques Centraux
O.R.S.T.O.M.
70-74, Route d'Aulnay
93140 Bondy, France

Liaison officer: Dr. P. Pelloux

GERMANY (FRG)

Ordinariat für Bodenkunde
Universität Hamburg
Von Melle Park 10
2000 Hamburg 13, BRD

Liaison officer: Dr. G. Miehlich

INDIA

Nat. Bur. of Soil Survey & Land Use Planning
Seminary Hills, Nagpur-440 006, India

Liaison officer: Dr. V.A.K. Sarma

INDONESIA

Centre for Soil Research
Jalan Juanda 98
Bogor, Indonesia

Liaison officer: Dr. M. Sudjadi

JAPAN

Tropical Agricultural Research Center
Min. of Agric. Forestry & Fisheries
Yatabe, Tsukaba, Ibaraki,
300-21 Japan

Liaison officer: Dr. Yutaka Arita

KENYA

Kenya Soil Survey
P.O. Box 14733, Nairobi, Kenya

Liaison officer: Mr. F.N. Muchena

MALAYSIA

Analytical Services, Dept. of Agric., H.Q.
Jalan Swettenham
Kuala Lumpur, Malaysia

Liaison officer: Mr. Lim Han Kuo

MOZAMBIQUE

INIA, Dept. de Pédologia
Caixa Postal 3658, Maputo, Mozambique

Liaison officer: Mr. L. Touber

NETHERLANDS

ISRIC
P.O. Box 353, 6700 AJ Wageningen, Netherlands

Programme Secretary: Dr. L.P. van Reeuwijk

Royal Tropical Institute
Mauritskade 63, Amsterdam, Netherlands

Liaison officer: Dr. F. van der Pol

NEW ZEALAND

Soil Bureau, DSIR
Private Bag, Lower Hutt, New Zealand

Liaison officer: Mr. L.C. Blakemore

NIGERIA

I.I.T.A.
PMB 5320, Ibadan, Nigeria

Liaison officer: Dr. A.S.R. Juo

SYRIA

The Arabic Center for the Studies of
Arid Zones and Dry Lands
P.O. Box 2440, Damascus, Syria

Liaison officer: Mr. J.-O. Job

UNITED KINGDOM

Tropical Soil Analysis Unit, LRCD
Min. of Agric., Fisheries & Food
Coley Park, Reading RG1 6DT, England

Liaison officer: Mr. R. Baker

U.S.A.

Soil Conservation Service
Room 393, Federal Building
100 Centennial Mall N.
Box 52503
Lincoln, NE 68508, U.S.A.

Liaison officer: Dr. J.M. Kimble

Dept. of Agronomy & Soil Science
College of Tropical Agriculture
3190, Maile Way
Honolulu, Hawaii 96822, U.S.A.

Liaison officer: Dr. J.A. Silva

VENEZUELA

CENIAP, MAC
Seccion Suelos
Maracay 200, Venezuela

Liaison officer: Dr. A.V. Chirinos

ISBN 90-6672-015-8