Soils Formed from the Andesitic and Basaltic Volcanic Ashes II. Soil Properties and Fertility Problems

著者	YAMADA Ichiro, SHOJI Sadao
journal or publication title	Tohoku journal of agricultural research
volume	26
number	3/4
page range	102-116
year	1976-03-30
URL	http://hdl.handle.net/10097/29701

Tohoku Journal of Agricultural Research
Vol. 26, No. 3–4, December 1975
Printed in Japan

Soils Formed from the Andesitic and Basaltic Volcanic Ashes

II. Soil Properties and Fertility Problems

Ichiro YAMADA, and Sadao SHOJI

Department of Agronomy, Faculty of Agriculture,
Tohoku University, Sendai, Japan

(Received, December 27, 1975)

Summary

The physical, chemical, and clay mineralogical properties of Utsunomiya and Sagamihara soils of which parent materials were andesitic and basaltic, respectively, were determined. On the basis of the results reported in the previous paper and in the present study, general discussion was made concerning the edaphic factors relating to plant growth in these soils togerther with Kawatabai soil derived from the dacitic ash.

Both Utsunomiya and Sagamihara soil profiles having fine texture, showed about 50 percent or more liquid phase and 20 percent solid phase.

Though allophane was dominant in the clay fractions of Utsunomiya and Sagamihara soils, the content was much greater in the latter than in the former. On the other hand, allophane was not found in the clay fraction of Kawatabi soil. The composition of crystalline clay minerals was dominated by Al-vermiculite in all the soils. Imogolite was observed in the clay fraction of the Sagamihara soil.

The percentages of total carbon and nitrogen were great in all the soils. However, the carbon nitrogen ratio was the lowest in Sagamihara, and the highest in Kawatabi. The humic acids of all the soils were determined to belong to the A type, which has the highest degree of humification.

The high CEC values of all the soil samples were ascribed not only to their humus fraction, but also to their inorganic colloid fraction. The amounts of exchangeable cations and base saturation degrees were much greater in Sagamihara, than in Utsunomiya and Kawatabi soils. The soil acidity was in this order: Sagamihara<Utsunomiya<Kawatabi. It was found that the amounts of the exchange acidity were closely related to the contents of Al-vermiculite. All the soils showed high phosphate absorption coefficients, especially the Sagamihara and Utsunomiya.

The results mentioned above indicate that most of the clay mineralogical and chemical properties of the soils are closely related to the rock types of the parent ashes.

Finally edaphic or soil factors having remarkable effects on the growth of crop plants were discussed. It was concluded that Sagamihara soil was extremely fertile. On the other hand, Kawatabi soil was the lowest in soil fertility.

In the previous paper (1), it was reported that Utsunomiya and Sagamihara soils had been formed from andesitic and basaltic parent ashes, respectively, and that the formation of the extremely deep humus horizons was mainly related to the juvenation of the old systems caused by intermittent ash deposits. Furthermore, irrespective of the difference in the petrological nature of the parent ashes, the profile characteristics of both soils were found to be similar.

It has been commonly insisted that not only the soil formation, but also soil properties are greatly influenced by the rock types of the parent ashes (2, 3). However, a recent investigation performed by Yamada *et al.* (4) indicated that there were important contradictions in the criteria adopted by soil scientists to determine the rock types of volcanic ashes. Therefore, the information concerning the relationships between the rock types of the parent ashes and the soil properties reported so far, should be reexamined carefully.

The object of the present paper is to study the physical, chemical, and clay mineralogical properties of Utsunomiya and Sagamihara soils, and to discuss the edaphic factors relating to plant growth in these soils together with Kawatabi soil derived from the dacitic ash (5).

Materials and Methods

The details of Utsunomiya and Sagamihara soils were described in the previous paper (1). The mechanical composition of the soil samples was determined by the pipett method after the removal of soil organic matter and a sonic treatment. The ratio of solid, liquid, and air phases was measured by the volumenometric method (6).

The whole clay fraction (<2u) was separated from the soil samples by the sedimentation method after the hydrogen peroxide treatment and then sonication. Size-fractions such as <0.2u, 0.2–1u, 1–2u, were obtained by the centrifugation of the deferrated <2u fraction (7). If necessary, the NaOH-treatment was employed (8).

After the various treatments, the X-ray diffraction patterns of oriented clay specimens were obtained with Cu-Kα radiation using Rigaku Denki Geigerflex. Infrared absorption spectra of the clay specimens were measured by using a Hitachi infrared spectrophotometer Model EPI–S_2. Electron optical observation of the clay specimens was carried out using JEOL Model JEM 100 B.

Total carbon and nitrogen contents were determined by the ignition method. The analysis of humus composition was made after Kumada's method (9). Wada and Haradas' method (10) was adapted to the measurement of cation exchange capacity (CEC) values of soil samples. Exchangeable cations of soils were extracted with 1N ammonium acetate solution. Then Ca and Mg ions were determined by Versene titration, and Na and K ions, by flamephotometry. Soil pH and exchange acidity values were determined by the standard method. For the determination of the phosphate absorption coefficient, the ratio of soil to solution of 2.5% $(NH_4)_2HPO_4$ was changed to 1: 5, instead of the standard ratio (1: 2.5).

Results and Discussion

Physical Properties

According to the soil structure, weathering degrees of heavy minerals, the content of phytolith, and so on, the present authors divided the profiles of Utsunomiya and Sagamihara soils into two parts, upper and lower (1). The same division was made concerning the profile of Kawatabi soil (5). As seen in Tables 1 and 2, Utsunomiya and Sagamihara soils are fine-textured from the top layers

TABLE 1. *Physical Properties of Utsunomiya Soil*

Sample No.	Mechanical composition (*Weight* %)					Three phase analysis(*Volume* %)		
	Coarse sand	Fine sand	Silt	Clay	Silt+ Clay	Solid phase	Liquid phase	Air phase
1	9.0	20.0	36.3	34.8	71.1	19.3	48.7	32.0
2	6.6	11.7	40.1	41.7	81.8			
3	12.9	10.0	32.0	35.2	67.2			
4	15.7	21.2	30.0	33.1	63.1	21.8	48.4	29.7
5	18.7	23.4	27.5	30.4	57.9			
6	15.7	24.7	27.0	32.6	59.6			
7	18.3	22.5	29.9	29.3	59.2	20.3	57.8	21.9
8	17.5	22.2	29.8	30.5	60.3			
9	20.8	19.5	32.1	27.6	59.7	19.1	63.4	17.6
10	19.8	20.6	31.5	28.2	57.0			
11	22.8	20.2	27.3	29.7	50.0			
12	25.4	23.9	28.9	22.0	50.9			
13	24.6	29.1	26.7	19.6	46.3			
14	28.5	30.7	22.0	18.9	40.9			
15	46.9	24.6	15.3	13.2	28.5			

TABLE 2. *Physical Properties of Sagamihara Soil*

Sample No.	Mechanical composition (*Weight* %)					Three phase analysis (*Volume* %)		
	Coarse sand	Fine sand	Silt	Clay	Silt+ Clay	Solid phase	Liquid phase	Air phase
1	13.0	22.3	29.6	35.0	64.6	20.5	49.4	30.2
2	10.9	22.7	28.9	37.5	66.4			
3	9.0	21.3	30.8	38.8	69.6			
4	6.5	20.5	32.3	40.7	73.0	19.5	50.9	29.6
5	7.3	19.0	39.5	34.1	73.6			
6	3.1	18.4	40.9	36.0	76.9			
7	1.6	14.6	47.8	36.0	83.8	17.5	60.0	22.5
8	1.6	12.4	42.1	44.0	86.1			
9	1.5	10.7	50.6	37.2	87.8	18.9	67.2	14.0
10	1.7	12.1	48.9	37.2	86.1			
11	2.7	19.2	44.6	33.5	78.1			
12	3.8	38.0	33.5	14.6	48.1			
13	11.3	42.4	28.5	7.7	36.2			

to 100 cm depth, and show no significant difference in the texture between the upper and lower parts. However, it is noticeable that the contents of the sand fractions decrease remarkably in the lower part of Sagamihara profile. Since considerable amounts of weathered large scoria particles were found to be present in the fresh soil samples of this part, the sonic treatment prior to the mechanical analysis broke these particles into the silt-size.

The percentage of the liguid phase was determined using the selected samples of fresh soils (Tables 1 and 2). It is greater in the lower parts than in the upper parts of both Ustunomiya and Sagamihara profiles, suggesting the higher contents of amorphous materials in the lower parts. On the contrary, the percentage of the solid phase is much less than that of the liquid phase and shows no significant difference among the soil samples.

Clay Mineral Composition

X-ray diffraction patterns given in Fig. 1 were obtained from the deferrated clay specimens (<2u) of the selected soil samples. All the specimens show intense 14–15 Å peaks and small 10 Å and 7 Å peaks. However, it should be noted that the peak intensity is greater in the Utsunomiya than in the Sagamihara specimens, and in the top layers of both profiles than in the other layers.

Figs. 2 and 3 show the X-ray diffraction diagrams of the <0.2u, 0.2–1u, and 1–2u fractions separated from the NaOH-treated <2u fractions of the top layers of both profiles. Since the size-fractions of all the soil samples show the same patterns to the various treatments, the diagrams of these specimens are not shown here. Both 14–15 Å and 10 Å peaks hardly expand after the treatment with ethylene glycole, indicating that the 10 Å peaks are the (001) diffraction of illite. The 7 Å peaks of all the specimens partly shift to 10.4 Å after the hydrazine treatment, showing that a part of the 7 Å peak is due to the (001) diffraction of kaolin minerals. After the heat treatment at 300°C, the 14–15 Å peaks shift largely to 10Å, but show the tailing to the low angle side. Therefore, almost all of the 14–15Å peak is attributable to the (001) diffraction of Al-vermiculite. The specimens subjected to the heat treatment at 550°C show the presence of small amounts of chlorite. From the results described above, the composition of crystalline clay minerals is dominanted by Al-vermiculite in all the soil samples.

Infrared absorption spectra of the defrrated <2u and <0.2u clay specimens are reproduced in Figs. 4 and 5. All the <2u specimens show the absorption bands at about 1090, 1030, 1000–950, and 800 cm^{-1} in the region of wave numbers ranging from 1300 to 600 cm^{-1}. Since some amounts of quartz were found to be present in all the <2u specimens by the X-ray analysis, the spectra at 1090 and 800 cm^{-1} are due to this mineral. The strong bands occurring at about 1030 cm^{-1} are attributable to Al-vermiculite and other layer silicates. The bands or shoulders at 1000–950 cm^{-1} disappear after the NaOH-treatment, showing that these

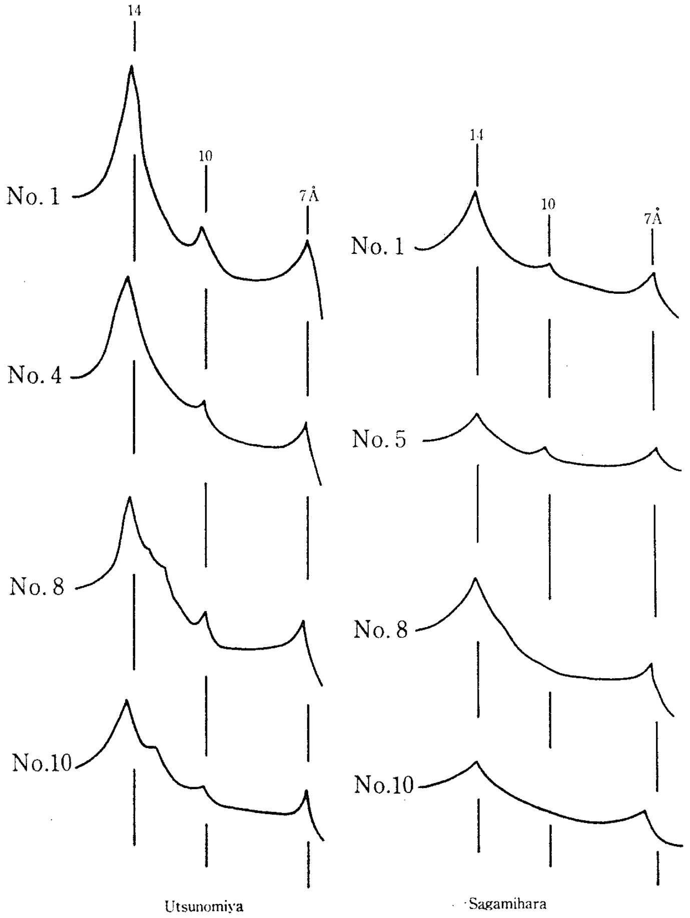

Fig. 1. X-ray Diffraction Patterns of the $<2\mu$ Clay Specimens (Ca-saturated).

absorption spectra are ascribed to allophane.

Absorption bands due to the crystalline minerals are scarcely found in all the <0.2u clay specimens except for the top layer of the Utsunomiya profile. Therefore, almost all of the components of the <0.2u fraction are allophane.

Comparing the band at 1000–950 cm^{-1} due to allophane, the band at 1030 cm^{-1} due to the layer silicates is much greater. Studying the infrared absorption of the artificial mixtures of crystalline clay minerals and allophane, Kobo and Oba (11) showed that the band due to allophane at 1000–950 cm^{-1} were recognized in the mixtures containing allophane more than 50 percent. Consequently, it is obvious that all the <2u clay specimens are also dominated by allophane.

As supposed in the X-ray diffraction analysis, the allophane contents of <2u specimens are smaller in Utsunomiya than in Sagamihara, and in the top layers than in the other layers of both profiles. On the contrary, it was indicated that allophane was absent in the clay fraction of Kawatabi soil (5, 12).

Electron optical observation shows that laminar opaline silica particles are

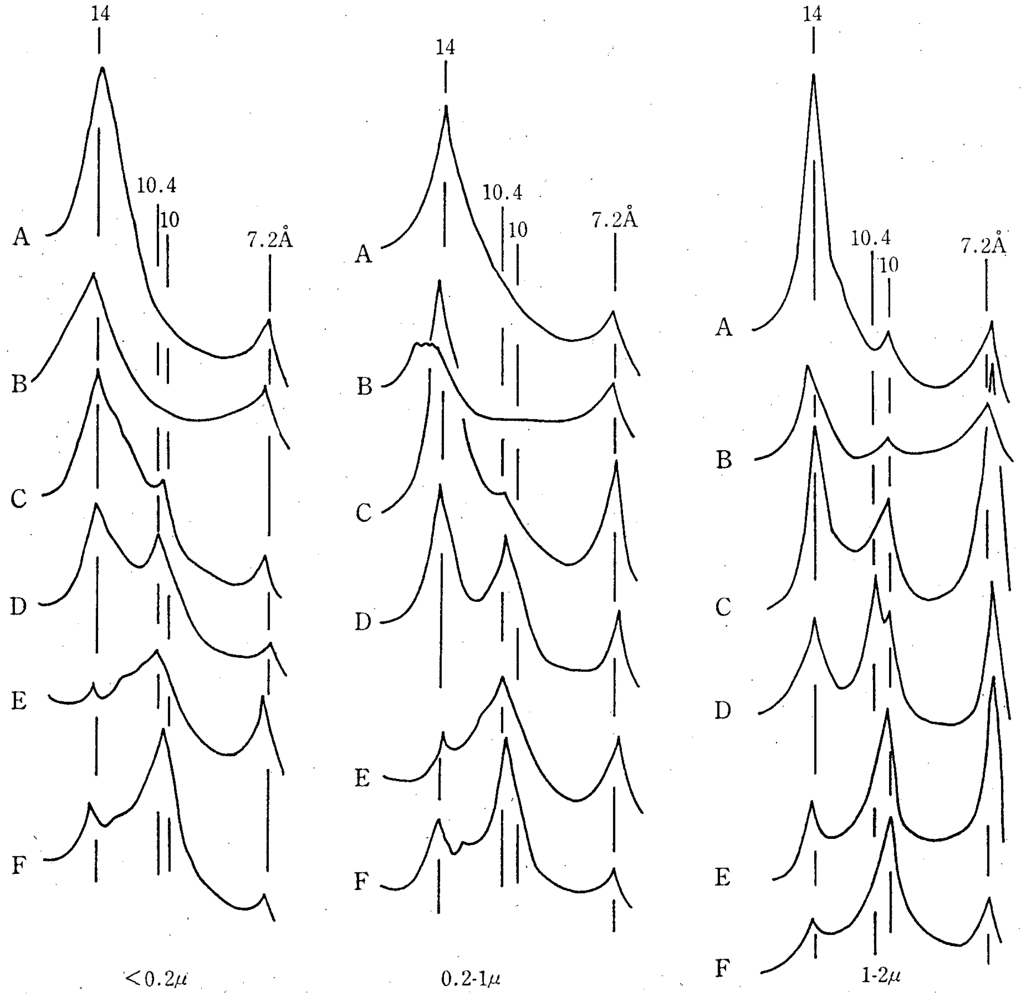

FIG. 2. X-ray Diffraction Patterns of the Size Fractions Separated from No. 1 Sample of Utsunomiya Soil.
A, Ca-saturated: B, Ca-saturated and ethylene glycole treated;
C, K-saturated and air-dried; D, K-saturated and hydrazine treated; E, K-saturated and heated to 300°C; F, K-saturated and heated to 550°C.

present in all the clay specimens (Plate 1). However, the numbers of these particles are larger in the top layers than in the other layers, as already reported by Shoji and Masui (13). Imogolite is found only in all the layers below the top of the Sagamihara profile and its content is relatively high in the lower part of the same profile (Plate 1).

From the foregoing results, it seems likely that the formation of clay minerals in volcanic ash soils is closely related to the rock types of their parent materials. However, further investigation must be done on the relation between the weathering of clay minerals and the rock types of the parent ashes.

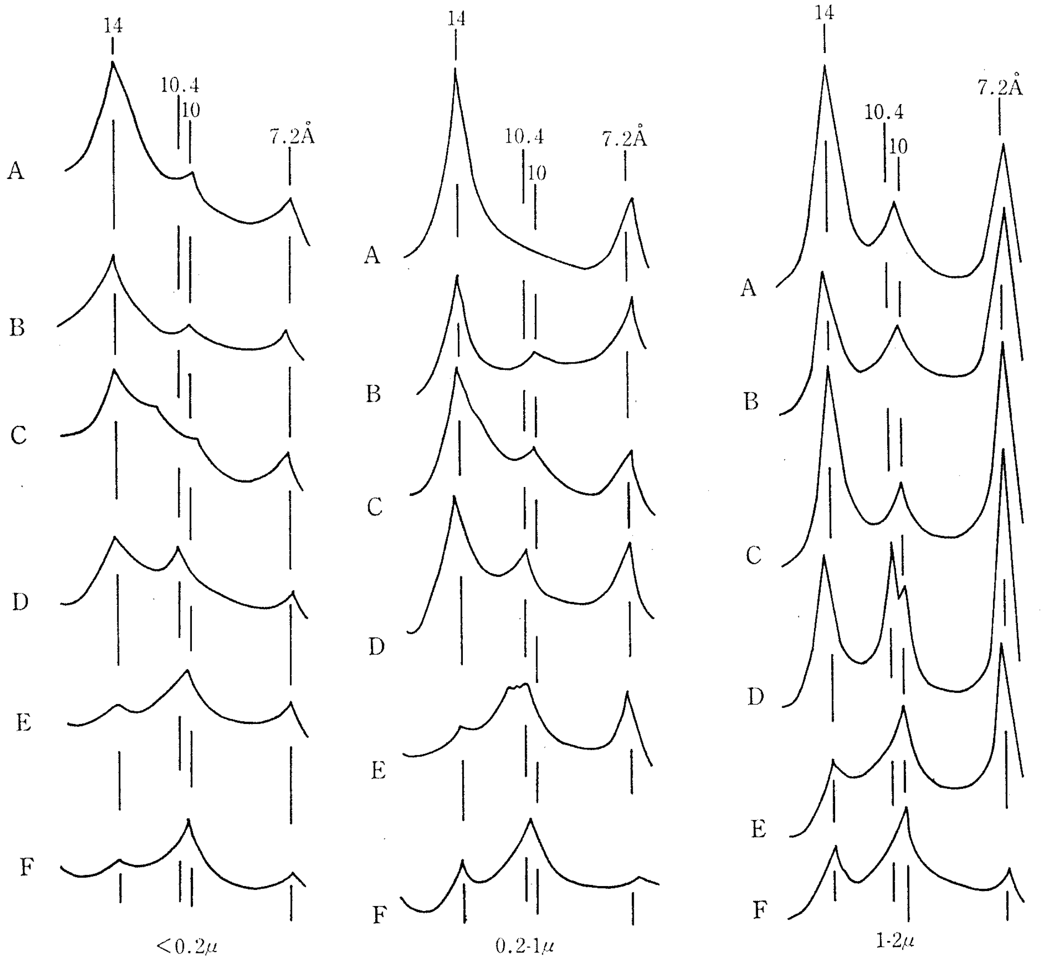

Fig. 3. X-ray Diffraction Patterns of the Size Fractions Separated from No. 1 Sample of Sagamihara Soil.
A, Ca-saturated; B, Ca-saturated and ethylene-glycole treated; C, K-saturated and air-dried; D, K-saturated and hydrazine treated; E, K-saturated and heated to 300°C; F, K-saturated and heated to 550°C.

Chemical Properties

The chemical properties of Utsunomiya, Sagamihara, and Kawatabi soils are given in Tables 3, 4, and 5, respectively. The average humus contents of the soil samples belonging to A-horizons are 17.2 percent in Utsunomiya, 16.3 percent in Sagamihara, and 17.0 percent in Kawatabi. However, the top layers of both upper and lower parts in all the profiles are slightly greater in the humus content than in the other layers. The percentages of total nitrogen are great in all the samples, reflecting their high humus contents and show slight differences in the mean values among three profiles. However, it should be noted that the mean carbon nitrogen ratios are 13.3 for Sagamihara, 15.9 for Utsunomiya and 18.1 for Kawatabi, indicating a close relation between the carbon nitrogen ratio and the petrological nature of the parent ashes.

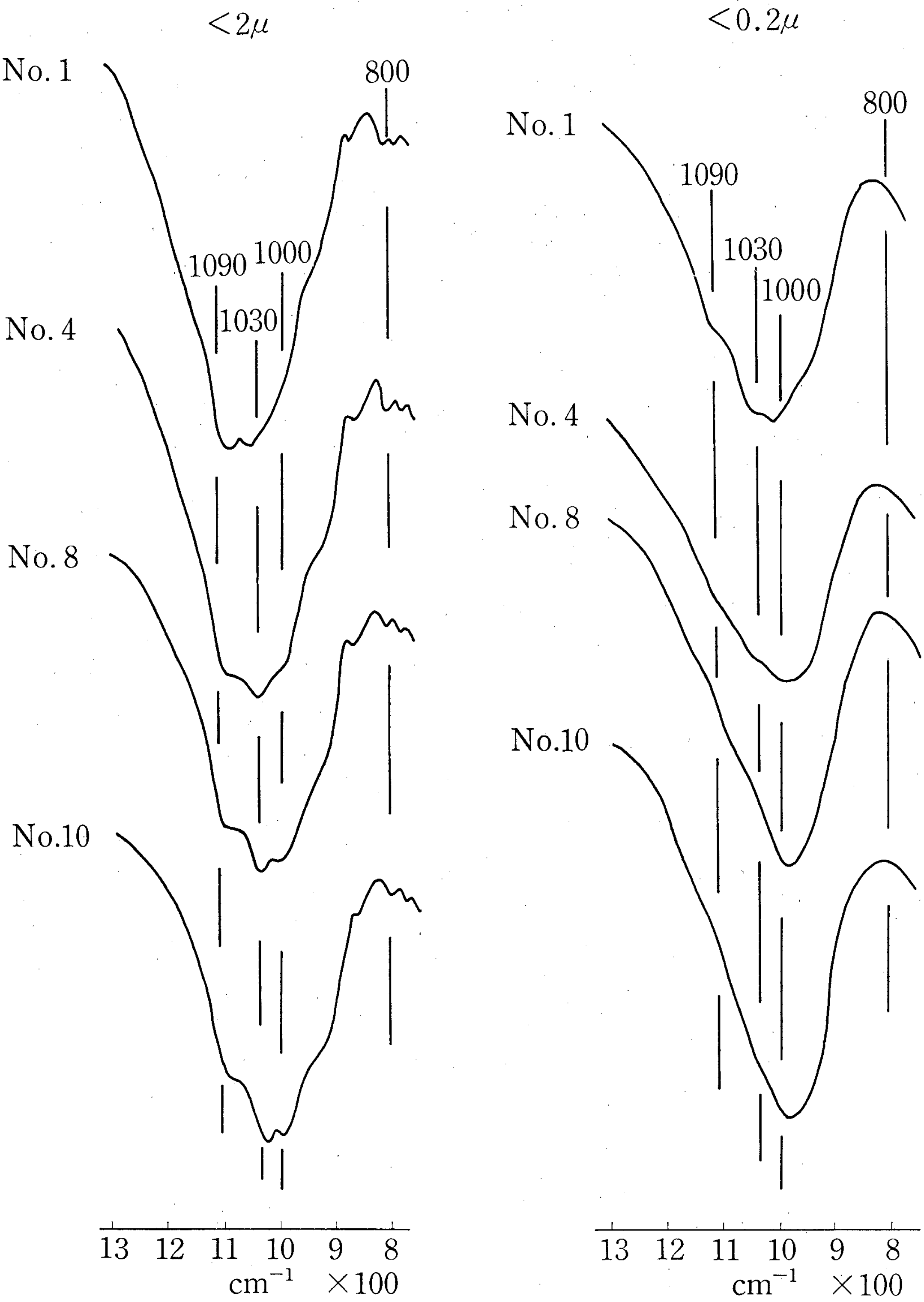

FIG. 4. **Infrared Absorption Spectra of the Clay Specimens of Utsunomiya Soil.**

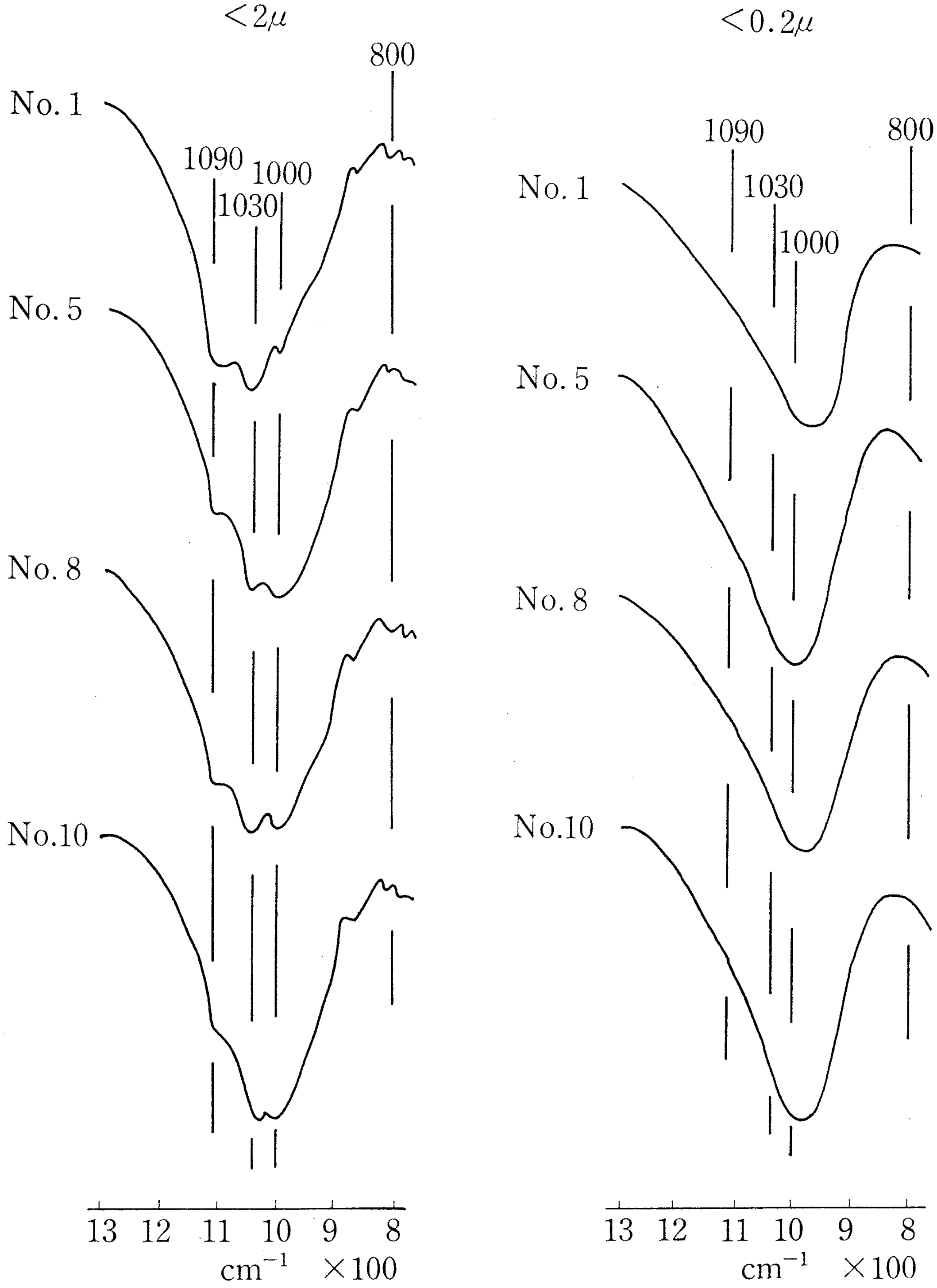

FIG. 5. Infrared Absorption Spectra of the Clay Specimens of Sagamihara Soil.

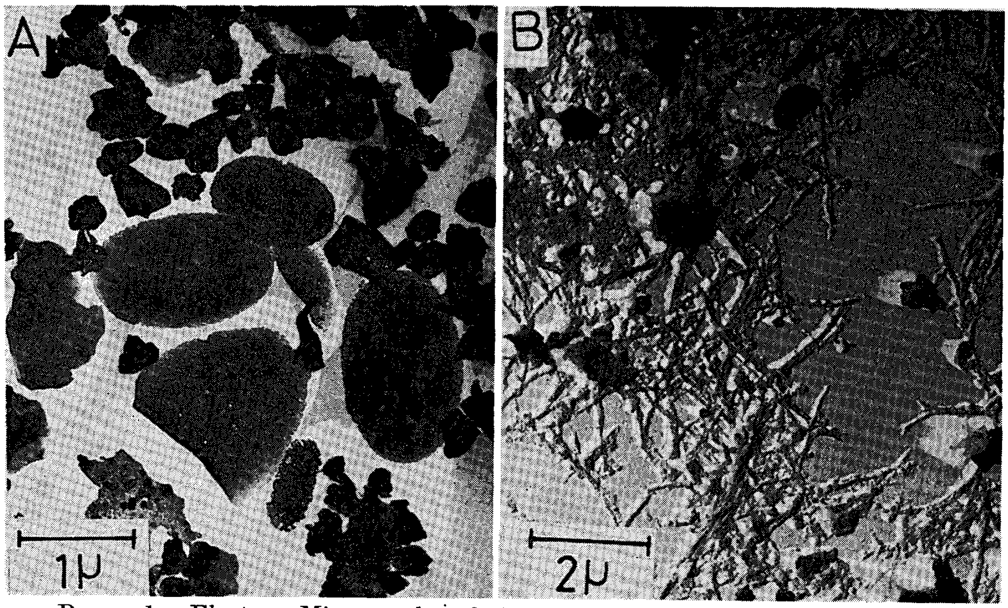

PLATE 1. Electron Micrographs of the Clay Specimens.
A, 1–0.2 u fraction separated form No. 1 sample of Utsunomiya soil
B, <0.2 u fraction separated from No. 10 sample of Sagamihara soil

About a half of the soil organic matter of the selected soil samples is extracted by 0.1N NaOH treatment (Tables 3, 4 and 5). Almost all of the samples show the PQ values greater than 60 percent, RF values greater than 110, and $\Delta \log K$ smaller than 0.5. Using a classification diagram basal on the values of $\Delta \log K$ and RF, Kumada et al (9) grouped humic acids into four major types; A, B, Rp and P types. According to this classification, the humic acids of all the samples are determined to be A type, or of the highest degree of humification.

Comparing the degrees of humification of the humic acids separated from different soils, it seems that the degrees are slightly greater in Utsunomiya than in Sagamihara and Kawatabi soils. On the other hand, the values of PQ and RF are relatively low in the top layers of all the profiles, probably reflecting the plentiful supply of plant residues to these layers. The values of PQ and RF are also slightly lower in the upper than in the lower parts in all the profiles.

The high CEC values of humus rich horizons in volcanic ash soils have been ascribed mainly to their humus fraction. The average CEC values and the humus contents of the humus horizons are 40.1 me/100 g, and 17.2 percent for Utsunomiya, 45.2 and 16.3 for Sagamihara, 21.8 and 17.0 for Kawatabi, respectively. Linear correlation equations between humus content and CEC are not significant for Utsunomiya, Sagamihara, and Kawatabi, but for Ustunomiya and Sagamihara. On the other hand, the mean clay percentages are 29.5 for Utsunomiya, 37.0 for Sagamihara, and 19.2 for Kawatabi. Furthermore, as mentioned before, allophane in the clay fraction is present in large amounts in Sagamihara and in considerably large amounts in Utsunomiya. Therefore, the content and property of inorganic

TABLE 3. *Chemical Properties*

Sample No.	Humus %	Total-C %	Total-N %	C/N	Humus composition				CEC (me/100 g)
					HE/HT[1)]	PQ[2)]	Δ log K[3)]	RF[4)]	
1	22.8	13.2	0.90	14.6	44	55	0.51	95	44.9
2	19.0	11.0	0.75	15.4	44	65	0.51	113	38.8
3	15.6	9.0	0.59	15.4					37.1
4	14.4	8.4	0.51	16.8	46	71	0.50	114	35.1
5	14.6	8.5	0.51	16.6	46	67	0.51	124	37.3
6	19.0	11.0	0.70	15.6					46.2
7	20.4	11.8	0.75	15.8	54	73	0.51	124	50.2
8	19.2	11.2	0.75	15.6	48	71	0.51	129	49.5
9	20.2	11.6	0.70	17.1	51	75	0.51	131	49.5
10	19.2	11.1	0.65	17.3	48	75	0.52	128	46.9
11	17.1	9.9	0.62	15.8					44.2
12	14.8	8.6	0.54	15.8					41.0
13	13.6	7.9	0.50	15.8					35.5
14	10.4	6.0	0.41	14.7					30.8
15	2.0	1.2	0.10	12.3					14.7

1) Percent of extracted humus by 0.1 N NaOH and 0.1 M $Na_2P_2O_7$ solutions in total
2) Percent of humic acid in extracted humus by 0.1 N NaOH solution.
4) K_{600} mμ/0.1 N $KMnO_4$ consumed by 30 ml of the humic acid in extracted humus
5) Soil: 0.2% $(NH_4)_2HPO_4$=1 g: 5ml
below No. 6, to the lower part.

TABLE 4. *Chemical Properties*

Sample No.	Humus %	Total-C %	Total-N %	C/N	Humus composition				CEC (me/100 g)
					HE/HT	PQ	Δ log K	RF	
1	20.3	11.2	0.88	13.3	48	55	0.52	90	42.7
2	17.4	10.1	0.77	13.2	48	58	0.49	111	39.0
3	16.8	9.8	0.80	12.4					43.3
4	18.1	10.5	0.82	12.8	48	66	0.49	115	44.5
5	17.2	10.0	0.83	12.2	48	61	0.50	114	45.0
6	17.9	10.4	0.76	13.7					47.6
7	20.6	11.9	0.85	13.9	43	63	0.51	122	51.7
8	19.5	11.3	0.83	13.8	46	65	0.53	117	50.1
9	17.8	10.3	0.79	14.5	45	66	0.53	114	52.4
10	19.7	11.4	0.80	14.5					52.5
11	12.7	7.4	0.60	12.3					46.1
12	7.8	4.5	0.39	10.7					37.6
13	6.0	3.5	0.31	11.0					34.6

NB; The soil samples from No. 1 to 6 belong to the upper part of the profile, and

colloid fractions also plays an significant role in the CEC of soil samples used for the present study.

It is interesting that the amounts of exchangeable cations and base saturation degrees are much greater in the Sagamihara profile, especially in the lower part of this profile than in the Utsunomiya and Kawatabi profiles, reflecting the rock types of their parent materials.

of Utsunomiya Soil

Exchangeable bases (me/100 g)				Degree of base saturation (%)	pH (H_2O)	pH (KCL)	Y_1	Phosphate absorption (mg P_2O_5/100g)[5]
Ca	Mg	K	Na					
0.46	0.28	0.31	0.08	2.6	4.05	3.95	20.4	3780
0.14	0.10	0.11	0.07	1.1	4.50	4.17	8.98	4930
0.14	0.02	0.07	0.06	0.8	4.75	4.18	5.70	4530
0.14	0.06	0.05	0.06	0.9	4.87	4.13	4.74	4090
0.20	0.08	0.05	0.07	1.1	4.87	4.30	1.97	4010
0.27	0.07	0.05	0.07	1.0	4.82	4.15	8.97	4650
0.21	0.09	0.06	0.08	0.9	4.82	4.27	8.28	5100
0.21	0.08	0.05	0.07	0.8	4.92	4.22	8.17	4930
0.25	0.10	0.04	0.08	1.0	5.08	4.22	6.41	5270
0.46	0.10	0.05	0.07	1.5	5.15	4.26	2.02	5090
0.48	0.13	0.03	0.08	1.6	5.33	4.35	3.14	5380
0.48	0.17	0.02	0.07	1.8	5.46	4.30	1.88	5070
0.44	0.11	0.04	0.06	1.8	5.60	4.20	1.16	4690
0.39	0.07	0.04	0.08	1.9	5.90	4.43	0.63	4530
0.12	0.02	0.02	0.09	1.7	6.20	4.56	0.22	2640

humus.

3) log K_{400} mμ-log K_{600} mμ of extracted humus by 0.1 N NaOH solution.
by 0.1 N NaOH.

NB; The soil samples from No. 1 to 6 belong to the upper part of the profile, and those

of Sagamihara Soil

Exchangeable bases (me/100 g)				Degree of base saturation (%)	pH (H_2O)	pH (KCL)	Y_1	Phosphate absorption (mg P_2O_5/100 g)
Ca	Mg	K	Na					
3.97	1.22	0.28	0.09	13.0	4.50	4.32	4.30	4180
1.95	1.02	0.16	0.06	8.2	4.80	4.45	1.86	4510
3.85	1.07	0.13	0.08	11.9	5.22	4.45	0.90	4810
5.68	2.00	0.12	0.07	17.9	5.39	4.45	0.55	5060
6.42	2.07	0.06	0.10	19.2	5.53	4.53	0.55	5210
6.58	2.51	0.08	0.14	19.6	5.55	4.48	0.44	5440
7.49	3.15	0.05	0.11	22.2	5.45	4.48	0.45	5790
7.57	2.82	0.05	0.14	21.1	5.40	4.45	0.42	5770
7.38	2.76	0.05	0.11	19.7	5.35	4.57	0.43	5920
7.58	2.34	0.03	0.13	18.9	5.37	4.55	0.44	6150
5.62	1.97	0.03	0.14	17.0	5.43	4.43	0.31	6130
4.73	1.48	0.04	0.15	17.1	5.58	4.52	0.50	5490
3.91	1.38	0.04	0.12	15.8	5.70	4.45	0.21	5620

those below No. 6, to the lower part.

The average pH value of each profile ranges from 5.0 to 5.3. However, the top layers of the upper parts in all the profiles show the lowest pH values, partly because of the existence of soluble organic acids. On the other hand, the average of exchange acidity values (Y_1) is 0.9 in Sagamihara, 5.3 in Utsunomiya and 12.1 in Kawatabi. The top layers of the upper and the lower parts of each soil profile tend to have higher exchange acidity values. Since the exchange acidity of soils

TABLE 5. *Properties*

Sample No.	Mechanical composition (%)				Humus %	Total-C %	Total-N %	C/N	Humus	
	Coarse sand	Fine sand	Silt	Clay					HE/HT	PQ
1	8.2	32.2	37.8	21.6	23.8	14.0	0.85	16.5	nd	68
2	5.6	40.5	37.0	17.0	10.9	6.4	0.38	18.9		
3	16.4	34.2	31.4	17.9	22.8	13.4	0.51	26.2	nd	76
4	14.9	25.8	35.3	26.9	23.1	13.6	0.84	16.2	nd	83
5	17.1	25.2	28.1	14.9	16.8	9.9	0.78	12.7	nd	76
6	18.8	35.0	29.5	16.8	3.8	2.8	0.17	16.2		

1) The data except humus composition, pH (KCL), Y_1, and phosphate absorption

NB; The soil samples from Nos. 1 to 2 belong to the upper part of the profile, and those

is ascribed to the permanent negative charges of 2: 1 layer silicates (15, 16), the amounts of the exchange acidity mentioned above appear to be closely related to the contents of Al-vermiculite of the soil samples on the basis of the results of X-ray analysis.

All the soil samples show high phosphate absorption coefficients, and the lower parts of all the profiles show a tendency to have higher coeffecients than the upper parts. As for the mean coefficients, those of the Utsunomiya and Sagamihara soil samples are much greater than that of Kawatabi, presumably reflecting the percentage of clay fraction and the content of amorphous materials in this fraction. Kato (17) and Yoshida (18) reported that allophanic volcanic ash soils absorb more phosphate than those containing larger amounts of layer silicates.

Edaphic Factors Relating to Plant Growth

Edaphic, or soil factors having remarkable effects on the growth of crop plants will be discussed briefly on the basis of the results mentioned so far.

Utsunomiya, Sagamihara, and Kawatabi soils with extremely deep humus horizons have well-developed granular, or blocky structure and high water permeability, and do not contain gravels. Therefore, all these soils are suitable for deep plowing, and so are highly resistant to drought hazard. However, wind erosion problems should be taken into consideration, because of the physical properties such as low bulk density and relatively unstable soil structure which are common to humus rich volcanic ash soils.

The contents of total nitrogen show slight differences among the three profiles. However, the carbon-nitrogen ratios are the lowest in Sagamihara, and the highest in Kawatabi. This fact suggests that the nitrogen mineralization potential is highly different among three soils.

All the soils have the high CEC values aiding to the retention of cations. It is remarkable that the amounts of exchangeable Ca and Mg ions are plentiful in Sagamihara soil samples. Therefore, the soil pH values of the Sagamihara soil *of Kawatabi Soil*1)

composition		CEC (me/100 g)	Exchangeable base (me/100 g)				Degree of base saturation (%)	pH (H_2O)	pH (KCL)	Y_1	Phosphate absorption (mg P_2O_5/100 g)
$\Delta \log K$	RF		Ca	Mg	K	Na					
0.48	83	27.2	0.59	0.42	0.69	0.18	6.9	4.40	4.15	21.9	2230
		15.7	0.22	0.09	0.34	0.17	5.2	5.00	4.39	4.82	3350
0.57	95	26.4	0.27	0.02	0.36	0.14	3.0	5.10	4.15	6.91	3890
0.59	98	25.0	0.29	0.04	0.19	0.15	2.7	5.10	4.20	17.7	4750
0.58	93	24.1	0.21	0.02	0.15	0.12	2.1	5.20	4.27	16.4	4160
		12.1	0.09	0.02	0.14	0.11	3.0	5.45	4.37	1.88	3340

coefficient were cited from Masui et al. 5) and Kato (unpublished).
below No. 2, to the lower part.

samples are greater than those of the Utsunomiya and Kawatabi soil samples. The values of exchange acidity due to the permanent negative charges of 2:1 layer silicates show that the acidity degrees are strong in Kawatabi, medium in Utsunomiya, and weak in Sagamihara. This fact is well coincident to the contents of Al-vermiculite in these soils. Consequently, the depth of crop rooting is considerably limited in Utsunomiya and Kawatabi profiles.

Though all the soil samples have high phosphate absorption coefficients, it seems likely that the availability of applied phosphate is greater in the Sagamihara soil with the highest contents of exchangeable Ca and Mg ions than in the other soils. As for the minor nutrient elements, the total and available Cu concentrations are higher in the Sagamihara than in the Utsunomiya and Kawatabi soils (19). However, large differences in the zinc contents among three soils was not found (19).

From the foregoing discussion, it is evident that the carbon-nitrogen ratio of soil organic matter, content of exchangeable Ca and Mg ions, concentrations of total and available Cu, and soil acidity are closely related to the rock types of the parent ashes. Therefore, compared with Utsunomiya and Kawatabi soils, Sagamihara soil is extremely fertile. On the other hand, Kawatabi soil is the lowest in soil fertility.

References

1) Shoji, S., Yamada, I., and Masui, J., *Tohoku J. Agr. Res.* **25**, 104 (1974)
2) Mohr, E. C., and Van Baren, F.A., "*Tropical Soil*" Interscience Publishers, Ltd. London, p 212 (1954)
3) Kobo, K., and Oba, H., *J. Sci. Soil Manure*, **44**, 41 (1973) (in Japanese with English summary)
4) Yamada, I., Shoji, S., Kobayashi, S., and Masui, J., *Soil Sci. Pl. Nutr.* **21**, 319 (1975)
5) Masui, J., Shoji, S., Saigusa, M., Ando, H., Kobayashi, S., Yamada, I., and Saito, K., *Tohoku J. Agr. Res.* **24**, 166 (1973)

6) Misono, S., *J. Sci. Soil Manure*, **29**, 67 (1958) (in Japanese with English summary)

7) Mehra, O.P., and Jackson, M.L., *Clays Clay Min.* **5**, 317 (1960)

8) Hashimoto, I., and Jackson, M.L., *Clays Clay Min.* **5**, 102 (1960)

9) Kumada, K., and Ota, N., *J. Sci. Soil Manure*, **36**, 57 (1965) (in Japanese with English summary)

10) Wada, K., and Harada, Y., *Proc. Intern. Clay Confer.* (Tokyo), **1**, 561 (1969)

11) Kobo, K., and Oba, H., *J. Sci. Soil Manure*, **45**, 1 (1974) (in Japanese with English summary)

12) Mizota, C., and Aomine, S., *Soil Sci. Pl. Nutr.* **21**, 201 (1975)

13) Shoji, S., and Masui, J., *J. Soil Sci.* **22**, 101 (1972)

14) Kumada, K., and Ota, N., *J. Sci. Soil Manure*, **38**, 267 (1967) (in Japanese with English summary)

15) Yoshida, M., *J. Sci. Soil Manure*, **41**, 483 (1970) (in Japanese with English summary)

16) Yoshida, M., *J. Sci. Soil Manure*, **42**, 329 (1971) (in Japanese with English summary)

17) Kato, Y., *J. Sci. Soil Manure*, **41**, 218 (1970) (in Japanese with English summary)

18) Yoshida, M., and Miyauchi, N., *J. Sci. Soil manure*, **46**, 89 (1975) (in Japanese with English summary)

19) Saito, K., "*Master Thesis*", P. 18 (1975) (in Japanese)