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PRELIMINARY REPORT ON SOIL CONDITIONS IN YAP ISLAND AND ULITHI ATOLL OF THE FSM

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Abstract

Seventy-one soil samples were collected from upland soils of Yap and four inhabited islands of Ulithi Atoll (Mogmog, Falalop, Asor, Fassarai Islands) of Yap State which were planted to taro, coconut palm and citrus trees. Chemical properties of the soil samples collected were examined and differences in the soils from the various islands were determined.

The soil samples collected from the four islands of Ulithi Atoll were alkaline since the soil pH was greater than 8.1. The soil samples collected on Yap were neutral (average pH=7.0). These differences were due to the method by which the islands were formed. Ulithi Atoll was formed by the upheaving of coral from a reef while Yap was formed by a volcanic eruption. The soil exchange capacity (EC) was higher in soils of the Ulithi Atoll islands than in those of Yap Island. The water content was very high in soils of taro patches while the soil water content was low in soils in which citrus and coconuts were growing. There were no clear differences in soil nitrogen, phosphate, potassium, calcium and magnesium among the samples collected on all the islands. The nitrogen, phosphate and potassium levels were low while calcium and magnesium content was high in all soil samples collected.

Keywords: chemical property, EC, pH, soil, water content

Introduction

The agricultural productivity of Yap State of the Federated States of Micronesia (FSM) is low. Taro, coconut, banana, and a few other tropical crops are the main crops grown on Yap Island and the four inhabited islands in Ulithi Atoll of Yap State.

The low yields of all crops grown in Yap State can be accredited to several factors, including geographic location, climatic conditions, and etc., but soil conditions could play a major role in the low yields obtained. Crops grow well and produce high yields on soils of good texture and chemical content, therefore an investigation of soil properties is needed to determine the role soils play in the low yields received in Yap State. In order to establish the physical and chemical property status of the soils of Yap State, 71 soil samples were collected from upland soils of Yap and the four inhibited islands of the Ulithi Atoll that were planted to taro, coconut palm and citrus. The soil properties of the samples collected were compared.

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Materials and Methods

A total of 71 soil samples were collected from Yap and the four inhabited islands (Mogmog, Falalop, Asor, and Fassarai) of the Ulithi Atoll. Of the 71 samples, 27 samples were collected on Yap Island, 12 were collected on Mogmog, 12 on Falalop, 8 on Asor and 12 samples were collected on Fassarai Island. A sampling plot of each island is shown in Fig. 1. Soil samples were obtained by digging to a 20 cm depth after determining the north latitude and longitude of each sampling position. The collected soil samples were brought to Kagoshima University under refrigeration. In a Kagoshima University laboratory, the principal chemical characteristics of the samples (pH, EC, water content, nitrogen (N), phosphate (P_2O_5), potassium (K_2O), calcium

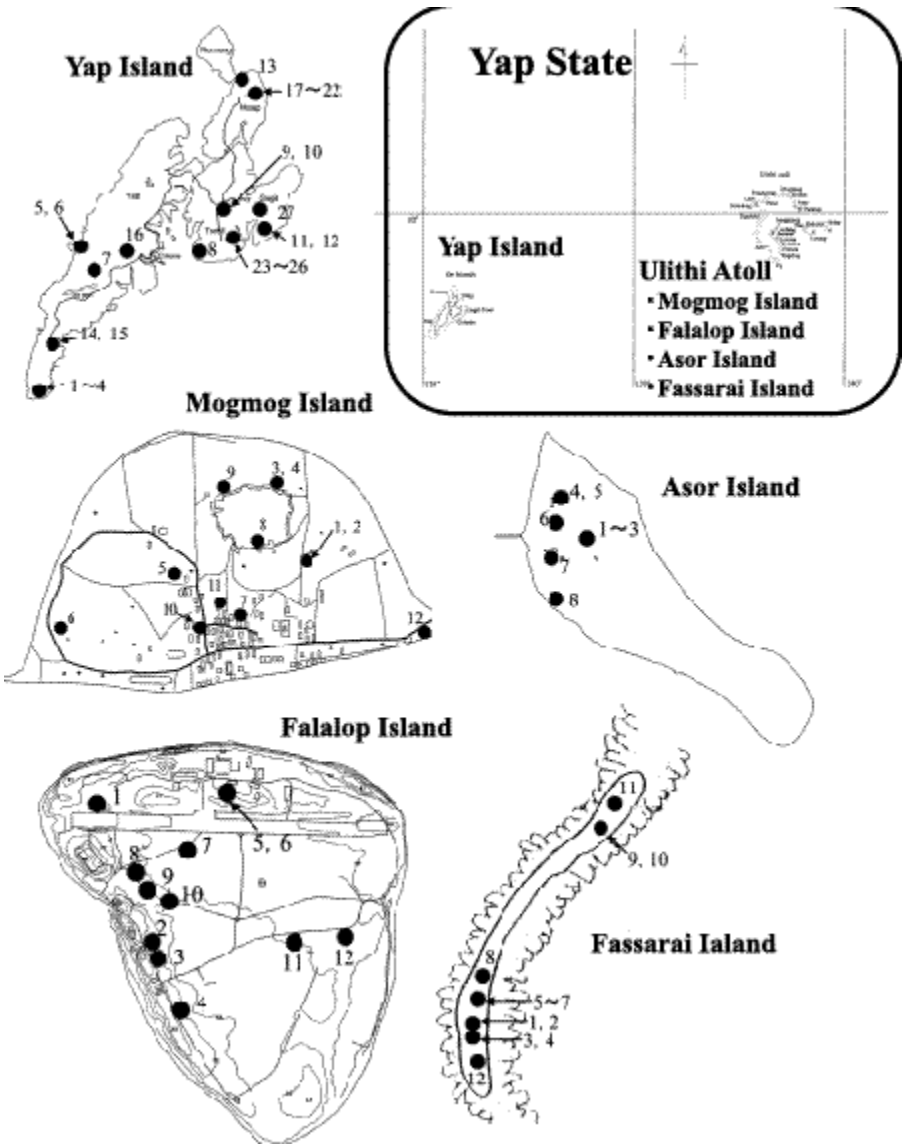

Fig.1 Locations of soil sampling plots

(CaO) and Magnesium (MgO)) were determined. The chemical determinations were conducted using standard laboratory methods and nitrogen, phosphate, potassium, calcium and magnesium analysis were calculated to percent or mg per soil dry weight.

Results and Discussion

Yap Island

The pH value of 27 soil samples (20 citrus plantings, 6 taro patches and 1 other) that were collected on Yap Island showed high coefficients of variation (C.V.) for soil pH that ranged from pH=4.7 to pH=8.8 with an average pH of 7.0. Thirteen of the 27 soil samples from Yap Island were alkaline with a pH greater than 7.5. Eight of the soil samples collected from Yap Island were acid with a pH of 6.5 or less while others were neutral in pH (pH=6.6 to 7.4). The exchange capacity (EC) was low in all soils sampled with an average EC value of 0.061. Twenty-one of the 27 soils had very low EC values that were less than 0.100. The soil water content of the samples collected on Yap Island varied between 8.8 and 85.5% with an average soil water content of 25.6%. The soil water content of soil samples taken from taro patches varied between 33.1 and 85.5% while the water content of soil samples taken from citrus plantings ranged between 8.8 and 31.3%. The nitrogen content of the soils sampled on Yap Island varied between 0.12 and 1.16% with an average nitrogen content of 0.40%. Phosphate content of the same samples varied between 0.53 and 6.32 mg/100g soil and the mean phosphate value was 2.42 mg/100g of soil. Twenty-four of 27 soil samples contained 3.01 mg of potassium per 100g of soil. Soil calcium content varied between 13.99 and 391.72 mg of calcium per 100g of soil with a mean value of 136.14 mg/100g of soil. Magnesium content varied between 8.95 and 117.72 mg/100g with a mean soil calcium value of 4.01 mg/100g of soil (Table 1).

Mogmog Island

The pH value of 12 soil samples (6 from citrus plantings, 5 from taro patches and 1 from a coconut planting) collected on Mogmog Island in Ulithi Atoll had a low C.V., were alkaline, and the pH values ranged from 7.5 to 8.6. The mean EC value of the soils sampled on Mogmog Island was 0.157 and the range in EC value was between 0.075 and 0.361. The pH and the EC values of soils sampled on Mogmog Island tended to be higher than those of Yap Island. The water content was highest in soils sampled from taro patches and was lowest in soils sampled in citrus plantings. The average, minimum and maximum nitrogen levels in the soils sampled were 0.97, 0.17 and 2.15%, respectively. The nitrogen content in soils obtained from taro patches tended to be higher than in samples taken from plots in which coconut or citrus was growing. Phosphate content of soil samples taken from Mogmog Island was much higher than those of Yap Island. The average, minimum and maximum values were 21.63, 0.58, and 183.50 mg/100g, respectively. The average value for potassium content of the Mogmog soil samples was 14.06 mg/100g of soil but eight of twelve soils showed a similar potassium content of 3.01 mg/100g of soil. The calcium content of the soils sampled on Mogmog Island was lower than those of Yap Island and the average, minimum and maximum calcium values of the Mogmog soil samples were 31.62, 2.80 and 75.55 mg/100g of soil, respectively. The magnesium content of the soils sampled on Mogmog Island was higher than those collected from Yap Island. Soil magnesium levels of the soils sampled on Mogmog Island were similar to the soil magnesium levels of soil samples taken from the other Ulithi Islands with an average soil magnesium content of around 100 mg/100g (Table 2).

Falalop Island

Twelve soil samples were collected from Falalop Island (8 from citrus plantings, 2 from taro patches, and 2 from coconut plantings). All soils sampled on Falalop were highly alkaline and the soil pH of all soils sampled on Falalop was greater than 8.1 with a mean pH value of 8.4. The mean C.V. for the pH values of the soils sampled on Falalop was 3.0. The pH of soils on Falalop Island were higher than that of the soil samples collected on Yap Island. The EC value of the soil samples collected from Falalop Island was 0.126 and minimum and maximum EC values were 0.053 and 0.206, respectively. The average, minimum and maximum soil water contents were 19.0, 3.9 and 48.7%, respectively. The water content of taro patch soils was as high in soil samples collected from taro patches on Falalop Island as they were in taro patches sampled on the other islands. The nitrogen content of the soils sampled on Falalop Island was the lowest of all the soils sampled on the islands of the Ulithi Atoll, although the soil nitrogen content from Falalop Island soil samples was higher than that of the soils sampled on Yap Island. The average, minimum, and maximum soil nitrogen values for soils sampled on Falalop Island

Table 1. Chemical properties of upland soil collected on Yap Island of the FSM

Location No.	Crop	North latitude	Longitude	pH	EC	Water content	N (%)	P_2O_5	K_2O	CaO	MgO
								(mg/100g・dw)			
1	Citrus	9.26.30	138.04.00	7.0	0.062	25.4	0.21	2.27	3.01	263.01	49.91
2	Taro	9.26.30	138.04.00	7.1	0.063	33.1	0.17	1.84	3.01	324.57	35.98
3	Citrus	9.26.19	138.03.51	8.3	0.135	19.4	0.38	1.28	3.01	13.99	92.52
4	Citrus	9.26.19	138.03.51	7.5	0.107	13.9	0.30	0.53	3.01	16.76	75.11
5	Citrus	9.30.56	138.04.49	7.9	0.022	21.7	0.20	2.21	3.01	114.72	107.60
6	Taro	9.30.56	138.04.49	8.7	0.011	35.4	0.12	0.99	3.01	156.69	68.65
7	Citrus	9.30.43	138.05.34	7.1	0.035	23.2	0.30	1.11	3.01	142.70	75.77
8	Citrus	9.31.31	138.09.14	8.0	0.022	28.7	0.22	0.64	3.01	64.35	30.51
9	Citrus	9.31.36	138.10.09	6.4	0.014	15.5	0.96	0.73	3.01	198.66	25.04
10	Citrus	9.31.43	138.10.07	6.9	0.067	19.5	1.04	0.58	3.01	64.56	85.39
11	Citrus	9.31.20	138.10.57	7.5	0.032	22.9	0.22	1.54	3.01	151.09	83.07
12	Citrus	9.31.20	138.10.57	8.5	0.113	17.4	0.14	1.02	3.01	53.16	56.87
13	Citrus	9.36.36	138.10.27	8.3	0.096	9.5	0.58	5.49	3.01	72.75	102.63
14	Citrus	9.28.17	138.04.23	8.4	0.101	8.8	0.17	3.45	3.01	-	121.37
15	Citrus	9.28.35	138.04.27	4.7	0.043	15.9	0.32	3.61	3.01	131.51	8.95
16	Citrus	9.30.36	138.06.46	7.8	0.085	20.7	0.34	6.32	3.01	36.37	98.98
17	Citrus	9.36.04	138.10.37	7.0	0.060	21.8	0.28	2.82	3.01	58.76	117.72
18	Taro	9.36.04	138.10.37	5.3	0.068	58.7	0.26	2.14	3.01	176.27	73.12
19	Taro	9.36.06	138.10.38	6.3	0.031	35.9	0.17	3.09	3.01	22.38	78.59
20	Taro	9.36.06	138.10.38	5.6	0.026	46.4	0.32	1.14	3.01	95.13	103.63
21	Citrus	9.36.08	138.10.43	8.3	0.117	15.7	0.41	4.37	3.01	25.18	96.00
22	Citrus	9.36.04	138.10.49	8.8	0.085	9.2	0.19	5.11	6.03	391.72	98.15
23	Taro	9.32.01	138.10.00	4.7	0.036	85.5	0.93	0.94	3.01	148.29	61.35
24	Citrus	9.31.53	138.10.08	5.9	0.022	31.3	0.41	2.59	3.01	139.90	85.06
25	Citrus	9.31.52	138.10.13	6.9	0.049	21.1	0.37	2.82	15.06	268.61	44.10
26	Citrus	9.31.48	138.10.15	6.5	0.034	20.0	0.53	4.68	9.04	237.83	50.73
27	Garden	9.32.01	138.10.22	7.8	0.113	14.9	1.16	1.95	6.03	170.68	73.62
Average	-	-	-	7.0	0.061	25.6	0.40	2.42	3.91	136.14	74.02
C.V.	-	-	-	17.6	60.039	64.3	73.35	67.16	67.04	72.87	39.18

were 0.49, 0.22 and 0.85%, respectively. Phosphate content of the soils sampled on Falalop Island was the lowest of the four islands of Ulithi Atoll and varied between 0.78 and 20.37 mg/100g of soil. The average soil phosphorous content was 4.21 mg/100g. Soil potassium levels of the soils sampled on Falalop Island were similar to the soil potassium levels of soil samples taken from Yap Island and Asor Island, but the potassium level of Falalop soils was lower than those of Mogmog Island and Fassarai Island. The calcium content of the Falalop Island soil samples were the highest of any soil sampled on the Ulithi Atoll but lower than that of Yap Island. The soil calcium minimum and maximum values for the Falalop Island soils was 2.80 to 492.45 mg/100g of soil. The soil magnesium content of Falalop Island soils was the lowest of all soils sampled from the Ulithi Atoll Islands but higher than that of Yap Island (Table 3).

Table 2. Chemical properties of upland soil collected on Mogmog Island in Ulithi Atoll of the FSM

Location No.	Crop	North latitude	Longitude	pH	EC	Water content	N (%)	P_2O_5	K_2O	CaO	MgO
								(mg/100g・dw)			
1	Citrus	10.04.58	139.42.42	8.0	0.091	11.4	0.43	1.20	3.01	75.55	93.01
2	Taro	10.04.58	139.42.42	7.9	0.307	89.1	2.07	183.50	45.19	16.79	108.43
3	Taro	10.05.00	139.42.41	7.6	0.361	79.6	2.03	5.94	84.35	11.19	104.45
4	Taro	10.05.00	139.42.41	7.5	0.208	78.7	1.84	5.71	9.04	11.19	107.77
5	Citrus	10.04.59	139.42.36	8.4	0.065	12.3	0.36	2.35	3.01	44.77	102.80
6	Citrus	10.04.55	139.42.29	8.6	0.124	15.1	0.72	2.29	3.01	-	103.63
7	Citrus	10.04.56	139.42.39	8.4	0.081	8.8	0.42	7.75	3.01	8.39	106.11
8	Taro	10.04.59	139.42.39	7.7	0.180	81.0	2.15	23.44	6.03	44.77	102.80
9	Taro	10.05.01	139.42.38	8.1	0.200	34.2	0.66	3.82	3.01	47.57	100.81
10	Citrus	-	-	8.5	0.117	16.6	0.35	4.57	3.01	53.16	95.83
11	Citrus	-	-	7.9	0.075	15.7	0.41	18.36	3.01	2.80	100.14
12	Coconut	-	-	8.6	0.078	7.4	0.17	0.58	3.01	-	107.27
Average	-	-	-	8.1	0.157	34.5	0.97	21.63	14.06	31.62	102.76
C.V.	-	-	-	5.1	61.649	89.9	82.02	237.93	179.13	77.60	4.60

Table 3. Chemical properties of upland soil collected on Falalop Island in Ulithi Atoll of the FSM

Location No.	Crop	North latitude	Longitude	pH	EC	Water content	N (%)	P_2O_5	K_2O	CaO	MgO
								(mg/100g・dw)			
1	Citrus	10.00.55	139.47.20	8.7	0.071	10.6	0.35	3.63	3.01	-	103.63
2	Citrus	10.00.39	139.47.25	8.7	0.053	7.8	0.22	1.12	3.01	41.97	106.78
3	Citrus	10.00.39	139.47.25	8.4	0.097	12.4	0.38	4.06	3.01	2.80	87.05
4	Citrus	10.00.32	139.47.32	8.3	0.148	14.3	0.85	1.88	6.03	-	104.95
5	Taro	10.00.56	139.47.30	8.3	0.142	26.9	0.51	0.78	3.01	-	101.30
6	Coconut	10.00.56	139.47.30	8.2	0.192	43.0	0.54	11.33	3.01	492.45	106.28
7	Taro	10.00.50	139.47.28	8.2	0.176	48.7	0.67	2.23	3.01	55.96	87.71
8	Citrus	10.00.46	139.47.27	8.1	0.206	3.9	0.52	1.07	6.03	-	106.78
9	Citrus	10.00.46	139.47.27	8.3	0.132	14.8	0.76	20.37	3.01	-	97.66
10	Citrus	10.00.46	139.47.27	8.4	0.084	11.6	0.29	1.93	3.01	47.57	102.80
11	Citrus	10.00.39	139.47.32	8.6	0.089	15.8	0.45	0.88	3.01	2.80	77.26
12	Coconut	10.00.42	139.47.45	8.9	0.117	18.2	0.40	1.20	3.01	-	84.72
Average	-	-	-	8.4	0.126	19.0	0.49	4.21	3.52	107.26	97.24
C.V.	-	-	-	3.0	39.108	72.6	38.14	139.36	33.36	177.22	10.57

Asor Island

The Asor Island soils, as was the case with the other Ulithi Island soils, were alkaline. The average pH was 8.2 with a 7.9 minimum pH and an 8.5 maximum pH. The average, minimum and maximum EC were 0.152, 0.068 and 0.294, respectively. The soil water content was high in taro patch soils (43.0 to 86.8%) while the soil water content of soils of citrus and coconut plantings was much lower (7.1 to 16.3%). The average soil nitrogen content was 0.92%, but 2 of the taro patch soils sampled had soil nitrogen levels greater than 2%. Soil phosphate content in one soil sample from a citrus grove was high (i.e. 11.64 mg/100g of soil). However, the remaining 7 citrus soils had low phosphate levels (less than 1.48 mg/100g). The phosphate content of the samples taken from the taro patches varied between 0.82 and 12.51 mg/100g. All soil samples from Asor Island showed similar potassium content in the range of 3.01 mg/100g. However, the calcium content fluctuated widely depending on sampling points. The average, minimum and maximum calcium values were 79.04, 2.08 and 170.68 mg/100g, respectively. The average soil magnesium content of Asor Island soils was 102.03 mg/100g, but the soil magnesium content did not fluctuate greatly among the sampling points (Table 4).

Table 4. Chemical properties of upland soil collected on Asor Island in Ulithi Atoll of the FSM

Location No.	Crop	North latitude	Longitude	pH	EC	Water content	N (%)	P_2O_5	K_2O	CaO	MgO
								(mg/100g・dw)			
1	Citrus	10.01.28	139.46.03	8.4	0.082	14.8	0.50	1.48	3.01	-	86.38
2	Citrus	10.01.28	139.46.04	8.4	0.093	16.3	0.38	0.78	3.01	81.14	96.83
3	Taro	10.01.28	139.46.02	7.9	0.189	86.8	2.16	12.51	3.01	61.56	113.41
4	Taro	10.01.33	139.46.00	7.9	0.294	67.2	0.97	2.49	3.01	-	105.12
5	Taro	10.01.33	139.46.00	8.1	0.252	43.0	0.47	0.82	3.01	-	102.13
6	Taro	10.01.31	139.45.58	8.0	0.142	80.8	2.32	8.16	3.01	2.80	110.42
7	Citrus	10.01.24	139.46.01	8.5	0.068	7.1	0.21	11.64	3.01	170.68	93.68
8	Coconut	10.01.22	139.46.05	8.4	0.095	11.6	0.33	1.28	3.01	-	108.27
Average	-	-	-	8.2	0.152	40.9	0.92	4.87	3.01	79.04	102.03
C.V.	-	-	-	3.1	55.941	80.9	92.41	104.09	0.00	88.02	9.00

Fassarai Island

As was the case with soils of the other Ulithi Islands, Fassarai Island soils were alkaline. The average, minimum and maximum pH values were 8.1, 7.7 and 8.8, respectively. The average, minimum and maximum EC of Fassarai Island soils was the highest of all soils sampled on the four Islands of the Ulithi Atoll and had a average EC value of 0.162. Soil water content of the taro patches sampled also fluctuated greatly. Minimum and maximum water content in soils of the taro patches was 22.0 and 84.0%, respectively. As was the case with other island soils, the soil water content of soils in which citrus was growing was low compared to the taro patches. The nitrogen level of Fassarai Island soils was similar to that of the other islands of the Ulithi Atoll. The average, minimum and maximum soil nitrogen content of Fassarai Island soils was 0.81, 0.29 and 1.97%, respectively. The phosphate content of Fassarai Island soils was the highest of all soils sampled from the 4 islands of the Ulithi Atoll and Yap Island. The average soil phosphorous content was 31.66 mg/100mg. The potassium content of Fassarai Island soils was lower than that of Mogmog soils but higher than those of Yap, Falalop and Asor Islands. The average soil potassium content sampled from Fassarai Island was 9.04 mg/100g. The mean calcium content of soils sampled on Fassarai Island was the lowest of the 4 islands of Ulithi Atoll and

Yap Island. Soil calcium in Fassarai Island soils was measured at 21.45 mg/100g of soil. The average, minimum and maximum magnesium values obtained for Fassarai Island soils was 98.09, 89.03 and 108.10 mg/100g, respectively (Table 5).

Table 5. Chemical properties of upland soil collected on Fassarai Island in Ulithi Atoll of the FSM

Location No.	Crop	North latitude	Longitude	pH	EC	Water content	N (%)	P_2O_5	K_2O	CaO	MgO
								(mg/100g・dw)			
1	Citrus	9.53.59	139.39.33	8.4	0.098	13.4	0.57	29.58	9.04	36.37	94.17
2	Citrus	9.53.59	139.39.33	8.2	0.106	14.5	0.43	14.85	0.00	30.78	101.80
3	Taro	9.53.59	139.39.33	7.7	0.229	-	-	-	-	-	-
4	Taro	9.53.59	139.39.33	7.6	0.173	84.0	1.97	64.84	0.00	0.00	108.10
5	Citrus	9.53.59	139.39.35	8.7	0.081	9.4	0.29	3.33	6.03	19.59	102.96
6	Taro	9.53.59	139.39.35	7.7	0.213	-	-	-	-	-	-
7	Taro	9.53.59	139.39.35	7.7	0.239	82.6	1.93	169.50	48.20	25.18	99.15
8	Citrus	9.54.01	139.39.33	8.4	0.106	12.5	0.50	16.84	6.03	53.16	91.19
9	Field	9.54.38	139.40.01	8.8	0.075	13.4	0.40	2.19	3.01	5.60	103.96
10	Taro	9.54.58	139.40.01	8.1	0.377	41.4	0.55	2.93	6.03	-	100.97
11	Taro	9.54.40	139.40.02	8.2	0.112	22.0	0.72	5.57	6.03	13.99	89.53
12	Citrus	9.53.50	139.39.34	8.2	0.134	16.0	0.77	6.94	6.03	8.39	89.03
Average	-	-	-	8.1	0.162	30.9	0.81	31.66	9.04	21.45	98.09
C.V.	-	-	-	4.9	54.972	93.9	75.62	164.46	155.56	78.53	6.80

Conclusions

Some chemical properties of upland soils of Yap and 4 inhabited islands of Ulithi Atoll were compared. Soils of the 4 islands of the Ulithi Atoll were alkaline with an average soil pH greater than 8.1. Yap Island soils had an average soil pH of 7.0 (neutral) although soil pH varied greatly between the Yap Island samples. The high soil pH found on the four islands of the Ulithi Atoll was probably due to the formation of the Atoll which was formed by the upheaving of a coral reef while Yap Island was formed by a volcanic eruption. The soil EC was higher in soils of the Ulithi Atoll Islands compared to those of Yap Island. Soil water content was very high in taro patch soils and low in soils of citrus and coconut plantings. Soil nitrogen content was high in some soil samples although soil nitrogen levels were low in most soils of all the islands surveyed. The high nitrogen samples could have resulted from the spreading of manure or fertilizer on the sampled area by the inhabitants. The soil phosphate and potassium content was low in all soil samples taken. Soil calcium and magnesium content was relatively high, however, it is not clear why the differences between islands exist.

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