西表島開墾地及び林地の土壌理化学性(生産環境学科)

Physical and Chemical Properties of the Soil in the Reclaimed Land and Forest of Iriomote Island

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Summary

Available phosphate and exchangeable Al in the soil were determined in order to refer them for better soil management measures as a part of previous investigation[4] on changes in physical and chemical properties of the soil abandoned after clearing forest. In addition some of physical and chemiical properties of the forest soil near the reclamation experiment site were investigated in the vertical extension for the same purpose.

The level of available phosphate in the soil was higher in the DG and DN plots that were cleared by a rakedozer than in the EG and EN plots that were cleared by a bulldozer. Exchangeable Al in the soil was higher in the EG and EN plots than in the DG and DN plots. Changes in the levels of availavle phosphate and exchangeable Al in the soil were not clearly observed for the time course of 15 years after clearing forest.

The vertical examination of some of the soil's physical and chemical properties in 2 forest sites revealed that soil nutrients tended to decrease steeply from the surface to a deeper layer, but reversely dispersion rate to increase.

It was deemed that intensive soil management should be practiced to control soil erosion and to improve soil fertility if the land was reclaimed from the forest by a bulldozer.

Introduction

On the soil that was abandoned after clearing forest, changes in physical and chemical properties were investigated and some parts were reported in a previous paper[3]. The present study was aimed to supplement the status of phosphate and Al in the soil used for previous investigation. In addition vertical changes of soil's chemical and physical properties were presented as a reference to the land management in the investigated area of Iriomote Island.

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Investigation I

1 . Materials and Methods

The experiment plots covered A plot that was under forest as control, DG plot that was abandoned after pangola grass cultivation for 3 years after clearing the forest by a rakedozer, DN plot that was left unused after clearing by the above method, EG plot that was abandoned after pangola grass cultivation after clearing the forest by a bulldozer, and EN plot that was left unused after clearing by the above method. The DG and DN plots were prepared by clearing forest by a rakedozer to leave the original surface soil in situ but the EG and EN plots were prepared by a bulldozer to flatten the ground. That is, the surface soil to a depth of 1 m or so was moved to lower ground and the subsurface soil was exposed by the use of bulldozer. These clearing and preparation was done in 1976.

Three surface soil samples (0-15 cm) were collected from each plot in 1976, 1979 and 1991. The soils were analyzed to determine physical and chemical properties. The major parts of determination were already reported in a previous paper[4]. The soil's status of available phosphate and exchangeable Al was investigated in this paper.

The determination of available phosphate and exchangeable Al followed a method stated elsewhere[1,5]. Namely, soil phosphate was extracted with 0.002 N H_2SO_4 and spectrophotometrically determined by Guinea - green B method at 630 nm wave length, and designated as available phosphate. Exchangeable Al was extracted 5 times with 1 N KCl solution at a ratio of soil to solution 1:10. The extracted Al and hydrogen ions were titrated with 0.1 N sodium hydroxide then back titrated for Al with 1 N HCl after an addition of 4% sodium fluoride.

2 . Results and Discussion

Available phosphate and exchangeable Al determined were shown in Table 1. To the same table some of the data reported previously were inserted in order to make it easier to understand soil characteristics. All values in Table 1 are the means and standard deviation of 3 soil samples from the respective experiment plots.

The level of available phosphate was higher in the A and DG plots than in other plots. The A plot was a forest as a control. There was some accumulation of organic matter on the very surface (± 2 cm) of the A plot soil. This layer may have been a little rich in available phosphate, but the soil down below this layer was not so. Consequently the soil samples collected from a depth of 0 to 15 cm showed a range from 0.3 to 0.5 mg P_2O_5/ 100 g.

In the DG plot, the surface soil was left in situ when it was cleared from forest and some fertilizers were given to grow a forage crop (pangola grass). Thus phosphate was maintained at the level somewhat same with the A plot. The DN plot was cleared in the same way with the DG plot but was kept naked. So available phosphate might have been lost by some erosion.

In the EG and EN plots, the original surface soils were moved aside to make the land flat when cleared from forest. So these plots were even poor in available phosphate. Some fertilizers were given to the EG plot to grow pangola grass for 3 years, thus the level of available phosphate in the EG plot was a little better than in the EN plot that was kept naked after clearing forest.

It was observed that wild grasses such as *Imperata cylindrica* and *Miscanthus*, and some tree species were invading to the experiment plots except for the plot A. A degree of vegetation invasion was more in the DG and DN plots than in the EG and EN plots. The difference in the vegetation invasion was assumed to be caused by the difference in the status of soil nutrient, pH and exchangeable Al in the soil among the plots.

The soil of the DG and DN plots appeared to have been supplied with organic matter from the invading

Table 1. Physical and chemical properties of the soil abandoned after clearing forest

Experi. plot	Year of sampling	pH (KCl)	Avail. phos. (mg P_2O_5/100g)	CEC (me/100g)	Base satu. (%)	Exch. Al (me/100g)	Al satu. (%)	Clay cont. (%)
A	1976	3.83±0.03	0.54±0.05	3.77±0.68	32.0±4.1	1.76±0.29	47.0±3.7	11.1±1.2
	1979	3.91±0.04	0.32±0.18	3.20±0.24	30.7±7.0	1.47±0.20	46.2±7.7	12.6±0.6
	1991	4.18±0.17	0.47±0.12	3.37±0.45	58.7±17.4	0.77±0.41	22.3±8.7	11.7±1.2
DG	1976	4.03±0.04	0.41±0.16	3.13±0.46	42.7±7.8	1.51±0.41	47.8±7.8	14.5±1.7
	1979	4.26±0.03	0.40±0.10	2.73±0.40	37.3±11.1	0.79±0.26	28.3±5.0	12.7±1.0
	1991	3.92±0.05	0.68±0.47	3.50±0.29	29.3±4.0	2.08±0.27	60.0±9.4	13.8±0.4
DN	1976	4.00±0.03	0.27±0.06	2.77±0.25	14.7±0.9	1.95±0.07	71.0±4.1	13.8±0.7
	1979	3.99±0.05	0.12±0.02	3.37±0.29	14.0±4.2	2.11±0.28	63.2±10.6	17.6±1.9
	1991	3.96±0.07	0.06±0.02	3.47±0.90	23.3±7.8	2.35±0.71	67.6±6.7	18.8±6.5
EG	1976	3.85±0.02	0.19±0.07	3.87±0.69	24.0±0.8	2.91±0.38	76.0±4.6	29.0±3.3
	1979	3.88±0.01	0.19±0.05	4.03±0.62	25.7±2.1	2.68±0.38	66.7±2.0	26.7±3.1
	1991	3.89±0.06	0.13±0.04	4.17±0.94	22.0±4.3	2.86±0.84	67.5±4.9	27.2±4.8
EN	1976	3.82±0.02	0.04±0.01	4.63±0.68	19.7±0.5	3.55±0.54	76.6±4.5	34.8±4.3
	1979	3.84±0.01	0.09±0.02	4.50±0.71	17.7±1.2	3.29±0.44	73.4±2.4	32.8±3.2
	1991	3.83±0.01	0.09±0.04	4.40±0.51	17.0±4.2	3.50±0.25	80.0±4.3	31.7±3.2

vegetation. However, the effect of organic matter on available phosphate was not enough to appear in the soil analysis.

Exchangeable Al in the soil of the respective experiment plots was shown in Table 1. Exchangeable Al was higher in the soil of EG and EN plots than in the soil of other plots. It was deemed that the land cleared by a bulldozer was exposed to adverse conditions of the soil, that was poor in nutrients, low in pH and high in exchangeable Al. Consequently more attention should be paid to soil fertility management in this kind of land. Changes in the quantity of exchangeable Al by the time course of 15 years were not clearly observed.

It is known that there is a close relation between soil pH and soluble Al[2]. The relation between all determinations of pH (KCl) and exchangeable Al in this investigation was expressed as $Y=-5.25x+2.29$ by a linear regression (where Y=exchangeable Al, x=pH (KCl) and $r=-0.788^{**}$) This relation was expressed better by a power regression as shown in Fig. 1. The pH (H_2O) values were about 1 unit higher than pH (KCl) in the investigated soil. So the relation between pH (H_2O) and exchangeable Al could also be presumed from Fig. 1. The relation between pH (KCl) or pH (H_2O) and exchangeable Al could be very useful in liming for a chosen crop to grow.

The relation between soil pH and exchangeable Al was also better expressed by a power regression than by a liner regression for Red and Yellow soils of Okinawa Island[3].

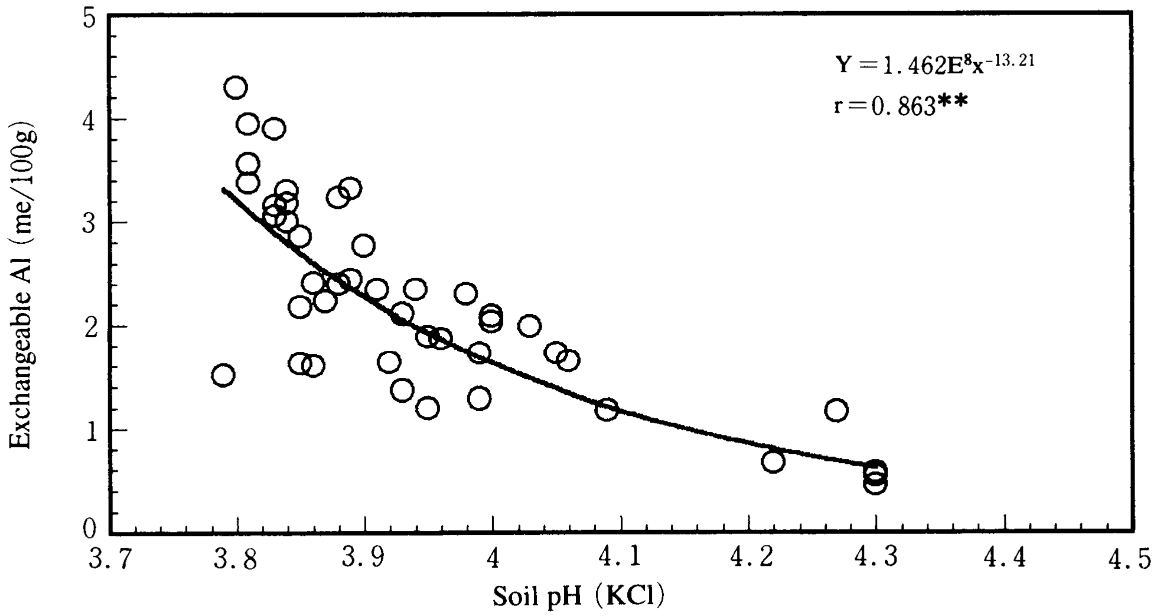

Fig. 1. Relation between soil pH and exchangeable Al in the soil cleared from forest in Iriomote Island

Investigation II

1. Materials and Methods

Soil samples were collected from various depths of 2 forest sites in 1992 in order to investigate vertical changes of physical and chemical properties of the soil around the above mentioned experiment site. One site of soil sample collection was in the A plot mentioned above, and the other site was at a cut of hill near Aramoto's experiment site, that was about 100 m apart from the A plot forest to the north.

The soil samples were analyzed for pH, cation exchange capacity (CEC), exchangeable bases such as calcium, magnesium, potassium and sodium, exchangeable Al, available phosphate and phosphate absorption coefficient as chemical properties. And also determined were particle size distribution and dispersion rate of 1/

Table 2. Physical and chemical properties of the soil in the vertical extention

Site	Depth (cm)	pH		CEC	Exchage. bases (me/100g)				Base satu.	Exch. Al
		H_2O	KCl	me/100g	Ca	Mg	K	Na	%	(me/100g)
A plot	0~15	5.0	3.8	6.47	0.93	1.24	0.16	0.16	38.5	3.18
	50	5.0	3.8	5.38	0.26	0.54	0.08	0.10	18.2	4.38
	100	4.9	3.8	5.83	0.04	0.50	0.11	0.11	12.9	5.49
Hill cut	0~15	5.1	3.8	5.72	0.90	0.95	0.15	0.17	37.9	2.36
	50	4.9	3.8	6.69	0.20	0.54	0.08	0.11	13.9	5.21
	100	4.8	3.9	4.90	0.10	0.30	0.07	0.10	11.6	4.52
	200	5.1	4.2	2.33	0.05	0.14	0.02	0.04	10.7	1.84
	300	5.1	4.1	2.39	0.03	0.20	0.04	0.03	12.6	1.82

Site	Depth (cm)	Avail. phos.	Phos. abs. coef.	Particle size distr. (%)				Texture	Disper. rate (%)
		(mg P_2O_5/100g)		C sand	F sand	Silt	Clay		Drl/20
A plot	0~15	0.11	421	5.5	54.2	8.5	31.9	SC	38.5
	50	0.08	374	2.5	57.2	12.1	28.3	SC	50.7
	100	0.07	374	1.8	53.1	17.3	27.8	LiC	47.5
Hill cut	0~15	0.40	256	6.7	67.7	9.1	16.6	SCL	35.0
	50	0.09	457	6.6	52.9	8.4	32.1	SC	41.7
	100	0.11	348	4.4	59.0	10.8	25.8	SC	45.4
	200	0.08	129	7.0	77.9	8.5	6.6	SL	47.1
	300	0.06	138	7.6	74.6	9.9	7.9	SL	45.3

20 cm particles. The most of analyses followed the methods described in the previous report[1]. Available phosphate and exchangeable Al were determined by the methods described in a former section.

2 . Results and Discussion

The vertical changes of soil in physical and chemical properties were shown in Table 2. The soil in the A plot was dark brown in a 0 to 15 cm layer and reddish orange from 15 to 100 cm depth. The soil at a hill cut was dark brown in a 0 to 15 cm layer, reddish orange from 15 to 130 cm and pale to dull orange from 130 cm to 300 cm.

From the surface soil layer to the deeper layers a distinct decrease in nutrient contents was clearly found at the both sites, although the soil texture was somewhat different at the same depth. Exchangeable Al was observed to increase from the surface to 100 cm depth. The dispersion rate of 1/20 cm particles was near 40, which is already susceptible enough to erosion. The soils at deeper layers showed even higher dispersion rate.

The data of Table 2 were very suggestive in that the reclaimed land would become very infertile for crop cultivation and be endangered to severe soil erosion, if the forest was cleared in a way to expose the subsurface soils as a new surface by the use of bulldozer. Intensive soil management should be practiced to control erosion and to improve soil fertility for the sustainable land use, if the land was opened in that way.

Conclusion

1 . Investigation I

The level of available phosphate in the soil of DG plot that was cleared from the forest by a rakedozer was maintained near that level in the soil under the forest (A plot), but it tended to decrease when the soil (DN plot) was kept naked after clearing forest. The soil in the EG and EN plots that were cleared by a bulldozer had a lesser level of available phosphate than the soil of DG and DN plots.

Changes of the available phosphate level were not clearly observed in the respective plot soil for the time course of 15 years after clearing forest.

Exchangeable Al was found more in the soil of EG and EN plots that were cleared by a bulldozer than in the soil of DG and DN plots that were cleared by a rakedozer.

It was deemed that in soil management much attention should be paid to the soil that was cleared by a bulldozer in a way to move the original surface soil aside.

2 . Investigation II

Physical and chemical properties of the soil investigated in the vertical extension showed from the surface to a deeper layer a steep decrease in nutrients, a gradual decrease in pH and a increase of exchangeable Al and dispersion rate.

It was deemed that an intensive soil management should be practiced to control soil erosion and to improve fertility for the sustainable use of the land, if the land was reclaimed by a bulldozer from the forest in this area.

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西表島開墾地及び林地の土壌理化学性

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要　約

西表島開墾地の土壌管理に資するため，前報（Oya et al 1994）の調査の一環として，開墾試験区土壌の可給態リン酸及び交換性アルミナを分析・測定した。また併せて開墾試験区周辺林地２カ所において，土壌理化学性の垂直変化について調査した。

(1) 開墾試験区土壌の可給態リン酸と交換性アルミナ

開墾試験区としてＡ区（対照区，林地），DG 区（レーキドーザーにより山成り開墾，３年間牧草栽培後放置），DN 区（同上により開墾後裸地状態で放置），EG 区（ブルドーザーにより開墾均平化，３年間牧草栽培後放置），EN 区（同上により開墾後裸地状態で放置）などを1976年に設置し，各区から開墾当初，３年後，15年後に表土（0～15cm）３点づつを採取して可給態リン酸と交換性アルミナを分析・測定した。

可給態リン酸はＡ区（林地）でも約0.5mg P_2O_5/100g と低い方であり，DG 区と DN 区はこれに近いレベルにあったが，EG 区と EN 区ではかなり低くＡ区の約３分の１であった。交換性アルミナはＡ区では0.8～1.8me Al/100g であったが，EG 区と EN 区では2.7～3.6me と著しく多い状態にあった。DG 区と DN 区はＡ区よりやや高いが，EG 区や EN 区より低いレベルにあった。開墾後の経年による可給態リン酸と交換性アルミナの量的変化については明確な傾向はみられなかった。

(2) 林地における土壌理化学性の垂直変化

土壌養分は表層から下層へ急激に減少し，一方で受食性の目安となる土壌の分散率は高くなった。

以上より，西表島の砂岩土壌地帯では，ブルトーザーにより下層土を露出させるような開畑を行うと，そこの土壌は肥沃度が著しく悪くなり，同時に土壌侵食も受け易くなる恐れがあるので，その場合の土壌管理には十分意を払う必要があると考えられる。