

## TARC Note

### Potentiometric Titration of Some Upland Soils in Thailand

Ion uptake by plants is influenced by soil pH directly and indirectly through the solubility of certain nutrient ions and extent of microbial activity. Plants can not grow well under extremely acid or alkaline conditions, for which the correction of soil pH is primarily required. The magnitude of the correction depends on the original pH value and the buffering capacity of the soil. As regards to the latter, soil constituents play an important role.

The objective of the present study is to;

- 1) Estimate the soil constituents and some chemical properties by using acid-alkali titration,
- 2) Characterize the soil in terms of the buffer intensity at a certain soil pH range.

Twenty six surface soils mostly from upland farmer's fields were used in this study. Great soil groups and their locations were as follows: Red Yellow Podzolic Soils: (1, 2, 3)\* Tak, (4) Lopburi, (5) Chengrai. Non Calcic Brown Soil: (6) Suphanburi. Reddish Brown Lateritic Soils: (7) Nakhon Sawan, (8, 9) Saraburi, (10) Chaiyaphum, (11) Lopburi. Renzina: (12, 13) Nakhon Sawan, (14) Kanjanaburi. Grumusols: (15, 16, 17, 18) Lopburi. Brown Forest Soils: (19, 20) Lopburi. Gray Podzolic Soils: (21) Cholburi, (22) Khon Khaen. Reddish Brown Latosol: (23) Chantaburi. Reddish Yellow Latosol: (24) Nakhonrachasima. Red Brown Earth: (25) Chaiyaphum. Acid Sulfate Soil: (26) Prajinburi. The soil samples were air-dried and passed through 2-mm sieve.

Titration was made by using glass electrode

\* Numerals in parentheses refer to soil sample number.

and automatic recording titrator (Hiranuma RAT 11). A volume of 250 ml of *N* KCl solution containing 5 g of soil was titrated with 0.1 *N* NaOH or 0.1 *N* HCl. The soil was initially shaken with 200 ml of *N* KCl for 1 hr. The use of KCl in the titration is to promote equilibration in the soil-solution system<sup>3</sup>. The acid or base is added stepwise at every moment when certain controlled amount of potential change occurred. The amount of titor is automatically controlled in such a way that avoids sudden change in pH in order to approach equilibration as much as possible.

Hand titration by adding 0.05 me base for every hour to a 10 g soil in 25 ml *N* KCl solution was also made to compare with the automatic titration.

Soil chemical properties pertinent to proton uptake and release reaction were determined. CEC, degree of base saturation, and organic matter content were measured by Na-Acetate (pH 8.2)<sup>6</sup>, NH<sub>4</sub>-Acetate (pH 7.0) extraction<sup>6</sup> and Walkley-Black method<sup>7</sup>, respectively. Carbonate content was estimated by determining inorganic carbon by the Kosaka method<sup>2,4</sup>. The measurement of soil pH was made in distilled water or *N* KCl solution at a 1 : 2.5 soil-solution ratio.

For some acid soils which show pH less than 5.5 in KCl, unbuffered KCl extraction at a soil-solution ratio of 1:20 was made to determine exchange acidity by NaOH titration<sup>6</sup>.

As shown in Fig. 1, the shape of hand titration curve and automatic titration curves with different titration rates differed each other, indicating that equilibration was not attained even at the lowest rate of titration by automatic titrator. For practical reason of operation, the condition (d) in Fig. 1 was employed for further study.

The magnitude of lime requirement can be estimated from base titration of some acid soils. Provided the field pH value required for the suitable plant growth is taken as 6.5, the pH in KCl is often known to show 5.5<sup>1</sup>). Lime requirement for correcting pH in KCl to 5.5 calculated from both hand and automatic titrations is shown in Table 1. Except soil No. 4, lime requirement equivalent to exchange

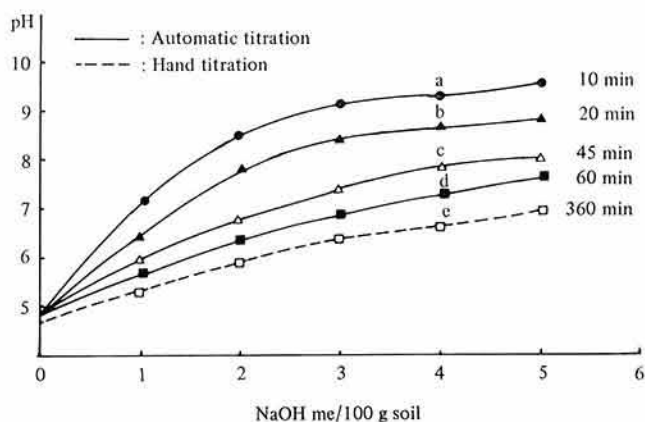


Fig. 1. Titration curves of Red Yellow Podzolic Soil (soil sample no. 2) under different titrating condition

Table 1. Lime requirement of some acid soils

No.	Soil Great group* <sup>1)</sup>	Original pH (KCl)	Bulk density* <sup>2)</sup>	Lime Requirement (ton/ha/15 cm* <sup>3)</sup> )		
				Exchange acidity	Automatic titration	Hand titration
2	RYPS	4.7	1.35	0.41	0.91	1.27
4	RYPS	4.2	1.38	0.52	0.41	0.57
5	RYPS	4.0	1.35	3.04	4.76	—
6	NCBS	5.0	1.40	trace	0.20	0.30
23	RBL	4.7	1.00	0.30	—	0.45
24	RYL	4.4	1.32	0.30	—	0.40
25	RBE	5.4	1.21	trace	—	trace
26	ASS	3.7	1.40	5.15	6.83	—

\*1) RYPS; Red Yellow Podzolic Soil, NCBS; Non Calcic Brown Soil RBE; Red Brown Earth, RYL; Red Yellow Latosol, RBL; Reddish Brown Latosol, ASS; Acid Sulphate Soil

\*2) Estimated from Ogawa (1975)<sup>5)</sup>

\*3) Provided liming material composed of CaCO<sub>3</sub> alone is used.

acidity is lower than those calculated from titration method, indicating that there is certain acidity, other than exchangeable Al and H, remained in the soil. Lime requirement calculated by automatic titration is always lower than by hand titration probably due to incomplete equilibration in the titration system. Liming to fields by the use of lime requirement values obtained by the automatic titration seems to be simple and safe when CaCO<sub>3</sub> is applied as liming material.

Fig. 2 and Table 2 show the titration curves and the chemical properties of some representative soils. Generally, the titration curve was primarily affected by the presence of free carbonate, amount of neutralizable Al-species and cation exchange capacity. Thus, it is estimated that the quantity and quality of clay minerals, free carbonate, organic matter and degree of base saturation play an important role in soil buffer intensity in different soil pH ranges.

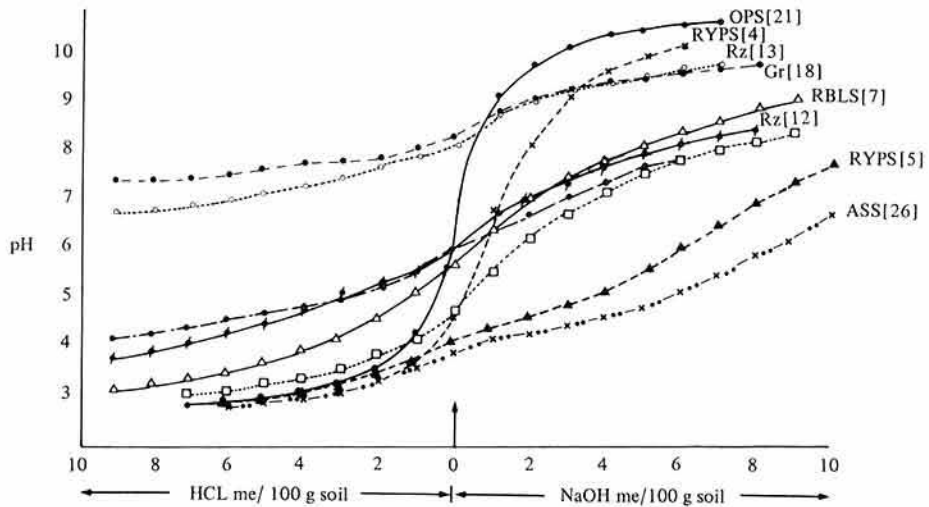


Fig. 2. Titration curves of soils

Table 2. Chemical properties of some representative soils

Soil No.	Great <sup>*1)</sup> soil group	pH		C.E.C. (me/100 g)	Base sat. (%)	Organic <sup>*2)</sup> carbon (%)	Inorganic carbon (%)	Acidity <sup>*4)</sup> (me/100 g)
		H <sub>2</sub> O	KCl					
18	Gr.	7.9	6.7	42.8	>100	2.75	1.49	—
13	Rz.	7.9	7.0	43.0	>100	1.75	0.89	—
26	ASS	4.3	3.7	28.2	18.3	0.79 <sup>*3)</sup>	trace	4.9
5	RYPS	—	4.1	12.1	42.6	2.3 <sup>*3)</sup>	trace	3.0
4	RYPS	5.5	4.2	3.1	58.3	0.35	0.08	0.5
21	GPS	6.5	5.9	6.1	77.4	0.23	0.05	—
20	BFS	7.2	5.8	57.9	98.5	3.26	0.28	—
2	RYPS	5.7	4.7	15.4	62.4	2.26	0.04	0.4
7	RBLS	6.7	5.5	24.2	77.1	1.23	0.03	—

\*1) Rz; Rendzina, BFS; Brown Forest Soil, GPS; Gray Podzolic Soil, Gr; Grumusol, RBLS; Reddish Brown Lateritic Soil, ASS; Acid Sulphate Soil, RYPS; Red Yellow Podzolic Soil

\*2) Kosaka method

\*3) Walkley—Black method

\*4) KCl one time extraction

Differential buffer intensity curves (Fig. 3) calculated from Fig. 2 indicate remarkable differences in buffer intensity among different soils. From the shape of these curves for all the 26 soils used in this study, a soil material class according to the soil constituents can be established. It is composed of four main types almost independent of great soil group (Fig. 4). Type I: soils with high free carbonate content which required more than 15

me proton/100 g soil to change soil pH from 6.5 to 9.5. Type II: soils with high exchange acidity, showing remarkably high buffer intensity at pH 4.5. Type III: sandy soils which have very low buffer intensity at weak acid to weak alkaline range and only 5 me proton/100 g soil is enough to change soil pH from 4.5 to 9.5. Type IV: clayey to loamy, neutral to weak acid soils showing relatively high buffer intensity in the pH range between 4 to

Table 3. Soil material class obtained from pH buffer curves and main soil characteristics

Soil material class	Dominant soil constituents and chemical properties	Great soil group	Number of samyles studied
Type I	Heavy clayey montmorillonitic, calcareous, High organic matter, CEC: 30-60 me/100 g soil, pH(KCl): 6.7-7.3, B.S.: 100%	Gr, Rz	6
Type II	Heavy clayey, 2:1 type clay mineralogy, Medium to low organic matter, CEC: 15-30 me/100 g soil, pH(KCl): 3.7-4.2, R.S.: 20-40% High exchangeable Al (3-6 me/100 g soil)	ASS RYPS	2
Type III	Sandy, mostly kaolinitic, non-calcareous Low organic matter, CEC: 3-10 me/100 g soil, pH (KCl): 4.2-5.9, B.S.: 70-80%	GPS, RBE RBLS, RYPS NCBS, RYL	7
Type IV	Sub-type a) Heavy clayey to clayey, non-calcareous High organic matter (newly formed), CEC: 40-55 me/100 g soil, pH (KCl): 5.8-6.7, B.S.: 100%, High Ca saturation	BFS Rz	3
	Sub-type b) Heavy clayey to clayey, non-calcareous CEC: 15-30 me/100 g soil, pH (KCl): 4.2-5.8, B.S.: 40-80%	RYPS RBLS RBL	8

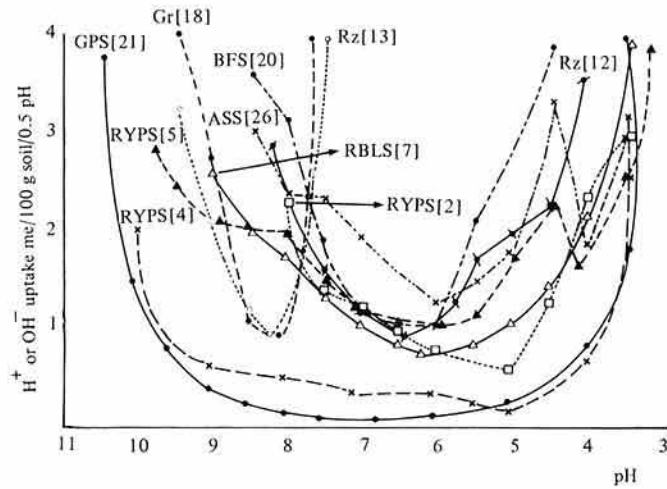


Fig. 3. Differential buffer intensity curve [in KCl]

8. The Type IV can be further divided into two subtypes, a and b, according to the buffer intensity at pH around 5 to 6. The main characteristics in terms of soil constituents and the chemical properties of each type are summarized in Table 3 and Fig. 4.

As far as the 26 surface soils are concerned,

a simple soil titration using automatic titrator, even under incomplete equilibration, can provide useful information on soil constituents and some of the chemical properties, from which one can assess a field condition of soil that probably occur under certain change in soil environment associated with any proton

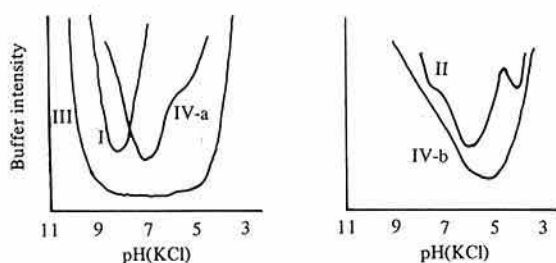


Fig. 4. Grouping of differential buffer curves

uptake and release reaction such as leaching process and liming or fertilization practices.

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