Relations Between Composition of Exchangeable Bases of Soil and Growth of Tea Plant

By KENJIRO IKEGAYA

Laboratory of Soil and Manure, Crop Division,
Tea Research Station

The adequate pH (H_2O) in the soil for the growth of tea plant is said to be 5.0~5.5.[1] However, since the climate of Japan is mild with much rainfall, there is much leaching of bases of soil and the soil is under the conditions which would acidify it. Besides, much nitrogen fertilizer is applied to tea field so that the tea soil is apt to be strongly acidic.

Therefore, in order to increase the productivity of tea soil, it is necessary to lime the soil. It is not appropriate, however, to determine the necessity of, or degree of, liming on the basis of pH of the soil alone.

It has been found from the investigation carried on tea soil that it is more appropriate to determine it on the basis of exchangeable bases of soil.[2),3)]

Consequently, since 1957 research on the changeable bases of soil and the growth of tea plant[4] was investigated and that was finished in 1961. Its result has been applied for the improvement of tea soil.

Relationship between composition of exchangeable bases of soil and growth of tea plant in the actual tea field

Tea soil in Japan can be roughly classified into two types—organic acid soil and mineral acid soil. The former is derived from volcanic ash soil and "Kuroboku" (diluvium), and the latter from diluvium, tertiary, mesozoic strata, paleozoic formation and igneous, red yellowish in color. They are distributed in about 50-50 ratio.

Tables 1 and 2 show the result of investigation carried out on the tea fields, showing good and poor growth of tea plant, bases on

Table 1. Soil reaction and composition of exchangeable bases in high productive tea soil

Soil	Horizon	pH		Cation exchange-able capacity	Excha. bases saturation			Base saturation
		H_2O	KCl		Ca	K	Mg	
Red yellowish soil	1	5.5	4.4	19.6 me	35.1%	6.0%	2.0%	43.1%
	2	5.0	4.2	11.7	36.3	5.6	5.4	47.3
	3	4.9	4.2	10.3	22.6	4.7	6.3	33.3
"Kuroboku" soil (organic)	1	4.2	4.0	25.1	27.4	4.8	2.9	35.1
	2	4.2	4.1	21.3	21.7	3.6	1.2	26.5
	3	4.6	4.5	14.6	44.0	8.4	9.5	61.9
Volcanic ash soil (organic)	1	6.1	5.0	49.6	25.4	1.9	5.3	32.6
	2	6.4	5.4	49.6	35.3	2.6	5.2	43.1
	3	6.7	5.7	67.8	33.3	1.3	5.2	39.8

Table 2. Soil reaction and composition of exchangeable bases in low productive tea soils

Soil	Horizon	pH		Cation exchange-able Capacity	Exchan. bases saturation			Base saturation
		H_2O	KCl		Ca	K	Mg	
Red yellowish soil	1	4.3	3.9	17.1 me	9.8%	2.9%	1.6%	14.3%
	2	4.4	4.1	13.6	4.4	1.9	1.3	7.6
	3	4.6	4.2	12.8	4.9	1.8	2.4	9.1
"Kuroboku" soil (organic)	1	4.4	4.2	36.2	17.5	2.0	3.1	22.6
	2	4.6	4.4	39.3	3.4	1.1	0.9	5.4
Volcanic ash soil	1	4.4	4.3	60.7	34.1	1.7	0.5	36.3
	2	5.3	4.8	68.9	9.9	2.0	0.8	12.7
	3	5.7	5.1	37.0	16.3	2.4	0.8	19.5

the composition of exchangeable bases of the soil, red yellowish one, "Kuroboku" and volcanic ash.

As the tables indicate, in the low productive tea soil, saturation of exchangeable Ca, K and Mg is comparatively lower compared with high productive tea soil. Furthermore, in the first layer of volcanic ash soil of low productive tea soil, saturation of Ca is higher than that of high productive tea soil, but saturation of Mg is extremely low, which would account for the excellent growth of tea plant.

Up to the third layer, saturation of Ca in high productive tea soil is 20~44%, and although saturation of Mg varies, depending upon the layers, it is approximately 5% on the average.

Relative relationship is observed between pH (H_2O) and saturation of bases in red yellowish soil, but no definite relationship between them can be recognized in organic soil. This is considered to be due to the big buffer action of soil.

Since the above results were obtained after the investigation made on the actual tea soil, the following pot experiments were conducted as to the relationship between the composition of exchangeable bases of soil and growth of tea plant.

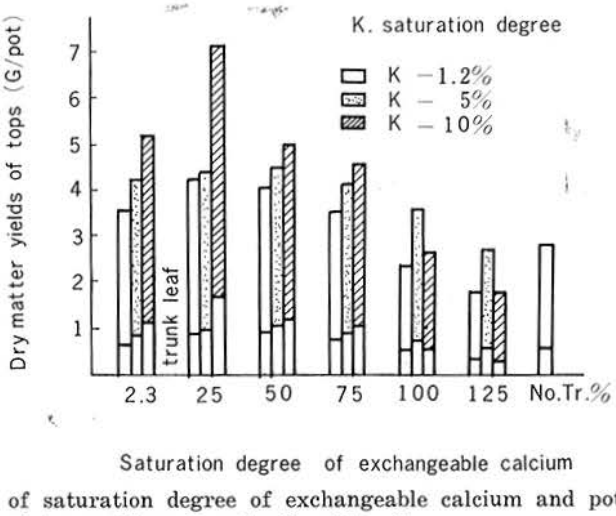

Fig. 1. Effects of saturation degree of exchangeable calcium and potassium on the growth of tea seedlings in red yellowish soil.

Saturation of exchangeable Ca, K and Mg and growth of tea plant

Pot experiments were carried out to find out the relationship between saturation of exchangeable Ca, K and growth of tea plant, with red yellowish soil and organic soil ("Kuroboku"), keeping the saturation of exchangeable Mg of the soil at 5%.

Saturation of Ca was varied from non-treated to 25%, 50%, 75%, 100% and 125%. Saturation of K was varied from non-treated to 5% and 10%.[5] The result is shown in Figs. 1 and 2, indicating dry matter of tops per pot.

These figures indicate that for both types of soil, it was found that when saturation of Ca was 25~50%, saturation of K, 10% and saturation of Mg, 5%, the growth of tea plant was the best.

Next, pot experiments were conducted to examine the relationship between saturation of Ca and Mg,[4] with red yellowish soil. The result is shown in Fig. 3, indicating the dry matter of tops.

It was found that when Ca saturation was 4.7% and 25%, the best growth was obtained with 25% Mg saturation. When saturation of Mg was increased to 50%, growth clearly deteriorated. At 50% Ca saturation, growth is best when Mg saturation is up to 5%, but above that saturation, growth was obstructed.

From the above results, the composition of exchangeable bases of soil appropriate to the growth of tea plant was observed when the saturation of (Ca + Mg) was 25~

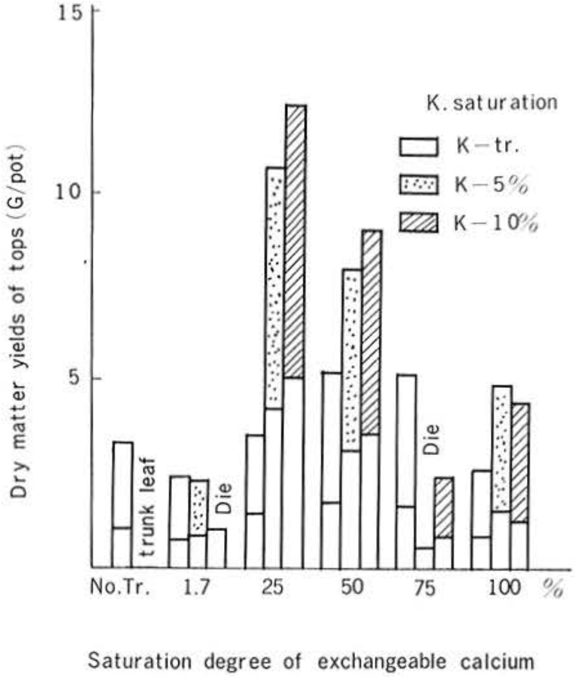

Fig. 2. Effects of saturation degree of exchangeable calcium and potassium on the growth of tea seedlings in "Kuroboku" soil.

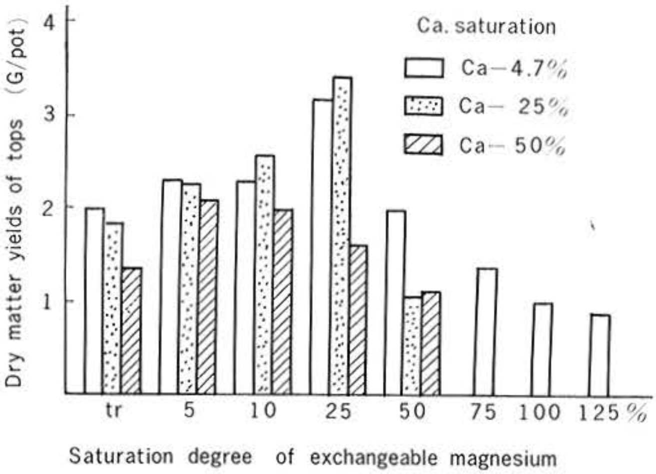

Fig. 3. Effects of saturation degree of exchangeable calcium and magnesium on the growth of tea seedlings in red yellowish soil.

50%, keeping the saturation of Mg to 5% as the minimum, and that of K, 5~10%.

Effect of Ca saturation on inorganic content of new, mature, old leaves and young stem

Pot experiments were conducted, using red yellowish soil to examine the effect of Ca saturation on the inorganic content of new, mature and old leaves and young stem, keeping Ca saturation at 2.3%, 25%, 50% and 100%, and K and Mg saturation at 5% respectively.[6]

It was found, as indicated in Fig. 4, that

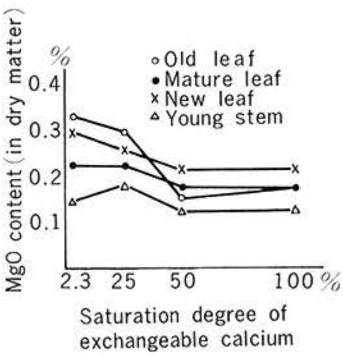

Fig. 4. Effect of saturation degree of exchangeable calcium on the magnesium content in old, mature, new leaves and young stem of tea plant.

when Ca saturation was up to 2.3~25%, Mg content was found mostly in old leaf, decreasing in new leaf, mature leaf and young stem, in that order.

However, when Ca saturation exceeded 50%, it was found principally in new leaf and decreasing in mature leaf, old leaf and young stem, in that order, i.e., it was indicated that when Ca is deficient, a great deal of Mg is absorbed in old leaf, to take the place of Ca.

However, in strongly acidic soil, both Ca and Mg are lacking, so that Mg deficiency most strongly appears in old leaf.

Most Ca, Mn and Al content was found in old leaf and decreasing in mature leaf, new leaf and young stem as maturity decreased. As Fig. 5 shows, Ca content in old leaf increased with the increased saturation of Ca. Fig. 6

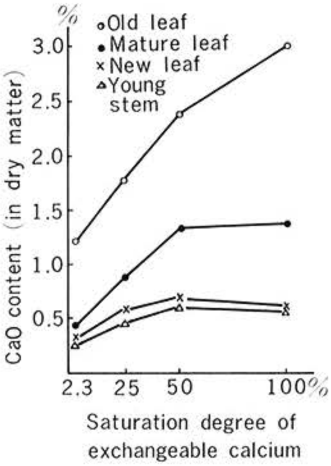

Fig. 5. Effect of saturation degree of exchangeable calcium on the calcium content in old, mature, new leaves and young stem of tea plant.

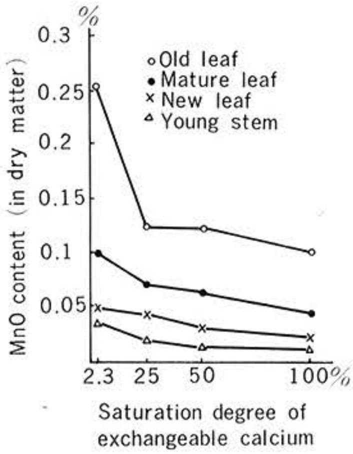

Fig. 6. Effect of saturation degree of exchangeable calcium on the manganese content in old, mature, new leaves and young stem of tea plant.

indicates that Mn content rapidly decreased when Ca saturation exceeded 50%. Al content showed the same tendency as that of Mn.

From the above results, it was surmised that the reason why the growth of tea plant becomes poor when Ca saturation exceeds 50%

is because of excessive Ca content and deficiency in Mn and Al in old leaf.

Present situation of application of base to tea soil

As stated before, tea soil in Japan is extremely acidic and lacking in Ca and Mg. Therefore, bearing the above results in mind, dolomite is often applied to the tea soil so that it would have the best composition of bases.

In tea plantation, it is impossible to apply dolomite all over the field so that it is applied only by broadcasting between the rows of tea. As a result, the application of dolomite is limited to about 1/5 of the total area, and to inorganic soil, 60~100 kg per 10 are and to organic soil, 150~200 kg per 10 are are applied at the beginning or the middle of September every year. However, before applying dolomite, thorough check is made on the reaction and composition of bases so that there will be no over liming.

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