A Method of Measuring Available Silicates in Paddy Soils

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Silicates contribute a great deal to the sound growth of rice plants, because they increase the resistance to disease and insect damage and lodging and take part in the regulation of transpiration. In soils, silicates occupy more than half weight of dried soil but the majority of the silicates are non-available. They become effective very slowly on the opportunities like the weathering of minerals, destruction of clay and the reduction of soils.

In paddy fields where the amount of available silicates is not sufficient for the absorption by rice plants, it becomes necessary to dress silicate fertilizers like calcium silicates. It is desirable to measure the available silicates for the judgement of needs of silicate fertilizers and the determination of the way to use them.

In paddy soils, silicates extracted by one mol acetate buffer solution were hitherto evaluated as available silicates. Since this method was thought out for measuring natural available silicates in soils, more investigations were necessary to clarify whether the acetate buffer soluble silicates could be considered as avaialble silicates in paddy soils where slags were dressed. Silicates extracted with acetate buffer solution were often evidently increased in soils treated with slags, and any correlation was hardly observed between the acetate buffer soluble silicates in soils and SiO_2 contents in rice straw (Fig. 1)[3]. It seems that the non-available silicates in slags dissolve in acetate buffer solution because of the too strong extracting condition. Nowadays slags have come into wide use in paddy fields, so it is not satisfactory to consider the acetate buffer soluble silicates as available silicates.

When we measure the amount of available nutrients in soils, it is to be desired that we measure them in the condition close to natural root environment as far as possible. From these points of view, we measured the silicates

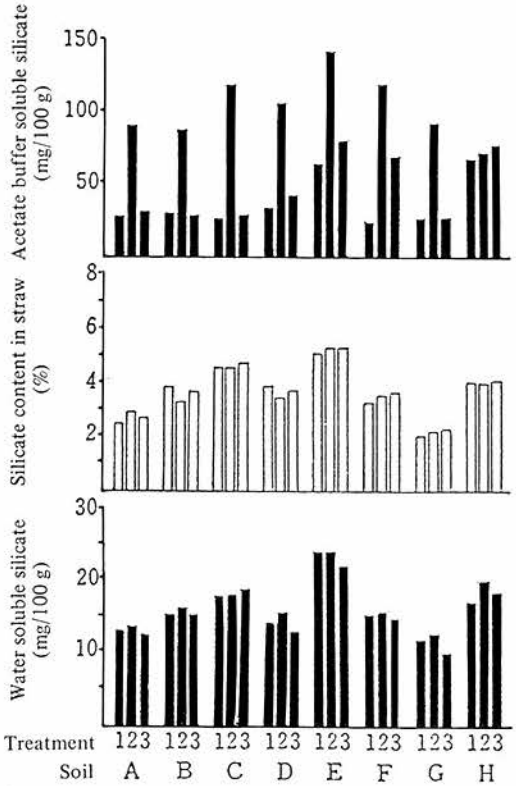


Fig. 1. Available silicate and silicate content in straw in various soils (pot experiment)
Treatment 1: Standard,
Treatment 2: Slag,
Treatment 3: Calcium carbonate.

extracted from soils by flooding incubation (water soluble silicates), and investigated the relations between the water soluble silicates and SiO_2 contents in rice straw. As we think that this new method is effective in assessing silicate availability of paddy soils, procedures to determine water soluble silicates, some examples of the application of this method, and problems involved are presented in this paper.

A new method of measuring available silicates in paddy soils

1) Sampling time and treatment of soils

Sampling time of soils is directly after rice harvesting and before winter crop sowing. The reason is described later. The soil samples should be dried in the air, and be passed through a sieve (diameter 2.0 mm).

2) Flooding incubation and quantitative analysis of silicates

The air-dried soil equivalent to 10 g of dry soil is put into a 100 m*l* cylindrical bottle (inner diameter about 4.5 cm), submerged in 60 m*l* water and kept in an incubator at 40°C. After one week, the supernatant in the bottle is extracted. If the supernatant is muddy, the muddiness must be separated by centrifugation or filtered to make it clear. Silicate in the supernatant is measured colorimetrically by the molybden blue method[1] and the amount measured is expressed as SiO_2 mg per 100 g of soil.

Study of measuring conditions

Quantity of silicates measured by the flooding incubation method varied due to the flooding incubation period, flooding conditions (a thickness of soil layer, ratio of water to soil), incubation temperature, sampling time of soils and so on. Consequently it is necessary to unify measuring conditions to compare the measured values mutually.

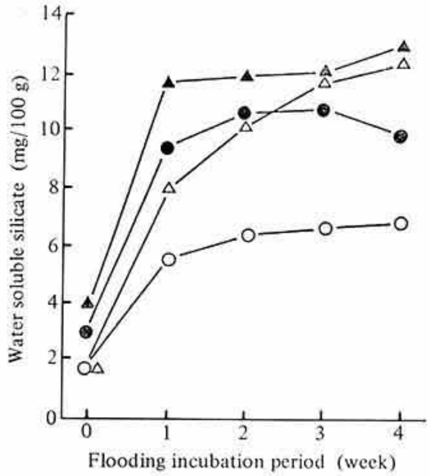


Fig. 2. Relation between the flooding incubation period and water soluble silicate
Incubation temperature was 30°C.

1) Flooding incubation period

Fig. 2 shows the time-course variations of water soluble silicates when two species of paddy soils were flooding-incubated. Water soluble silicates increased rapidly in the first week, irrespective of the soils contained slags or not, and subsequently showed a tendency to increase slowly. Silicate dissolution is closely related with soil reduction, and the sufficient correlation was observed between the water soluble silicates after four weeks at 30°C and that after one week at 40°C (at least $r=0.9^{**}$), so that we adopted one week at 40°C as an incubation period and temperature to accelerate soil reduction and shorten the incubation period.

2) Flooding conditions

The thinner the soil layer or the higher the ratio of water to soil, the more amounts of water soluble silicates in flooded soils tended to dissolve[5]. It is considered that the dissolution relates to solid-liquid equilibrium. We used a 100 m*l* cylindrical bottle as a receptacle and 60 m*l* distilled water to submerge 10 g of the soil. In many cases, the

Table 1. Variation of water soluble silicate in paddy fields where no slag had been applied

Treatment	1982		1983		1984	
	Jun. 25	Oct. 22	Jun. 27	Oct. 22	Jun. 4	Oct. 22
Compost[a]	25.1	19.3	22.8	17.5	25.2	19.9
No compost	15.2	10.4	13.6	9.4	15.3	12.6

a) : Compost was dressed from 1976 to 1981 every spring and fall.

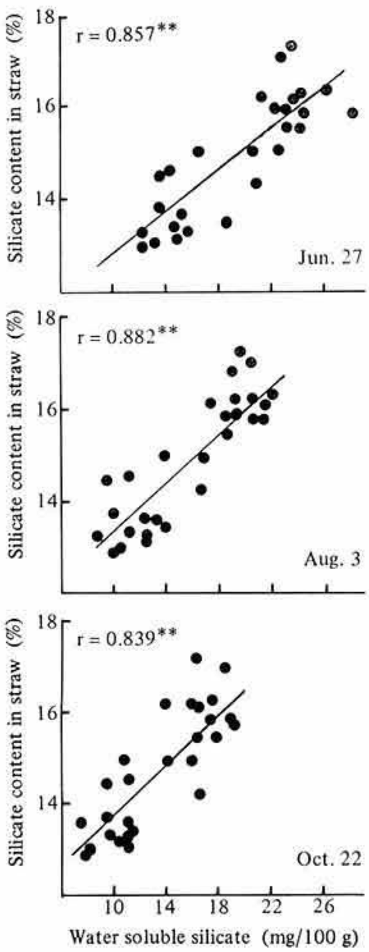


Fig. 3. Relationship between water soluble silicate in soils at different sampling times and silicate content in straw at harvesting time (the paddy fields in Shikoku Nat. Agr. Exp. Sta., 1983)

above condition is good enough to measure silicates colorimetrically.

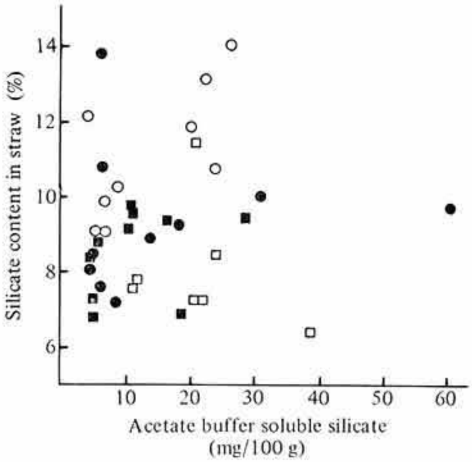
3) Sampling time of soils

The results of measurement of water soluble silicates in soils at different sampling times showed that the amount of water soluble silicates was large in the early stage of rice growth and slowly decreased with time toward the stage of harvesting. It was estimated that the result was caused by the silicate absorption by rice plants. Table 1 shows the annual variation of water soluble silicates in paddy soils without slag dressing. The amount of water soluble silicates decreased in fall, but in the early stage of rice cultivation next year, it was restored to the original level of the previous year, which indicates a certain value according to soil fertility. Regardless of the soil sampling days, sufficient correlations were observed between the water soluble silicates in soils and the SiO_2 contents in straw (Fig. 3)[6].

According to the results of these experiments, we determined that the soil samples should be taken from fields in the autumn before the succeeding winter cropping. From a view point of estimating the available silicates to rice plants, it is desirable to make soil sampling before the rice cropping, but this method loses the chance for giving the guidance in fertilizing the rice crop because it takes at least two weeks from the soil sampling to the quantitative analysis of silicates.

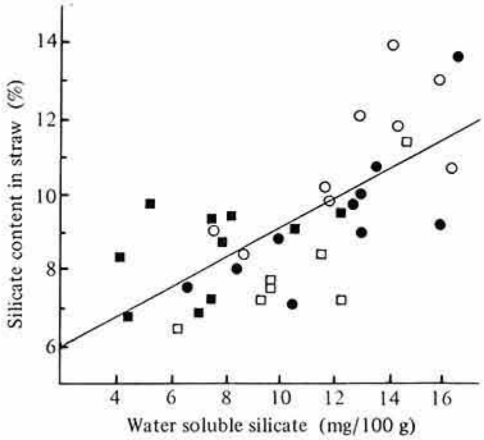
Examples of application of the new method

Rice plants absorb a large amount of silicates from irrigation water[2], so that it is estimated that the quantity of silicates uptaken is dominated by the quality of irriga-



Prefecture	Number	r
● Tokushima	10	0.082
○ Kagawa	9	0.709*
□ Ehime	7	0.221
■ Kochi	10	0.315
Total	36	0.098

Fig. 4. Relationship between acetate buffer soluble silicate and silicate content in straw on the spot paddy fields



Prefecture	Number	r
● Tokushima	10	0.773**
○ Kagawa	9	0.753*
□ Ehime	7	0.833*
■ Kochi	10	0.429
Total	36	0.708**

Fig. 5. Relationship between water soluble silicate and silicate content in straw on the spot paddy fields

tion water. We studied the relation between the water soluble silicates and the silicate content in rice straw cultivated in four prefectures (in Shikoku) differing in the quality of irrigation water. The summarized results are as follows:

(1) No correlation was found between the silicate content in straw and the acetate buffer soluble silicates for the data of each prefecture except Kagawa, or for the data of four prefectures taken as a whole (Fig. 4).

(2) In contrast, considerably high correlation was found between the silicate content in straw and the water soluble silicates for the data of each prefecture except Kochi, and for the data of four prefectures taken as a whole (Fig. 5).

In this study, paddy fields which were created by carrying in the topsoil or those dressed with the large amount of mountain soils were also used. In such soils, silicate content in rice straw was relatively high, but its correlation to soil silicates was remarkably disturbed. The reasons for the disturbed correlation were that increased nitrogen and silicate release were caused by the effect of air drying of the former soil and the decreased silicate dissolution per unit weight of soil caused by an increased portion of sand or increased silicate absorption due to the increase of rhizosphere in the latter soil. These exceptional paddy soils were excluded from Figs. 4 and 5.

The above result indicates that the amount of water soluble silicates correlates with silicate content in straw even in the paddy fields differing in the quality of irrigation water and fertilization. It was estimated that the water soluble silicates are considerably useful as an index of soil silicate availability in the area where the temperature is nearly equal in the rice cultivation period.

Problems involved

The supernatant of some soils has a tinge of faint green before the addition of reducing reagent (Na_2SO_3), and even after the blue color development the color is greenish, making the absorbance too high. It is estimated that this phenomenon is caused by a reducing material like Fe^{2+}, though in the present experiment, this phenomenon didn't appear. This problem was solved with the colorimetric method by Okuda et al.[4].

The analitical method which takes two weeks from soil sampling to measurement is undesirable as a diagnostic method of soils on the spot, so that a more rapid method is desirable. It should be worth while to examine the extract on using a reducing buffer. The mechanism of the increase of silicate caused by the soil reduction should be made clear beforehand.

It is desirable to adopt the measurement of available silicates of soils as a practical method to assess the need of silicate fertilizers. For that purpose, it is necessary to define a new standard of soil diagnosis by a more applicable method which is different from the former method (acetate buffer method). This is a subject of the future study. In this connection, we propose the flooding incubation method to meet the need. Accumulation and analysis of many results obtained with the same method in many spots are needed. We would be happy if anyone who is interested in the diagnosis of soil silicates should give us his advice.

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