

STATUS OF AVAILABLE SILICA IN THE RICE SOILS OF KERALA STATE (INDIA)*

I. Evaluation of different methods for determination of available silica in soil

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Among the cultivated crop plants rice is considered to be a heavy feeder on silica. In Kerala, rice is grown on base unsaturated and partly de-silicated laterite soils. It is also grown on river-borne alluvia! soils (*Karapadom* soils), peat soils (*Kari* soils), reclaimed lake-bed soils (*Kayal* soils) of the *Kuttanad* area and the black soils of Palghat district. In all these soils there exists the possibility of enormous losses of silica by leaching and erosion. This fact considered in the light of the findings of Padmaja and Verghese (1966) that application of silicates increases rice yields brings to the forefront the problem of availability of silica in these soils. Since there is no information available on this, detailed studies were undertaken with a view to ascertaining the available silica status of the above said rice soils. The present communication which forms a part of these studies discusses the results of the investigations conducted on the choice of suitable extractants for determining the available silica in the soils.

Materials and Methods

Soil samples from the top 9-inch layer of eleven representative wet land tracts and six samples of soil from adjacent garden lands were collected for the study (see Table 1 for details). About 100 rice plants were also collected at random from the same fields at the time of harvest and the dry weight of straw and grains recorded separately •

Water, 0.2 N hydrochloric acid (Kawaguchi and Hattovi, 1959), 0.025 M citric acid (Ueda and Yamaoka, 1960) and 0.5 N sodium bicarbonate (Olsen's extractant for available phosphorus) were shaken at 1 : 10 ratio in polythene bottles with fresh soils equivalent to 20 g of the air dried soils for the preparation of the water extract and with 20 g of the air dried soils for the preparation of the other extracts for six hours at room temperature. Silica, iron and aluminium were determined by the modified silico-molybdate (Murthy *et al.*, 1965), the O-phenanthroline and the

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TABLE 1

Details of soil samples studied

Serial number	Soil number	Location	Soil condition and crop	Soil type
1	1a	Vellayani	Dry land - garden	Red loam
2	1b	do	do	do
3	2a	do	Wet land - paddy	do
4	2b	do	do	do
5	3a	Thaliparamba	Dry land - paddy (Modan)	Laterite
6	3b	do	Wet land - paddy	do
7	4a	Onattukara	Dry land - garden	Coastal alluvium (sandy soil)
8	4b	do	Wet land - paddy	do
9	5a	Ambalavayal	Dry land - garden	Forest soil
10	5b	do	Wet land - paddy	do
11	6	Karamana	Wet land - paddy	Laterite
12	7a	Chittor	do	Black soil
13	7b	do	do	do
14	7c	do	do	do
15	8a	Chithiramangalam	do	Lake-bed soil (<i>Kayal</i> soil)
16	8b	Alleppey R Block	do	do
17	9	Mundar	do	Peat soil (<i>Kari</i> soil)
18	10	Neelamperoor	do	River-borne alluvium (<i>Karapadam</i> soil)
19	Ha*	Bellary	do	Black cotton soil
20	11b*	do	Dry land - garden	do
21	12a	Pattambi	do	Laterite
22	12b	Pattambi	Wet land - paddy	do

* Collected from outside the State for comparison

aluminon methods (Jackson, 1958) respectively p^H was determined in soil suspension (soil to water ratio 1 : 2.5) using glass electrode, organic carbon by the wet chromic acid method of Walkley and Black (Piper 1950) and sulphate by the barium chromate colorimetric method (Sandell 1959). Silica in plant materials was determined after digestion with a mixture of nitric, sulphuric and perchloric acids in 10 : 1 : 4 ratio. Silica after dehydration was treated with 0.5 N hydrochloric acid, filtered and washed free of adhering metallic irons with 6 N hydrochloric acid. The residue was brought in to solution by treatment with hot 5 percent sodium hydroxide (Jackson, 1958) and silicon determined colorimetrically by the method already described. The filtrate from the tri-acid digestion was used for the determination of iron and aluminium. Mechanical analysis was conducted following the international pipette method (Piper, 1950).

Results and Discussion

Results presented in Tables 2 and 3 show that the amount of silica extracted by the four different extractants depends not only on the nature of the extractants but also on soil characteristics such as texture, p^H , moisture regime and the amount of aluminium and iron. The sand fraction does not seem to have appreciable influence on the amount of silica extracted by any of the extractants other than 0.5 N sodium bicarbonate, which extracts relatively higher amounts of silica. This has been observed in soils having a fine fraction (silt + clay) of less than 10 percent, Sodium bicarbonate being an alkaline reagent probably brings into solution crystalline silica or silicate minerals as anions (Jackson and Sherman, 1953). More over silica extracted by sodium bicarbonate is not

entirely available to plants as revealed by the low uptake of silica by rice plants grown on sandy soils as seen in Table 6.

The silica extracted by 0.025 M citric acid is found to be positively correlated with the fine fraction i.e., silt plus clay (Fig. 4). A similar correlation is not seen for hydrochloric acid soluble silica. More over Fig. 2 shows that a significant and positive correlation exists between the amount of silica on the one hand and the amounts of iron and aluminium extracted by the hydrochloric acid on the other suggesting simultaneous release of silica and aluminium into solution by hydrolysis of aluminosilicate minerals. That an acidic environment leads to the dissolution of aluminosilicates in humid regions has been reported by Acquaye and Tinsley (1963). It is seen in Table 5 that an inverse relationship exists between silica on the one hand and iron and aluminium on the other extracted by citric acid. These results indicate the superiority of citric acid as an extractant for the determination of available silica. Analysis of plant tissues reveals that a high content of silica is invariably associated with a low content of aluminium and iron as is seen from Table 6. Therefore it seems justifiable to consider citric acid extractable silica as more plant available.

From Figures 1 and 3 it is evident that a significant correlation exists between the silica content of rice plants and the amount of silica extracted by hydrochloric and citric acids. From the steepness of the regression lines it appears that citric acid is a more reliable extractant for predicting the available silica status of the rice soils of the State. Citric acid has been chosen for the evaluation of the available silica status of the degraded soils of Japan by Ueda and Yamaoka (1959).

A scrutiny of Tables 1 and 2 will also reveal that in spite of the considerable removal of silica by successive rice crops wet land soils always contain a higher amount of silica as compared to adjacent dry lands. This may be due to the accumulation of silica leached down from the adjacent up lands as well as due to solubilisation of silica by mineral acids produced in some wet land soils. Results

given in Table 4 show that when subjected to drying such soils release higher amounts of water soluble silica. This may be attributed to the dissolution of silica by sulphuric acid produced consequent to oxidation of sulphides on drying. Mineral acid production in some of the paddy soils of Kerala State has been demonstrated by Money (1961).

TABLE 2

Important chemical and physical characteristics of dry and wet land paddy soils of Kerala

Soil No.	p ^H	coarse sand	fine sand	silt	clay	organic carbon	Water solubles (as ppm on moisture free basis)		
							SiO ₂	Al ₂ O ₃	Fe ₂ O ₃
1a	5.2	35.9	14.2	12.1	34.0	0.5	15.0	1.2	0.8
1b	5.2	56.0	11.2	10.6	21.0	1.0	12.0	1.0	1.0
2a	5.1	33.0	16.4	10.5	38.3	1.8	22.5	0.5	2.2
2b	4.8	48.0	10.0	11.2	25.0	1.6	26.5	0.4	1.5
3a	5.4	35.1	15.6	13.6	32.0	2.2	15.0	1.0	1.0
3b	5.3	26.0	23.0	22.8	26.5	1.5	23.5	0.5	0.5
4a	5.5	72.7	14.0	9.3	2.0	0.3	10.0	1.0	1.5
4b	5.4	63.0	23.0	6.7	3.0	0.7	8.3	0.9	1.3
5a	5.1	24.6	24.4	16.0	34.0	1.0	27.0	0.6	2.0
5b	5.3	30.0	26.8	16.5	31.8	1.1	33.8	0.6	1.7
6	5.4	21.0	26.4	18.5	31.9	1.6	16.0	0.5	2.5
7a	7.8	30.0	20.5	8.3	35.8	0.8	70.0	1.6	2.5
7b	7.7	27.0	17.0	10.3	39.0	1.5	75.0	0.9	3.2
7c	8.0	33.0	16.0	12.5	35.0	0.5	50.0	1.0	3.0
8a	7.2	6.9	19.0	27.7	36.3	2.0	39.3	0.8	8.5
8b	7.3	6.5	18.0	20.4	42.0	1.7	24.3	0.5	2.0
9	3.6	7.8	10.0	7.5	38.8	11.2	56.8	8.6	41.5
10a	2.8	2.0	12.4	17.3	49.6	4.3	105.0	8.8	39.0
11a	8.7	12.0	18.0	14.0	41.5	0.6	50.0	0.8	1.0
11b	8.3	15.0	19.0	11.0	39.0	0.4	50.0	1.0	1.5
12a	5.6	45.0	19.6	8.5	22.6	0.6	16.3	0.8	1.3
12b	5.4	40.0	20.0	10.0	28.0	0.7	30.0	0.9	0.5

TABLE 3

Silica extracted from Soil by different extractants
(as SiO₂ in ppm on moisture free basis)

soil No.	water	0.5 N Sodium bicarbonate	0.025 M Citric acid	0.2 N hydrochloric acid
1a	15.0	120	200	330
1b	12.0	100	325	450
2a	22.5	120	345	480
2b	26.5	113	345	480
3a	15.0	50	305	550
3b	23.5	106	330	510
4a	10.0	238	90	200
4b	8.3	240	100	192
5a	27.0	50	235	600
5b	33.8	112	325	525
6	16.0	90	380	600
7a	70.0	250	310	1000
7b	75.0	512	350	1200
7c	50.0	412	525	900
8a	39.3	187	705	780
8b	24.3	225	645	800
9	56.8	100	375	500
10	105.0	50	435	900
11a	50.0	175	690	1925
11b	50.0	187	435	1300
12a	16.3	63	225	300
12b	10.0	100	300	350

TABLE 4

Water soluble silicates and sulphates in soils before and after drying
(as ppm on moisture free basis)

Soil No.	Before SiO ₂	drying SO ₄	After SiO ₂	drying SO ₄	Soil No.	Before SiO ₂	drying SO ₄	After SiO ₂	drying SO ₄
2a	17.50	20	22.5	50	7a	65.13	506	70.0	575
2b	23.50	60	26.5	125	7b	61.66	571	75.0	900
3b	22.75	13	24.0	80	8a	32.97	361	40.0	375
5b	30.00	46	34.0	60	8b	21.17	238	24.0	250
6	12.00	20	16.0	40	9	49.85	2317	57.0	5300
					10	36.50	1215	105.0	5500

TABLE 5

Soluble Silica, Aluminium and Iron extracted by the acidic extractants
(as ppm on moisture free basis)

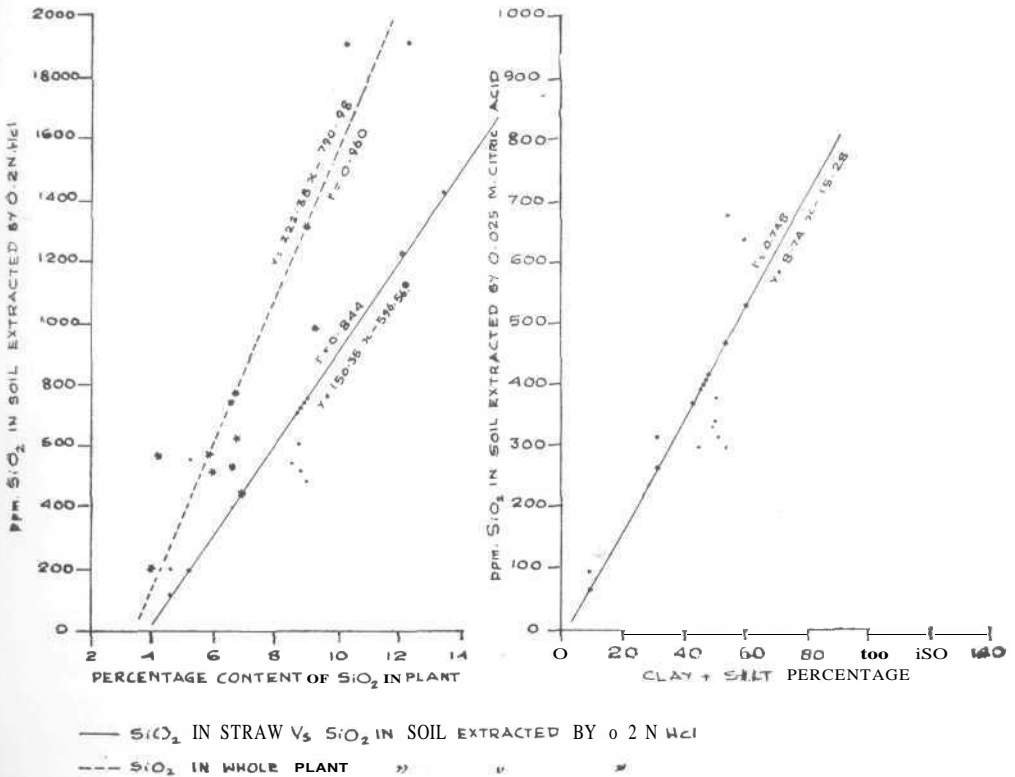
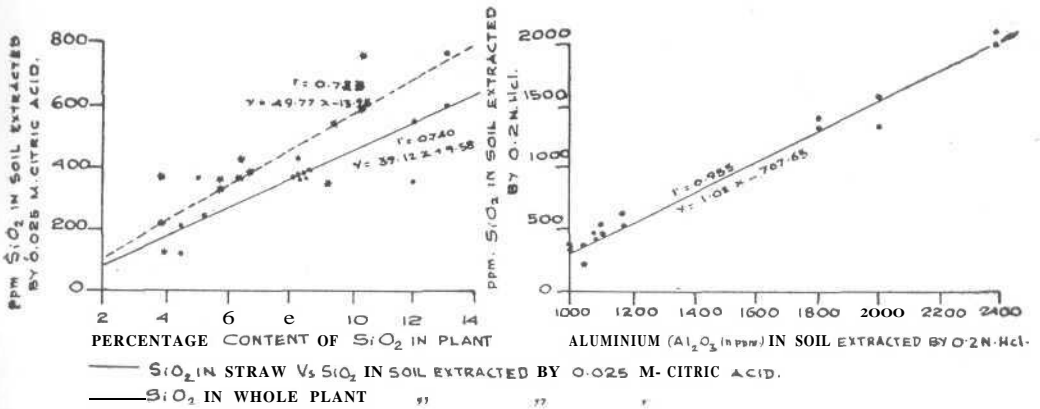
Soil No.	0.2 N hydrochloric acid			0.025 M citric acid		
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃
1a	330	1000	2200	200	960	1330
2a	450	1100	1530	325	1000	900
4b	190	1048	430	100	556	160
5a	600	1184	620	360	1130	400
5b	530	1126	3430	340	1125	2530
7a	1000	2000	30	310	680	39
7b	1200	1800	40	350	720	50
11a	1930	2400	20	690	204	47

TABLE 6

Silica, Aluminium and Iron in the straw and grain of different varieties of rice
grown in the different types of soil

Soil No.	Variety	Yield in g per 100 plants		SiO ₂		Al ₂ O ₃		Fe ₂ O ₃	
		straw	grain	straw	grain	straw	grain	straw	grain
(In percentage on moisture free basis)									
2a	PTB-9	2350	1833	8.89	4.40	0.09	0.01	0.06	0.01
2a	PTB-26	2300	2150	8.44	5.27	0.13	0.02	0.08	0.02
3a	Modan	500	300	5.27	2.43	0.24	0.01	0.11	0.02
3b	PTB-9	3824	1620	8.66	3.07	0.09	0.02	0.13	0.01
4b	UR-19	1000	800	4.49	2.54	0.17	0.02	0.11	0.01
5b	WND-2	3133	3200	8.48	3.66	0.12	0.03	0.13	0.07
5b	SLO-17	2233	1133	8.37	3.66	0.18	0.21	0.08	0.01
5b	MTU-19	6066	5470	8.78	3.56	0.13	0.02	0.06	0.01
6	Taichung-65	3700	4440	8.63	3.50	0.20	0.01	0.09	0.01
6	PTB-4	4375	4000	8.09	4.50	0.09	0.01	0.10	0.01
6	PTB-16	5000	4000	8.96	5.33	0.09	0.01	0.06	0.01
7a	PTB-26	2130	1820	12.10	6.25	0.07	0.01	0.04	0.01
11a	GEB-24	2800	2000	13.50	6.62	0.06	0.01	0.04	0.01

On evaluation of available silica



- Fig. 1, *Top left*: Correlation between the silica content of the rice plants and the silica extracted from the soils by 0.025 M. citric acid.
- Fig. 2, *Top right*: Correlation between silica and Aluminium extracted from the soils by 0.2N. Hydrochloric acid.
- Fig. 3, *Bottom left*: Correlation between the silica content in rice plants and the silica extracted from the soils by 0.2N. Hydrochloric acid.
- Fig. 4, *Bottom right*: Correlation between silica extracted by 0.025 M. citric acid and the fine fractions (silt + clay) of the soil.

Summary

Among the four different extractants tried 0.025 M citric acid is found to be the most reliable for assessing the available silica status of the rice soils of Kerala State. Wet land soils have in general a higher available silica status than adjacent dry land soils. Drying a wet land soil increases the water soluble silica content by 15 percent approximately.

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