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

II. Silicon uptake by different varieties of rice in relation to available silica contributed by soil and irrigation water.

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Since 1934 Japanese scientists have observed that silicon is beneficial for normal growth and yield of rice. Silicon has also been shown to influence the uptake of other nutrients by rice plants (Yoshida *et al*, 1959, Mioshi and Ishi 1960 and Okuda and Takahashi 1961). In recent years there have been a number of reports to show that application of silicates enhances the yield of rice (Okamoto 1957, Yoshida *et al* 1957 and Padmaja and Verghese 1966).

Due to the high rainfall and consequent heavy leaching Kerala soils are likely to contain only low amounts of available silica. It was therefore felt that a study of available silica contributed by the different soils and irrigation waters and its absorption by different varieties of rice might throw light on the nature of response of plants to application of silicates in soil.

Material and Methods

Soil and plant samples used were the same as detailed in the earlier contribution (Nair and Aiyer 1968). Oven dry plant samples were digested with tri-acid mixture of nitric, sulphuric and perchloric acids in the ratio 10 : 1 : 4 and the silica after dehydration was treated with 0·5 N hydrochloric acid. This was filtered and the residue washed free of metallic ions with 6 N hydrochloric acid. The residue was brought into solution by treatment with hot 5 percent sodium hydroxide (Jackson 1958) and silicon determined colorimetrically by the silico-molybdate method as modified by Murthy *et al* (1965). The washings and the filterate were made to volume for the analysis of Al, Fe, P, Ca, Mg, Mn, and K. Aluminium was determined using aluminon at pH 4·2 (Snell and Snell 1957) (the interference due to iron being removed by thioglycollic acid), iron by the O-phenanthroline method (Jackson 1958), phosphorus by the chloro stannus-reduced molybdo phosphoric blue colour in sulphuric acid system (Truog and Meyer 1929), calcium and magnesium by the versene method as described in U.S.D.A. Hand book No. 60 (Anon. 1954), manganese by oxidation with potassium

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periodate in presence of phosphoric acid to potassium permanganate and reading the colour at 540 mu (Jackson 1958), potassium turbidimetrically by using cobalti nitrite solution (Lindner 1944) and total nitrogen by the Kjeidahl's method (Piper 1950).

Eleven samples of irrigation water from different sources were collected and after removing the suspended impurities by filtration were analysed for soluble silica content, calcium and magnesium as described above. Sodium was determined by the zinc uranyl acetate method (Anon. 1954).

Results and Discussion

Figure 1 presents data on the average available silica status of eight different soil types as adjudged by four different extractants. The silica extracted by 0·025M citric acid ranges between 200 to 1500 Kg/Ha with average value at 700Kg/Ha.

Table 1 gives the data on the silica content of irrigation waters. River waters have a higher silica content (12ppm) than well waters (5 to 7 ppm). On an average the irrigation waters can be assumed to contribute about 30 Kg/Ha/rice crop.

Table 1

Analysis of irrigation waters in Kerala

Source of water	PH	SiO_2 ppm.	Sodium adsorption ratio
Well (Cannanore)	6·7	5·8	nd
Well (Kozhikode)	6·5	6·8	nd
Well (Vellayani)	6·8	6·9	0·7
Well (Kovalam)	6·2	6·5	20
Lake (Vellayani)	6·9	5-0	2·0
Kariar river	5·7	5·0	7·4
Chithiramangalam canal	5·7	63	4·5
Perinchani dam	6·0	120	0·9

nd-not determined.

Tables 2 and 3 present data on the chemical composition of grain and straw of rice plants collected from different locations. Irrespective of varietal differences and soil variations the ratio of silica in grain to straw is maintained approximately at 2 : 1. Variations in total silica content of plants could mainly be attributed to the differences in the available silica status of the soils. PTB 26 grown in the red loams of Vellayani (soil No. 2 a) and the black soils of Palghat (Soil No. 7 a) show a remarkable difference in their silica content. Different varieties of rice like SLO 17, MTU 19 and WND 2 grown in the forest soils of Ambalavayal (soil No. 5 b) show no significant difference in the silica content of grain and straw inspite of considerable variations in yields of both grain and straw. The varieties PTB 4, PTB 16 and Taichung 65 grown on the same tract at Karamana (soil No. 6) show no significant difference in silica content of grain and straw though the yields are comparable. Thus the silica content of the rice plant is found to be quite independent of the variety but is dependent on the available silica status of the soil. Similar results have been reported from Japan (Park *et al* 1964).

The silica content of grain and straw varies from 4 to 12 percent and plants with a silica content of 8 percent give fairly high yields. Goto (1960) claimed that a minimum of 12 to 13 percent silica is essential for higher yields. He based this finding on a positive correlation obtained between applied silica and yield. No such relationship is evident in the present studies between the silica content and yield under normal cultivation practices since the samples have been collected from cultivators' fields of widely varying soil types. However such a clear idea on this relationship can be obtained only from properly laid out field experiments with graded doses of applied silicates.

When the relationship between the silica contents of the rice grain and straw and each of the nutrients is considered, low contents of silica in plant tissues are seen associated with relatively high values for phosphorus (Tables 2 and 3). A higher percentage of silica does not seem to influence the phosphorus content. A higher content of silica in plant is invariably associated with low values for the metallic ions iron, aluminium and manganese. Similar nutrient interactions in rice plants have been recorded by Okuda and Takahashi (1961) though only from nutrient culture studies.

Based on the results of the present studies an average rice crop (2000 Kg grain and 2000 Kg straw per hectare) removes about 250 Kg of silica per hectare (Fig. 2). Kerala soils contain on an average about 700 Kg of available silica per hectare and irrigation waters may coatribute about 30 Kg per hectare per rice crop. Ueda and Yamaoka (1959) have reported response by rice to application of silicates in Japanese soils with an average available silica content of 3500 Kg/Ha. Compared to such soils the rice soils of the State can be considered to have a low available silica status. For high yielding varieties the removal of silica may be as high as 830 Kg/Ha/crop (Anon 1964). There is thus a strong case for resorting to silicate application for the high yielding varieties of rice. The results obtained also emphasise the need for conducting correlation studies between available silica

Table 2

Percentage chemical composition of different strains of rice grains on moisture free basis

Soil No. *	Variety	Grain in g per 100 plants	SiO_2	N	P_2O_5	K_2O	CaO	MgO	Al_2O_3	Fe_2O_3	MnO_2
2 a	PTB-9	1883	4·40	1·15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0·009
[illegible] a	[illegible]	[illegible]	[illegible]	1·10	[illegible]	[illegible]	0·13	[illegible]	0·02	[illegible]	0·014
3 [illegible]	[illegible]	[illegible]	2·48	[illegible]	[illegible]	0·37	0·15	0·27	0·01	[illegible]	0·013
[illegible] b	PTB-9	1620	8·07	0·88	[illegible]	[illegible]	[illegible]	[illegible]	0·02	0·01	[illegible]
4 b	[illegible]	800	2·54	[illegible]	0·71	0·44	0·18	[illegible]	[illegible]	0·01	[illegible]
5 b	[illegible]	[illegible]	[illegible]	[illegible]	0·45	[illegible]	[illegible]	0·19	[illegible]	0·07	[illegible]
5 b	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0·17	[illegible]	0·01	[illegible]
5 [illegible]	[illegible]	5470	[illegible]	1·10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	4440	[illegible]	1·40	0·70	[illegible]	[illegible]	0·18	[illegible]	[illegible]	[illegible]
[illegible]	PTB-4	[illegible]	4·50	[illegible]	0·70	[illegible]	[illegible]	[illegible]	0·01	[illegible]	0·009
[illegible]	PTB-16	[illegible]	[illegible]	[illegible]	0·72	[illegible]	[illegible]	0·25	[illegible]	0·01	[illegible]
7 [illegible]	PTB-26	[illegible]	6·25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0·01	0·01	[illegible]
11 [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0·40	[illegible]	[illegible]	0·15	0·01	[illegible]	[illegible]

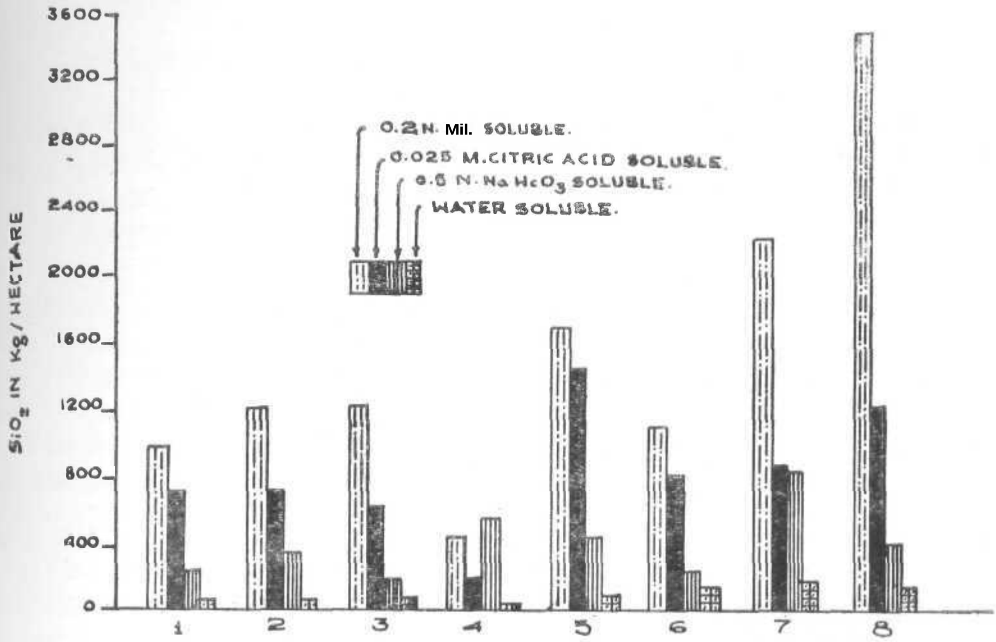
* See Nair and Aiyer 1968 for details.

Table 3

Per cent chemical constituents of different varieties of rice straw on moisture free basis

Soil No.*	Variety	Straw in g per 100 plants	SiO_2	N	P_2O_5	K_2O	CaO	MgO	Al_2O_3	Fe_2O_3	MnO_2
2 [illegible]	PT[illegible]-9	[illegible]350	[illegible]·89	[illegible]·07	0·06	1·09	0·36	0·33	0·09	0·06	0·065
[illegible] a	PTB-26	230[illegible]	[illegible]·44	0·81	[illegible]·07	0·99	0·44	0·32	0·13	0·08	0·062
3 a	Mod[illegible]	5[illegible]	5·27	0·31	[illegible]·34	0·91	0·69	0·31	0·24	0·11	0·039
[illegible] b	PT[illegible]-9	1824	[illegible]·6[illegible]	0·56	0·15	1·32	0·20	0·30	0·09	0·13	0·0[illegible]8
4 b	[illegible]R-19	1000	4·49	0·74	0·43	1·60	0·44	0·35	0·17	0·11	0·050
[illegible] b	WND-2	3133	[illegible]·48	0·62	0·06	1·11	0·64	0·27	0·12	0·13	0·075
5 b	SLD-17	2233	[illegible]·37	0·71	0·05	1·65	0·67	0·29	0·18	0·08	0·090
5 b	[illegible]U-19	6[illegible]66	[illegible]·78	0·65	0·05	1·73	0·56	0·27	0·13	0·06	0·075
[illegible]	Taichung-65	3700	8·63	0·92	0·18	2·42	0·50	0·41	0·12	0·09	0·075
[illegible]	P[illegible]B-4	4375	[illegible]·09	0·48	0·18	1·23	0·31	0·43	0·09	0·10	[illegible]·098
6	P[illegible]6	50[illegible]0	[illegible]·96	0·43	0·17	1·44	0·30	0·37	0·09	0·06	[illegible]·1[illegible]1
7 [illegible]	PTB-20	[illegible]130	12·10	0·35	0·05	2·00	0·44	0·39	0·07	0·04	[illegible]·010
11 a	GEB-24	2800	13·50	0·40	0·05	1·60	0·53	0·36	0·06	0·04	[illegible]·015

* See [illegible]r and Aiyer 1968 for details.



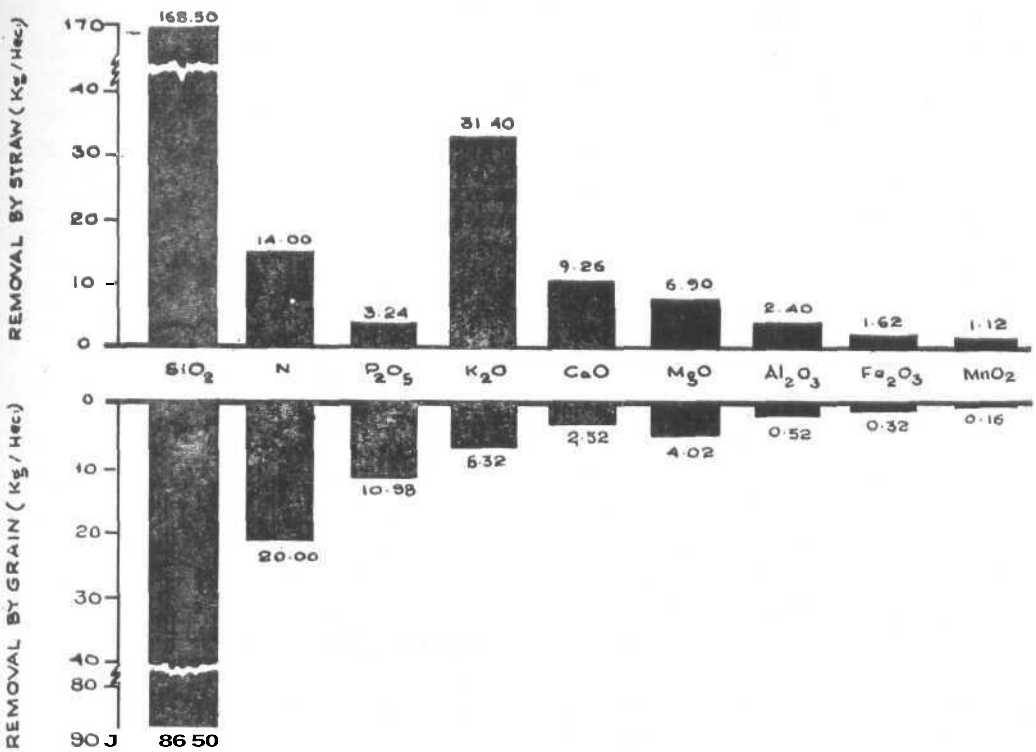


Fig. 1 (Above) Average available silica in eight different (1 to 8) soil types, adjudged by four different extractants

Fig. 2 (Below) Eates of removal of the different nutrients from soil by paddy straw and grains.

content in the soil and response to application of different forms and graded doses of silicates under field conditions.

Summary

On an average Kerala soils contain about 700 Kg of citric acid soluble (available) silica per hectare. Irrigation water contributes about 30 Kg of silica per hectare per crop of rice. An average rice crop removes about 250 Kg of silica per hectare under Kerala conditions.

The silica content of the rice plant is independent of the variety but is dependent on the available silica status of the soil. The ratio of silica content of straw and grain is maintained at 2:1 irrespective of varietal differences and soil variations,

A low content of silica in the rice plant is associated with high values for phosphorus. A higher percentage of silica, however, does not seem to influence the phosphorus content. A high value for silica is invariably associated with a low value for the metallic ions iron, aluminium and manganese.

Based on the removal of silica by an average rice crop and the available silica status of the rice soils of the State a strong case exists for application of silicates especially for the high yielding varietes of rice•

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