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EXTRACTABLE ALUMINIUM IN THE RICE SOILS OF KERALA

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More than 80% of the rice soils of Kerala being acidic, they are likely to contain large amounts of soluble and exchangeable aluminium which may cause direct as well as indirect harmful effects on the rice plant. Very little work has been done to study the distribution of aluminium in Kerala soils and to correlate it with the degree of soil acidity, aluminium content of the rice plant grown in these soils and with other soil chemical characteristics. This paper embodies the results obtained in a study conducted in the College of Agriculture, Vellayani.

Materials and Methods

Twenty surface soil samples from the wetland paddy fields of the major rice tracts of Kerala viz., the kari, karapadam, kayal and low level laterites were used for the study. The chemical composition of the samples was determined by standard procedures (Piper, 1950) and is given in Table 1. Ten gramme of the air dried soil samples were extracted with three different extractants viz. one normal potassium chloride, one normal ammonium acetate and distilled water (Ayers *et al,* 1965) at different soil solution ratios and adjusted to different pH values. Extraction with one normal potassium chloride was carried out at different soil solution ratios viz., 1 :10, 1 :20 and 1:40. One normal ammonium acetate was adjusted to pH 4.8, 6 and 8 and were used to determine the extractable aluminium. For water soluble aluminium, the samples were thoroughly wetted with distilled water, drained for 20 hours and filtered under suction. The aluminium obtained using the different extractants was determined colorimetrically with aluminon reagent as suggested by Yuan and Fiskell (1959). The results are presented in Table 2. The correlation coefficients between extractable Al using ammonium acetate at different pH values and water are given in Table 3. Similar correlation coefficients worked out for extractable Al with different soil solution ratios using one normal potassium chloride and water are presented in Table 4. Rice plants were collected from the same locations and the tops were analysed for aluminium colorimetrically in the hydrochloric acid extract of the plant ash. Results are given in Table 5.

Results and Discussions

The study on extractable Al in the various soil types shows that the amount extracted depends not only on the nature cf the extractants, but also

Table 1 Analysis of the **soil** samples used for estimating *aluminium*

Soil Type	Location	PH	C. E. C. me/100 g	Organic Carbon %	Fe_2O_3 %	Al_2O_3 %	Clay %
Kan	Vaikom	3.1	58.0	13.3	9.8	6.8	67.5
,,	Vadayar	4.1	38.0	12.6	9.3	6.1	59.5
,,	Karumadi	4.3	35.0	9.1	4.8	5.5	60.6
,,	Ampalapuzha	4.0	45.0	9.4	10.5	8.5	69.0
,,	Ellichira	4.3	35.1	11.0	7.0	10.5	61.0
,,	Nilamperur	4.6	34.0	17.6	9.9	12.1	59.0
,,	Thakazhi	4.9	31.0	15.7	9.0	10.5	60.9
,,	Kavalam	4.3	35.0	16.5	14.1	10.5	65.0
Kayal	Vellayani	5.1	28.0	2.8	9.8	13.0	51.0
,,	Vechoor	6.5	20.1	5.3	10.4	8.0	49.0
,,	Mundar	6.4	14.0	5.5	5.5	8.5	50.5
,,	Trichur Kole	5.3	35.6	11.4	5.9	16.9	55.0
Karapadam	Madirampally	4.3	36.4	2.4	10.5	19.5	45.0
,,	Mundar	5.5	25.1	2.8	9.5	10.5	40.0
,,	Nedumudi	5.4	30.0	1.4	8.5	12.5	39.5
,,	Purakad	4.3	35.0	4.9	10.5	16.5	46.0
Low level Laterite	Pattambi	5.2	5.8	1.7	9.5	17.5	25.0
,,	Vellayani	5.2	5.8	1.2	19.6	12.6	30.0
,,	Mavelikkara	4.8	15.8	4.5	10.5	13.6	25.5
,,	Trichur	5.3	23.0	1.7	12.3	15.9	20.0

on soil characters such as pH, clay content, CEC, organic matter content, the pH of the extractant and on soil to soil solution ratio employed for the extraction. The maximum quantity of Al from most of the soils was extracted with ammonium acetate adjusted to pH 4.8 and minimum with water.

The pH of the soil influences the amount of Al extracted by the different extractions and this is revealed by the significant negative correlation

Table 2 Aluminium extracted by various extractants (in ppm)

Soil type	In Ammonium Acetate			In Potassium Chloride			Water
	pH 4.8	pH 6.0	pH 8.0	1:10	1:20	1:40	
Kari	7000	1225	250	3700	6065	11000	16
,,	3005	600	120	1800	3800	8640	10
,,	2015	400	SO	1471	2750	3953	8
,,	2550	980	125	1810	3806	5706	10
,,	3000	400	78	1300	2710	3708	8
,,	1500	301	50	685	895	1915	7
,,	750	250	35	750	975	1C50	7
,,	2015	404	82	975	1080	2700	5
Kayal	676	225	40	202	216	275	5
,,	275	40	5	85	95	115	1
,,	525	45	6	95	325	140	1
,,	670	201	35	150	250	375	4
Karapadom	2550	395	81	2000	3010	3750	2
,,	575	200	40	200	350	475	3
,,	580	176	42	216	375	480	4
,,	2750	385	75	738	890	980	8
Low level laterite	600	201	39	143	156	175	5
,,	675	196	40	152	175	189	5
,,	1000	266	40	925	1050	1375	6
,,	700	201	36	1180	1275	1300	5

between the two ($r = -0.7\%$ for ammonium acetate adjusted to pH 4.8. r = — 0.80% for one normal potassium chloride and r — — 0.80 for distilled water). This is to be expected, since Al is more soluble under acid conditions. In general, the extractable Al tends to reach a minimum value in samples near nuetral pH which corresponds to nearly 100% base saturation. This result is in conformity with the amphoteric properties of Al as demonstrated by Magistad (1925).

Table 3 Correlation coefficients for the aluminium extracted by water and one normal ammonium acetate

Extractants used	X_1	X_2	X_3	X
One normal ammoniun acetate adjusted to pH 4.8	1.00			
One normal ammonium acetate adjusted to pH 6.0	0.8939**	**1.0**		
One normal ammonium acetate adjusted to pH 8.0	0.96099*	0.9606**	1.0	
Water	0.8292**	0.8728**	0.8713**	1.0

** Significant at 0.01% level

Table 4 Correlation coefficients for the aluminium extracted by water and one normal potassium chloride

Extractants used	X_1	X_2	X_3	X_4
One normal potassium chloride 1:10	1.0			
One normal potassium chloride 1:20	P.9714**	1.0		
One normal potassium chloride 1:40	0.9296**	0.7734**	1.0	
Water	0.9678**	0.7957**	0.8145**	1.0

** Significant at 0.01% level

There is significant correlation between the clay content of the soil and the Al extracted by one normal ammonium acetate adjusted to pH 4.8 ($r = +0.51$). Since the clay fraction contributed to the CEC of the soils, this relationship suggests that part of the Al extracted is exchangeable in nature. Similarly, significant correlation is obtained between CEC of the soil and Al extracted by one normal potossium chloride ($r = +0.75$) and not between the Al extracted by normal ammonium acetate, suggesting that normal ammonium acetate extracts larger amounts of Al from forms other than exchangeable Al.

The pH of the extractants has also influenced the Al extracted from the different soil types. Thus, in the kari and karapadom soils, it rose sharply as the pH decreased and in kayal and low level laterites it registered relatively lower values for extractable Al probably due to the presence of lime shells in the kayal soils (Kurup 1966) and due to the high iron oxide concretionary

Table 5 Analysis of rice plant

Plants collected from	Soil pH	Aluminium in Plant %
Vaikom (Kari)	3.1	0.150
Ampalapuzha (Kari)	4.0	0.120
Vellayani (Kayal)	5.1	0.065
Purakad (Karapadom)	4.3	0.100
Vellayani (Low level laterite)	5.2	0.075
Mavelikara (do)	4.8	0.089
Trichur (do)	5.3	0.080

fractions present in the surface horizons of the low level laterite soils. Similar results have been obtained by Ayers *et al.* (1965). The content of extractable Al in the poorly drained Kari and Karapadom soils seems to substantiate the work of Ragland and Colemen (1959) who found the percentage base saturation of Al to increase with decreased drainage. Moreover, the high acidity of the soil is responsible for the dissolution of the alumino-silicate minerals present in them.

The effect of soil solution ratio on the Al extracted with one normal potassium chloride shows that higher ratios (1 :40) extracted on the average, more than 3 times as much Al than in 1:10 ratio in the Kari soil and 1.5 to 2 times in the Karapadom soils and in the Kayal and low level laterite soils only slight increases were observed. These results suggest that exchangeable Al is not the principal source of Al in the kari and karapadom soils, while it is a dominant source of Al in the kayal and low level laterites.

Studies on the uptake of aluminium by the rice crop and correlation of the same with potassium chloride extractable aluminium ($r = +0.95$) ammonium acetate extractable aluminium ($r = +0.80$) and water ($r = +0.95$) suggest that better correlations are obtained with water and normal potassium chloride. Inter correlation studies (Table 4 & 5) between water as an extractant and one normal ammonium acetate adjusted to different pH values and between water and one normal potassium chloride in different soi! solution ratios indicate that both water and one normal potassium chloride are suitable extractants. For predicting toxic levels of aluminium in rice soils both one normal potassium chloride and water therefore appear to be suitable extractants.

Summary

Twenty surface soils representing four major rice soil types of Keraia viz., the Kari, Karapadom, Kayal and low level laterites were extracted with different extractants viz.. one normal potasium chloride at different soil solution ratios, one normal ammonium acetate adjusted to different pH values and water and the alluminium estimated. Based on the results, one normal potasium chloride with a soil solution ratio of 1 :10 and water were adjudged to be good for predicting toxic levels of Al in this soils. The result obtained further indicate that most of the Al extracted is of the exchangeable type in the case of Kayal and low level laterite soils, while it is not so in the case of Kari and Karapadom soils.

The results of the present investigation thus project the need for a very systematic evaluation of the extractable Al content of the highly acid rice soils of Kerala in relation to the existence of Al toxicity to the rice crop.

സംഗ്രഹം

കേരളത്തിൽ നെല്ലുകൃഷി ചെയ്യുന്ന നാല പ്രധാന മണ്ണിനങ്ങളായ കരി, കരപ്പാടം, കായൽ, roio<s>°om പ്രദേശങ്ങളിലുള്ള വെട്ടുകൽ മണ്ണുകം എന്നിവയെ പ്രതിനിധാനം ചെയ്യുന്ന ഇരുപത്തു ഉപരിതല fflsro സാമ്പിളുകളിൽ rarasoOBloonolceacrn എക°സ°ചേഞ്ചബിം അലൂമിനിയം വിവിധതരം ലായനികളം ഉപയോഗിച്ച് നിർണ്ണയം ചെയ്തു. ഇങ്ങനെ ലഭിച്ച ഫലങ്ങളെ അടിസ്ഥാനമാക്കി മണ്ണിൽ അടങ്ങിയിരിക്കുന്ന raroejiDlciDlcs2)rat3)l6in5o വിഷാക്ത പരിധി നിർണ്ണയിക്കുന്നതിനു° ഏക നോർമൽ പൊട്ടാസ്യം ക്ലോറയിഡു ലായനി 1:10 എന്ന അനുപാതത്തിലോ അല്ലെങ്കിൽ വെള്ളമോ ഉപയോഗിക്കാവുന്നതാണെന്നു കണ്ടു. കൂടാതെ കായൽ നിലങ്ങളിലെയും ro)os>°om വെട്ടുകൽ നിലങ്ങളിലെയും fflgfploa അടങ്ങിയിരിക്കുന്ന raraGjfffllmlcxzxaTmlro^ ഏറിയ പങ്കും എക്സ്ചേഞ്ചബിം rai^oaJlfojcTDGo-jooo കരി, കരപ്പാടം എന്നീ നിലങ്ങളിലെ മണ്ണിൽ മറ്റു രൂപങ്ങളിലുള്ള അലൂമിനിയവും അടങ്ങിയിരിക്കുന്നതായും മനസ്സിലാക്കി.

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