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IMPLICATIONS OF CHANGES IN SOIL pH ON THE Al, Fe AND Mn STATUS OF THE MAJOR COCONUT GROWING SOILS OF KERALA

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The indirect adverse effects of soil pH, rather than its direct effect due to H^+ ions, on plant growth are well recognised. The important consequences of the lowering of soil pH in relation to plant growth have been summarised by Hewitt (1953). Of these, in acid soils, heavy metal toxicities merit special attention. In as much as the very "soil acidity complex" is governed by both H^+ ions and Al^{3+} ions, studies on Al-soil pH relationships with respect to plant growth have earned considerable importance (Magistard, 1925; Pratt, 1961; Burgers and Pember, 1923) Toxic effects of Mn were also reported by Daji (1948) and Hewitt (1946). It is now well recognised that lowering of soil pH will favour increase in concentrations of Al and Mn in soil. Iron was also found to be a contributing factor to soil acidity though to a lesser extent than Al. This has been reported by Bhumbla and Mc Lean (1965) and Takkar *et al.* (1973). The information regarding the Mn and Fe status of Kerala soils is meagre (Pisharody and Muthunayagam, 1966). The present study was, therefore, taken up in order to assess the status of Mn and Fe in these soils and the relationships between soil pH and these elements and Al.

The soils used in this study fall under 5 major groups growing coconut viz. laterite, red sandy loam, alluvial, reclaimed marshy and coastal sandy. The reclaimed marshy is a made up soil, usually with silt and clay, found in Pokkali areas of the Kerala State and coconuts are grown on mounds or raised beds. The water table in this area is very near to ground surface at about 30-45 cm.

From each soil group 20 samples were taken at random from locations covering the whole of Kerala. The samples were taken from coconut basins at a distance of 150 cm from the bole of the palm to a depth of 0.50 cm. The air dried samples were analysed for exchangeable Al using the method of Chapman (1961) and exchangeable Fe and different Mn fractions by the methods suggested by Jackson (1967). The pH was measured in water (1 : 2.5), in N KCl (1 : 2.5) and in 0.01 N $CaCl_2$ (1 : 2) using glass electrodes. Simple linear correlations were worked out between pH values and concentrations of Al, Fe and Mn fractions. The difference in pH values between different suspensions were also calculated and designated as Δ pH.

Results and Discussion

The mechanical composition of the soils is given in Table 1. The data pertaining to exchangeable Al, exchangeable Fe and different Mn fractions are furnished in Table 2.

Comparison of the mean values revealed that the concentrations of Al and Fe were highest in the reclaimed marshy soil followed by laterite, alluvial and red sandy loam while coastal sandy soil registered the least. Water soluble Mn was also found to be the least in coastal sandy soil (0.1 ppm) as against ten times or more of this concentration in other soils. In the case of exchangeable and easily reducible Mn the following order was observed: Laterite = red sandy loam > alluvial > reclaimed marshy > coastal sandy.

Table 1

Mechanical composition of soils (Percent)

Soil type	Clay	Silt	Fine sand	Coarse sand
Laterite	25.0 — 41.5	6.4 — 10.0	15.3 — 22.5	28.9 — 46.2
Alluvial	43.0 — 52.0	11.3 — 13.3	9.2 — 10.9	15.0 — 37.6
Reclaimed marshy	39.7 — 46.9	24.3 — 26.4	4.6 — 6.8	3.5 — 3.6
Coastal sandy	1.9 — 2.3	0.8 — 1.2	0.5 — 3.0	96.3 — 98.0
Red sandy loam	13.8 — 18.0	3.8 — 4.3	2.6 — 3.8	73.0 — 79.0

Al was found to be negatively and significantly correlated with soil pH in all the soils except in the alluvial where no significant relationship was obtained (Table 3) Exchangeable Fe was found to be negatively correlated with pH in red sandy loam, reclaimed marshy and coastal sandy soils. This indicates that Fe also contributes to acidity in these soils. In other words with lowering of pH, Fe concentration in these soils also increases in addition to that of Al. Bhumbla and Mc Lean (1965) also found such a relationship with pH. Considering the solubility of Fe which precipitates at a much lower pH (about 3.5) than Al, this element assumes more importance in reclaimed marshy soil than in any other type of soil studied. Considering the high concentration of Al and Fe, this soil would be worst affected by lowering the pH and toxicity of these elements to plants might be expected.

Table 2

Status of Al, Fe and Mn in different soils (ppm)

Soil type	Exchangeable Al		Exchangeable Fe		Manganese					
					Water soluble		Exchangeable		Easily reducible	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range
Laterite	55.90	traces—176.00	10.20	1.8 —34.80	0.84	traces—2.88	14.90	1.44 —43.92	44.10	traces—118.80
Alluvial	54.10	1.0 —210.00	9.00	traces—24.60	1.60	traces—2.24	6 90	0.7 —23.40	32.00	0.7 —158.40
Reclaimed marshy	92.90	1.0 —342.00	18.60	3.32—102.00	1.20	traces—9.72	3.10	traces—21.25	6.00	traces— 36.36
Coastal sandy	5.70	traces— 37.00	3.10	traces— 6.60	0.10	traces—1.26	0 85	traces— 7.20	2.10	traces— 23.32
Red sandy loam	32.30	1.0 —128.00	2.50	2.60 — 7.35	1.20	traces—8.64	11.70	traces—40.68	46 40	3.6 —108.00

Table 3

Correlation coefficients (r) between pH and soil Al, Fe and Mn

Soil type	Y pH X	Exchangeable Al	Exchangeable Fe	Mn		
				Water soluble	Exchangeable	Easily Reducible
Laterite	Water	—0 53*	NS	NS	NS	NS
	KCl	NS	NS	NS	NS	NS
	$CaCl_2$	NS	NS	NS	NS	NS
Red sandy loam	Water	—0.67**	—0.60**	NS	—0.51*	NS
	KCl	—0.61**	NS	NS	—0.50*	NS
	$CaCl_2$	NS	NS	—0.48**	—0.55*	NS
Reclaimed marshy	Water	—0.71**	NS	NS	NS	NS
	KCl	—0.62**	NS	NS	NS	NS
	$CaCl_2$	—0.80**	—0.71**	—0.45*	NS	NS
Alluvial	Water	NS	NS	—0.54*	NS	NS
	KCl	NS	NS	NS	NS	NS
	$CaCl_2$	NS	NS	NS	—0.60**	NS
Coastal sandy	Water	—0.63**	—0.67**	NS	—0.54*	—0.54*
	KCl	—0.79**	NS	NS	—0.51*	—0.49*
	$CaCl_2$	NS	NS	NS	NS	NS

* Significant at 5% level
** Significant at 1% level

NS — Not significant

Table 4

Influence of medium of measurement on soil pH values

Soil type	Range of pH			Mean difference (Δ pH)*		
	Water (1 : 2.5)	N. KCl (1 : 2.5)	10-M $CaCl_2$ (1 : 2)	KCl and H_2O	$CaCl_2$ and H_2O	KCl and $CaCl_2$
Laterite	4.30 — 7.20	3.95 — 6.75	3.90 — 6.75	—1.10	—0.80	—0 30
Red sandy loam	4.45 — 7.80	3.75 — 6.35	4.00 — 7.10	—1.10	—0.80	—0.30
Reclaimed marshy	3.00 — 8.55	2.90 — 8.00	3.00 — 7.60	—0.61	—0.51	—0.10
Alluvial	3.85 — 7.40	3.40 — 6.90	3.60 — 7.50	—0.94	—0.63	—0.32
Coastal sandy	5.10 — 8.90	3.90 — 8.40	4.20 — 7.70	±	±	±

* N o definite trend was observed in the case of coastal sandy soil

Negative correlations between pH and the different Mn fractions have been reported by may workers (Zande *et al*, 1959; Biswas and Gawande, 1964; Sharma and Motiramani, 1964). In the present study water soluble and exchangeable manganese were negatively correlated with pH in red sandy loam and alluvial soils, while in reclaimed marshy soil only water soluble fraction gave such a relationship. None of the soils except coastal sandy gave a negative correlation with easily reducible Mn showing that conversion into manganic oxides (Mn^{3+} and Mn^{4+}) takes place in this soil with rise in pH. In this context it may be pointed out here that most of the samples in this group (18 out of 20) had a pH of 6 or above 6.

The pH values obtained in both water and electrolyte suspensions and the difference between them designated as (ΔpH) are furnished in Table 4. In all soils except in coastal sandy soil the pH values obtained in either KCl or $CaCl_2$ was lower than that obtained in water suspension. In other words Δ pH values were negative except for coastal sandy soil where it was either positive or negative. The difference was again larger in comparatively less acidic soil (laterite and red sandy loam), lesser in alluvial and least in highly acidic reclaimed marshy soil. Al^{3+} or hydroxy Al extracted by electrolytes gets hydrolysed in soils having a higher pH (in water suspension) and this may be the reason for the larger difference in pH values obtained in electrolyte and water suspensions. Recent work of Kissel *et al*. (1971) showed that the higher amount of acidity in the unbuffered KCl extracts of soil could be due to the hydrolysis of hydroxy-Al.

Moreover these results throw light on the nature of the charge associated with these soils. Since Δ pH values between electrolyte and water suspensions are negative in all soils except coastal sandy soil it can be said that these soils do have a net negative charge while the coastal sandy has either positive or negative charge.

Summary

The Mn and Fe status of different soil groups of Kerala State were studied. The concentration of exchangeable Fe was highest in reclaimed marshy soil followed by laterite, alluvial and red sandy loam and least in coastal sandy soil. Mn status of red sandy loam and laterite was higher than that of other soils. Soil pH was found to be correlated negatively with KCl exchangeable Al in all soils except in alluvial where it is not significant. Such a relationship was found between exchangeable Fe also in red sandy loam, reclaimed marshy and coastal sandy soils. Water soluble and exchangeable Mn gave negative correlation coefficients with pH in three soils while easily reducible Mn was not found to be correlated with pH except in coastal sandy soil. The difference in soil pH values (— Δ pH) measured in electrolyte and water suspensions was found to increase with decreasing acidity of soil. (Key words: Mn fractions of Kerala soils; Soils Fe; Soil Al; Δ pH)

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സംഗ്രഹം

കേരളത്തിലെ മണ്ണുകളിൽ മിക്കതും അമ്ലത്വം കൂടുതലുള്ളതാണ്. സാധാരണയായി ചെടികളിൽ ഇങ്ങനെയുള്ള മണ്ണുകളിൽ ചില ധാതുലവണങ്ങളുടെ അംശം ചെടികൾക്ക് ആപൽക്കരമാവുന്ന പരിധിവരെ വർദ്ധിക്കുന്നതു് കണ്ടിട്ടുണ്ട്. കേരളത്തിലെ തെങ്ങുകൃഷി ചെയ്യുന്ന പ്രധാന മണ്ണിനങ്ങളായ ചെങ്കൽമണ്ണ്, ചുകന്ന പശിമരാശിമണ്ണ്, എക്കൽമണ്ണ്, നികത്തിയെടുത്ത ചളിമണ്ണ്, ചരൽമണ്ണ്, ഇവയിൽ അടങ്ങിയിട്ടുള്ള ഇരുമ്പ്, മാംഗനീസ്, അലൂമിനിയം, മുതലായ ലോഹങ്ങളും അമ്ലത്വവും തമ്മിലുള്ള ബന്ധത്തെപ്പററി സമഗ്രമായ ഒരു പഠനം നടത്തിയതിൽ എക്കൽ മണ്ണൊഴികെയുള്ള എല്ലാ മണ്ണുകളും പൊട്ടാസിയം ക്ലോറൈഡ് ലായനിയിൽ അലിഞ്ഞുവരുന്ന (എക്സ്ചെയിഞ്ചബിൾ) അലൂമിനിയവും, അമ്ലത്വവുമായി അസന്നിദ്ധമായ ബന്ധം ഉണ്ടെന്ന് വ്യക്തമായി. അതായതു് അമ്ലത്വം കൂടുന്തോറും അലൂമിനിയത്തിൻെറ അളവ് വർദ്ധിച്ചു കാണുന്നു. ഇതേ രീതിയിലുള്ള ബന്ധം ഇരുമ്പിനെ സംബന്ധിച്ചേടത്തോളവും, ചുവന്ന പശിമരാശിമണ്ണ്, ചളിമണ്ണ്, ചരൽമണ്ണ് ഇവയിലും കാണുകയുണ്ടായി. വെള്ളത്തിൽ ലയിക്കുന്ന മാംഗനീസിൻെറ അംശവും വിനിമയം ചെയ്യപ്പെടാവുന്ന (എക്സ്ചെയിഞ്ചബിൾ) മാംഗനീസിൻെറ പ്രവർത്തനവും ഇതേരീതിയിൽ തന്നെയാണ്. പക്ഷെ എളുപ്പത്തിൽ വിജാരണം ചെയ്യപ്പെടാവുന്ന മാംഗനീസിൽ ഈ ബന്ധം ചരൽമണ്ണിൽ മാത്രമേ കാണാൻ സാധിച്ചുള്ളു.

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