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Effect of Lime Level as Indicated by Different Methods on Soil Properties*

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ABSTRACT

A pot culture experiment was conducted to study the effect of lime levels as estimated by different methods on soil acidity, exchangeable cations and nutrients availability. The extent of raise in soil pH was in proportion to the quantity of lime added. Lime additions based on IWB method, reduced the extractable acidity to the maximum extent. Lower lime levels maintained more Mg and K on exchange complex and increased the available N and P. Sulphur availability increased with increase in lime levels.

Soil acidity is considered to be one of the important limiting factors for the low productivity of soils of Uttar Kannada district, Karnataka State. In order to provide an optimum condition for plant growth liming is an important aspect of soil management practice in acid soils. It is estimated that accurate amount of lime to be added not only to neutralise the soil acidity but also to supply enough calcium for plant growth. Mclean (1970) pointed out that at higher base saturation of soil, Ca^{++} ions absorbed on pH dependent charges with concomitant release of cations. Thus the nutrients availability is enhanced. The increased microbial activity due to liming enhanced availability of N, P and S. Information in this regard in respect of acid soils of Uttara Kannada district, Karnataka State are however limited. An investigation was therefore, conducted to study the effect of the application different levels of lime as estimated by different methods on the changes in soil pH, $BaCl_2$ – TBA extractable acidity, exchangeable Ca, Mg and K and available N, P and S after the harvest of groundnut in pot culture experiment.

MATERIAL AND METHODS

The soil sample was collected from surface layer (0–20 cm) of typical groundnut growing area of Ankola, situated in coastal region of Uttara Kannada district of Karnataka State. The Physico–Chemical properties, Nutrient status and Lime requirement by four different methods are given in Table 1. Lime levels were tried at 1/2, 1.0, 1.5 and 2.0 times LR along with control–I (no lime + no fertilizer) and control–II (no lime + recommended dose

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Table 1. Physical and Chemical properties of the soil used for study

Property / Constituent	
Physical properties	
Mechanical analysis	
Fine sand %	12.65
Coarse sand %	40.10
Silt %	27.40
Clay %	18.50
Textural clase	Sandy loam
Maximum water holding capacity %	40.00
Chemical properties	
pH (1 : 2.5 soil : water ratio)	5.2
Electrical conductivity	
(1 : 2.5 soil : water extract) at 25°C dS / m	0.20
Organic matter %	2.86
$BaCl_2$ – TEA extractable acidity (c mol k^{-1})	15.30
Calcium	2.15
Magnesium	1.50
Potassium	0.272
Cation Exchange capacity (c mol k^{-1})	21.375
Available Nitrogen kg / ha	340.80
Available phosphorus kg / ha	14.62
Available sulphur kg /ha	23.75
Lime requirement tons / ha	
Puri's exchangeable calcium method	7.3
Improved Woodruff buffer (IWB) method	18.0
SMP – Simple buffer (SMPSB) method	9.0
SMP – Double buffer (SMPDB) method	6.03

of fertilizer for groundnut). Ground lime stone with 65% $CaCO_3$ and 2.4% $MgCO_3$ was used as a liming material. Lime was allowed to react with acid soil (10 kg) in a pot at 60 per cent of Maximum water holding capacity for three weeks. Groundnut (Var Dh. 8) was sown as a test crop. After the harvest of groundnut, soil samples were drawn and analysed for pH, $BaCl_2$ – TEA extractable acidity (Black 1965). Exchangeable cations and available N, P and S (Jackson, 1973).

RESULTS AND DISCUSSION

Soil pH : There was sequential and significant increase in the soil pH with lime levels over control (5.3) and fertilizer treatment (5.55). Among the lime requirement methods studied, IWB method raised the soil pH at a maximum (6.47) followed by SMPSB (6.32)

Puri's (6.25) and SMPDB (6.63) methods (Table 2). The extent of raise in pH was in proportion to the quantity of lime added. Accordingly the amount of lime added as per IWB methods was maximum and resulting pH of the soil was also maximum.

$BaCl_2$ - TEA extractable acidity : Neutralization of $BaCl_2$–TEA extractable acidity consequent to incremental addition of lime was sequential and significant over control and fertilizer treatment (Table 2). Liming at 1/2 LR level rapidly reduced the extractable acidity, at this level the rate of reduction was 8.0 c mol k^{-1} over control. Though the incremental addition of lime significantly neutralised the extractable acidity, the rate of neutralization was slowed down. During neutralization, active acidity neutralizes first followed by potential acidity. Once the active acidity is neutralised it requires higher amount of lime to neutralize the potential acidity (Coleman and Thomas, 1967). Lime additions based on IWB method reduced the extractable acidity to the

Table 2. Effect of lime levels as indicated by different methods on soil pH and $BaCl_2$ – TEA extractable acidity after harvest of gronudnut

Treatment	LR Methods				Mean
	Puri's	IWB	SMPSB	SMPDB	
	pH (1 : 2 Soil water ratio)				
Control – I	5.30	5.30	5.30	5.30	5.30
Control – II	5.55	5.55	5.55	5.55	5.55
1 / 2 LR	6.33	6.48	6.40	6.13	6 33
1 0 LR	6.48	6.90	6.63	6.23	6.51
1.5 LR	6.78	7.20	6.90	6.40	6.82
2.0 LR	7.05	7.40	7.13	6.55	7.02
Mean	6.25	6.47	6 32	6.03	—
	$BaCl_2$ – TEA extractable acidity (c mol k^{-1})				
Control – I	14.35	14.35	14.35	14.35	14.35
Control – II	14.20	14 20	14 20	14 20	14 20
1 / 2 LR	5.50	4 45	5.20	8.73	5.97
1.0 LR	4.31	3.53	4.24	7.02	4.78
1.5 LR	3 60	2.51	2.99	5.79	3.73
2 0 LR	2 68	1.14	2.15	5 05	2.74
Mean	7.44	6.70	7.18	8.19	—

	pH		$BaCl_2$ – TEA extractable acidity	
	S.Em. ±	C.D. at 5%	S.Em. ±	C.D. at 5%
Treatments	0.014	0.040	0.005	0.186
Method	0.020	0.087	0.053	0.152
T × M	0.049	0.140	1.131	0.372

maximum extent (6.7 col k^{-1}) followed by SMPSB (7.18 c mol k^{-1}), Puri's (7.44 c mol k^{-1}) and SMPDB (8.19 c mol k^{-1}) methods. This follows the amount of lime additions as estimated by these methods.

Calcium : The increase in exchangeable calcium was in direct proportion with increase in lime level. Liming as estimated by IWB method increased the exchangeable calcium to a higher level (7.51 c mol k^{-1}) followed by SMPSB (6.28 c mol k^{-1}) methods. This follows the order of magnitude of estimation of lime requirement. The increase in charge density due to liming has greater affinity for higher valent ions. Thus Ca being divalent cation and its higher solution concentration due to liming increased its concentration on exchange complex. The results are in conformity with that of Bartlett and McIntosh (1969).

Magnesium : Application of lime at 1/2 LR level significantly increased the exchangeable magnesium (1.77 c mol k^{-1}). Subsequent increase in the liming levels decreased the exchangeable magnesium significantly. Increase in exchangeable magnesium at lower lime level indicates its synergestic effect on Magnesium. This may be because, at lower levels of lime additions the increase in charge density on exchange surface might have also preferred the small amount of Mg present in lime and decrease in exchangeable Mg at higher level of lime is in agreement with the findings of Grimme *et al* (1977) and Beemaiah (1980) that the higher lime additions to the acid soils results in the higher solution concentration with respect to calcium which might compete with Mg on exchange site. Lime additions as estimated by SMPDB method retained significantly higher Mg on exchange complex (1.39 c mol k^{-1}), followed by Puri's (1.17 c mol k^{-1}), SMPSB (1.04 c mol k^{-1}) and IWB (0.84 c mol k^{-1}) methods.

Potassium : Liming increased the exchangeable K^+ at lower level (1/2 LR). Incremental addition of lime decreased the exchangeable K^+ significantly (Table 3). At lower level of lime addition calcium has synegrestic effect on potassium. This supports the view of Solankey *et al.* (1971) who reported that liming increased the release of non exchangeable potassium in acid soils. Decrease in exchangeable K at higher lime levels indicates that antagonistic effect of Ca over K. Similar findings were reported by Sudhir and Ananthanarayana (1986). Lime addition based on SMPDB method caused to retain more K on exchange complex (0.132 c mol k^{-1}) followed by Puri's (0.122 c mol k^{-1}), SMPSB (0.115 c mol k^{-1}) and IWB (0.092 c mol k^{-1}) methods.

Nitrogen : Application of lime with incremental level increased available N upto 1.5 LR (410.43 kg/ha) over control (332.5 kg/ha) and fertilizer treatment (349.13 kg/ha). The increase in the available N on liming is attributed to the greater N fixation by microbes (Solankey *et al* , 1971), stimulating effect of Ca on N availability (Longanathan and Krishnamoorthy 1976) and to the higher rate of mineralization of soil organic matter as a result of greater microbial

Table 3. Effect of lime levels as indicated by different LR methods on exchangeable cations after harvest of groundnut

Treatments	LR Methods				Mean
	Puri's	IWB	SMPSB	SMPDB	
			Calcium ($CMOLK^{-1}$)		
Control – I	1.75	1.75	1.75	1.75	1.75
Control – II	2.10	2.10	2.10	2.10	2.10
1 / 2 LR	5.38	8.03	6.39	5.31	6.23
1.0 LR	6.30	9.35	7.69	5.60	7.23
1.5 LR	7.78	10.93	9.00	6.31	8.47
2.0 LR	9.00	12.88	10.77	6.97	9.90
Mean	5.36	7.51	6.28	4.67	—
			Magnesium ($CMOLK^{-1}$)		
Control – I	1.00	1.00	1.00	1.00	1.00
Control – II	1.08	1.08	1.08	1.08	1.08
1 / 2 LR	1.94	1.19	1.91	2.06	1.77
1.0 LR	1.48	0.75	1.13	1.96	1.33
1.5 LR	0.91	0.56	0.63	1.05	0.79
2.0 LR	0.60	0.44	0.50	0.88	0.60
Mean	1.17	0.84	1.04	1.34	—
			Potassium ($CMOLK^{-1}$)		
Control – I	0.077	0.077	0.077	0.077	0.077
Control – II	0.107	0.107	0.107	0.107	0.107
1 / 2 LR	0.167	0.109	0.160	0.167	0.151
1.0 LR	0.144	0.091	0.138	0.154	0.132
1.5 LR	0.125	0.099	0.122	0.151	0.122
2.0 LR	0.112	0.071	0.087	0.138	0.102
Mean	0.122	0.092	0.115	0.132	—

	Calcium		Magnesium		Potassium	
	S.Em. ±	C.D. at 5%	S.Em. ±	C.D. at 5%	S.Em. ±	C.D. at 5%
Treatment	0.199	0.569	0.050	0.143	0.005	0.013
Method	0.163	0.465	0.041	0.117	0.004	0.011
M x T	0.400	1.138	0.100	0.286	0.007	0.026

activity in the limed soils (Pal and Mendal, 1985). The decrease in the available N on addition of higher amounts of lime is due to loss of N by surface volatilization at higher pH and on $CaCO_3$ ground surface. The results are in confirmity with Motiramani and Verma (1957) and Solankey *et al.* (1971). Liming as estimated by SMPDB method caused maximum increase in the available N (377.32 kg/ha) followed by Puri's (373.02 kg/ha), SMPSB (372.95 kg/ha) and IWB (369.21 kg/ha) methods (Table 4).

Table 4. Effect of lime level as indicated by different LR methods on available Nitrogen, Phosphorus and Sulphur

Treatments	LR Methods				Mean
	Puri's	IWB	SMPSB	SMPDB	
		Nitrogen kg / ha			
Control – I	332.50	332.50	332.50	332.50	332.50
Control – II	349.13	349.13	349.13	349.13	349.13
1 / 2 LR	369.91	392.77	367.41	354.11	371.05
1.0 LR	381.96	403.16	384.45	382.38	387.99
1.5 LR	421.85	388.61	430.10	401.08	401.43
2.0 LR	382.74	349.13	374.06	444.72	387.67
Mean	373.02	369.21	372.95	377.32	
		Phosphorus kg / ha			
Control – I	12.50	12.50	12.50	12.50	12.50
Control – II	15.50	15.50	15.50	15.50	15.50
1 / 2 LR	18.24	13.49	16.30	19.56	16.91
1.0 LR	15.16	12.13	13.89	19.38	15.14
1.5 LR	13.64	10.74	13.33	16.56	13.57
2.0 LR	13.83	9.20	11.11	15.31	12.11
Mean	14.74	12.34	13.89	16.55	
		Sulphur kg / ha			
Control – I	22.00	22.00	22.00	22.00	22.00
Control – II	25.00	25.00	25.00	25.00	25.00
1 / 2 LR	32.25	31.50	30.50	27.00	30.31
1.0 LR	35.50	34.25	37.80	30.50	34.51
1.5 LR	40.75	41.75	41.00	32.75	39.03
2.0 LR	44.25	46.75	43.00	37.75	42.94
Mean	33.29	33.54	33.02	24.17	—

	Nitrogen		Phosphorus		Sulphur	
	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%	S.Em.±	C.D. at 5%
Treatment	0.770	2.195	0.761	2.170	0.509	1.451
Method	0.629	1.792	0.213	0.607	0.456	1.185
M × T	1.541	4.390	0.522	1.488	1.018	2.902

Phosphorus : Initial additions of lime at 1/2 LR level enhanced the P availability (16.91 kg/ha) by 35.25 per cent over control (12.5 kg/ha) and by 9.1 per cent over fertilizer treatment (15.5 kg/ha). Further, increase in lime addition (Table 4) was found to decrease the available P. The increase in available P content of soils due to liming may be attributed to the release of native P (Kar, 1974), solubalization of Fe and Al bound P as a result of increase in OH ion concentration and precipetation of active Fe and Al into their insoluble forms of hydroxides and thereby decreasing their activity in soil solution. It may also be due to greater microbiological activity at the favourable pH causing rapid mineralization of organic P (Pal and Mandal, 1985). Decrease in the available P content at higher lime levels is due to the formation of Ca–Phosphate of low solubiliy at higher level of calcium activity. The order of superiority of LR methods with respect to P availability was SMPDB > Puri's > SMPSB > IWB.

Sulphur : There was sequential increase in available sulphur with incremental addition of lime over control (22.0 kg/ha) and fertilizer treatment (25.00 kg/ha). Maximum available sulphur was 42.44 kg/ha at 2.0 LR level (Table 4). Among lime requirement methods, IWB method caused maximum increase in available S at all the lime levels followed by puri's, SMPSB and SMPDB methods. This follows the amount of lime additions as per these methods. Korentager *et al.* (1983) reported that the amount SO_4^{2-} released increases with increase in lime rate, which is attributed to the increase in the rate of mineralisation of organic matter due to liming and/or to increase in salinisation of sparingly soluble sulphate compounds which have been postulated to be present in very acid soils.

Application of lime as estimated by SMP–double buffer method caused to retain more Mg and K on exchange complex and availability of nitrogen and phosphorus was maximum.

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