

STUDIES ON RELATIONSHIPS OF NUTRIENT POTENTIALS, SOIL ACIDITIES AND ZERO POINT OF CHARGE (pH_{ZPC}) WITH SOIL PROPERTIES FOLLOWING LIME AND POTASSIUM APPLICATION IN AN ACID MOUNTAIN SOIL FROM WESTERN HIMALAYAS

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The current study revealed that lime potentials has had a significant positive correlation with pH , yet negative with organic carbon and different forms of Al and Fe in the experimental soil. Likewise, phosphate potential was found to be positively correlated with organic carbon and different forms of Al and Fe, whereas negatively with pH . However, different forms of acidities and zero point of charge (pH_{ZPC}) have had a significant yet positive association with organic carbon and different forms of Al and Fe, but a negative one with pH .

Key Words: Lime Potential; Different Forms of Acidity; pH_{ZPC}

Introduction

The productivity potential of a given soil is considerably influenced by soil acidity in the mountain soils of Western Himalayas. However, to overcome this problem, liming has been suggested¹. Since, potassium competes with calcium in a liming programme, the influence of lime and potassium on lime potential, phosphate potential, soil acidity and zero point of charge (pH_{ZPC}) were studied and finally the individual and collective influence of several soil properties on them was assessed after the harvest of crops in a wheat-soybean-linseed sequence.

Materials and Method

A field experiment was conducted at the experimental farm of H.P. Agricultural University, Palampur, H.P. to observe the direct effect of lime with and without potassium on wheat (CV S-308) during rabi 1987-88, while the residual effect of lime with and without potassium as per treatments was studied on soybean (CV Punjab No. 1) during kharif 1989 followed by linseed (CV Himalini) during rabi 1988-89.

There were four levels of lime 0, 1.85, 3.7 (lime requirement) and 7.4 t CaO/ha and three levels of potassium viz., 0, 30 and 60 kg K₂O/ha which were replicated four times in a randomised block design. The important soil properties at the initiation of the experiment are given in Table I. For lime potential, soil was shaken with 0.01 M CaCl₂ solution and then pH was determined. For phosphate potential, the same reagent with the same concentration

containing known amount of phosphorus was used and then P content was determined colorimetrically³. The exchange acidity was determined by leaching the soil with 1N unbuffered KCl solution and titrating the leachate with 0.1 N NaOH⁴. For pH-dependent acidity, 1 N KCl pre-leached soil was extracted with barium chloride-triethanolamine, whereas for total acidity the soil was directly extracted with the same reagent and then the extract was titrated with 0.2 N HCl in both cases^{5,6}; for pH_{ZPC} determination, the soil was shaken with different concentrations at different pH values and the change in pH was again brought to the original value by the addition of an acid or base, then curves were prepared and their point of intersection gave the ZPC¹². The different forms of Al and Fe were determined by the method of Ballard and Fiskell⁷, whereas routine soil properties by the method of Jackson⁸. The simple coefficients of correlation were worked out by the method laid down by Snedecor and Cochran⁹.

Results and Discussion

Relationship of Lime and Phosphate Potential with Soil Properties

Lime potential has had a significant positive correlation with pH ($r=0.39^{**}$), whereas a negative one with exchangeable Al ($r=-0.37^{**}$)

Table I
Important physico-chemical properties of the soil at the initiation of the experiment

Sr. No.	Properties	Mean values
1.	pH (1 : 2.5)	5.7
2.	<i>Mechanical analysis</i>	
	(i) Sand (%)	30
	(ii) Silt (%)	40
	(iii) Clay (%)	28
	(iv) Textural class	Silty clay loam
3.	Organic carbon (%)	0.78
4.	Lime potential	3.86
5.	Phosphate potential	7.32
6.	<i>Different forms of acidities (C mol(p⁺)/kg):</i>	
	(i) Exchangeable	0.84
	(ii) pH dependent	10.50
	(iii) Total	11.72
7.	CEC (C mol (p ⁺)/kg)	12.10
8.	<i>Forms of Al and Fe (ppm):</i>	
		<i>Al</i> <i>Fe</i>
	(i) Exchangeable	15 28
	(ii) Extractable	53 80
	(iii) Amorphous	423 2152
	(iv) Crystalline	1415 1667
	(v) Total	19677 24470

Table II
Co-efficients of correlation of lime potential, phosphate potential, different forms of acidities and pH_{ZPC} with soil properties

	pH	Organic carbon	Exchange-able Al	Extract-able Al	Amor-phous Al	Crystal-line Al	Exchange-able Fe	Extract-able Fe	Amor-phous Fe	Crystal-line Fe
	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀
Lime Potential (Y ₁)	0.39** (15)	-0.18 (3)	-0.37** (14)	-0.19 (4)	-0.23 (5)	-0.23 (5)	-0.15 (2)	-0.17 (2)	-0.23 (5)	-0.25 (6)
Phosphate potential (Y ₂)	-0.16 (2)	0.13 (2)	0.14 (2)	0.06 (0)	0.02 (0)	0.06 (0)	0.13 (2)	0.11 (1)	0.07 (0)	0.06 (0)
Exchangeable acidity	-0.91** (83)	0.86** (74)	0.96** (92)	0.95** (91)	0.92** (85)	0.95** (90)	0.83** (69)	0.79** (63)	0.90** (81)	0.93** (87)
pH-dependent acidity	-0.83** (69)	0.74** (54)	0.84** (70)	0.80** (64)	0.87** (76)	0.82** (67)	0.79** (62)	0.76** (58)	0.88** (77)	0.81** (66)
Total acidity	-0.84** (70)	0.80** (64)	0.80** (64)	0.83** (69)	0.85** (73)	0.91** (83)	0.77** (60)	0.76 (58)	0.90** (81)	0.91** (83)
pH _{ZPC} (Y ₆)	-0.95** (90)	0.85** (72)	0.95** (90)	0.94** (89)	0.92** (84)	0.93** (86)	0.94** (88)	0.94** (89)	0.92** (85)	0.90** (81)

Figures in parentheses indicate per cent variation explained
 **Significant at 1 per cent level

(Table II). The significant positive association of lime potential with pH could be explained on the grounds that as the pH of the soil increases, so does the lime potential. A negative relationship with exchangeable Al could be due to the fact that Al on hydrolysis produces H^+ causing acidity¹.

Phosphate potential was not significantly correlated with pH, organic carbon and different forms of Al and Fe.

Different Forms of Acidities and Soil Properties

Among the different forms of acidities, the soil pH exhibited a significant and negative influence on exchangeable, pH-dependent and total acidity, the values of '*r*' being -0.91^{**} , -0.83^{**} and -0.84^{**} explaining around 83, 69 and 80% individual variation in these components (Table II). However, organic carbon had a positive yet significant influence on exchangeable ($r=0.86^{**}$), pH dependent ($r=0.74^{**}$) and total acidity ($r=0.80^{**}$) explaining 74, 54 and 64% variation (Table II).

Likewise, the individual variation accounted for in exchangeable acidity due to variation in exchangeable Al, extractable Al, amorphous Al and crystalline Al was 92% ($r=0.96^{**}$) and 91% ($r=0.95^{**}$), whereas variation due to the exchangeable Fe, extractable Fe, amorphous Fe and crystalline Fe was 69% ($r=0.83^{**}$), 63% ($r=0.79^{**}$), 81% ($r=0.90^{**}$) and 87% ($r=0.93^{**}$), respectively (Table II). Similarly, the individual variation in pH-dependent acidity, total acidity and pH_{ZPC} due to the variation in exchangeable Al were explainable to the extent of 70% ($r=0.84^{**}$), 64% ($r=0.80^{**}$) and 90% ($r=0.95^{**}$), whereas due to extractable Al, the variation was 64% ($r=0.80^{**}$), 69% ($r=0.83^{**}$) and 89% ($r=0.94^{**}$) respectively. The variation due to amorphous Al was accounted for to the extent of 76% ($r=0.87^{**}$), 73% ($r=0.85^{**}$) and 84% ($r=0.92^{**}$), whereas due to crystalline Al, it was 67% ($r=0.82^{**}$), 83% ($r=0.91^{**}$) and 86% ($r=0.93^{**}$) respectively (Table II). Furthermore, the accountability of individual variation in pH-dependent and total acidity due to exchangeable Fe was 62% ($r=0.79^{**}$) and 60% ($r=0.77^{**}$); due to extractable Fe, it was 58% ($r=0.76^{**}$) and 58% ($r=0.77^{**}$), 70% ($r=0.88^{**}$) and 81% ($r=0.90^{**}$); due to amorphous Fe and whereas due to crystalline Fe, it was 66% ($r=0.81^{**}$) and 83% ($r=0.91^{**}$) respectively.

The negative correlation of different forms of acidities with pH is obvious. The positive association of organic carbon with exchangeable acidity is due to the formation of humic complexes with exchangeable Al and Fe, which upon hydrolysis contribute to acidity. A similar kind of association of organic carbon with pH-dependent acidity could be explained on the basis of the existence of pH-dependent exchange sites on organic matter, i.e., humic acids^{3,7} and pH-dependent acidity is a major part of total acidity; therefore, the relationship of total acidity with organic matter is natural. Al and Fe ions on the exchange sites yield protons on hydrolysis and as such a positive relationship between acidities and different forms of Al and Fe is explainable.

pH_{ZPC} and Soil Properties

The pH_{ZPC} of the soil was correlated significantly and negatively with pH and positively with organic carbon and different forms of Al and Fe.

The individual variation in pH_{ZPC} due to pH , organic carbon, exchangeable Al, extractable Al, amorphous Al, crystalline Al, exchangeable Fe, extractable Fe, amorphous Fe and crystalline Fe was 90% ($r = -0.95^{**}$), 72% ($r = 0.85^{**}$), 90% ($r = 0.95^{**}$), 89% ($r = 0.94^{**}$), 84% ($r = 0.92^{**}$), 86% ($r = 0.93^{**}$), 88% ($r = 0.94^{**}$), 89% ($r = 0.94^{**}$), 85% ($r = 0.92^{**}$) and 81% ($r = 0.90^{**}$), respectively.

The negative correlation of pH_{ZPC} with pH is due to the fact that an increase in pH of the soil produces negative charge¹². The positive yet significant relationship of pH_{ZPC} with organic carbon and different forms of Al and Fe is explained on the ground that organic carbon and different forms of Al and Fe lower the pH and consequently pH_{ZPC} .

It is, therefore, concluded that the lime potential, different forms of acidities and pH_{ZPC} are significantly influenced by soil properties which have relevance in reclaiming them by applying lime and potassium.

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