

Evaluation of Soil Tests for Phosphorus in Lowland Ecosystem

R.K. Kaleeswari, R. Indirani, P. Saravanapandian, M.R. Latha and K. Prabhakaran

Department of Soil Science and Agricultural Chemistry,
Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Abstract: Available P status as estimated by different extractants and its relationship with different inorganic P forms as influenced by various organic manures and P fertilizers under wetland ecosystem is reported. The P extracting power of different extractants was in the order: Mehlich I > Bray I > Truog > Olsen > Morgan. Olsen and Bray No.1 extractants were consistent in extracting P from specific P fractions than the other three extractants. Among the inorganic P forms, Fe-P and saloid-P are the major contributors to available P as estimated by different extractants. The contribution of Fe-P fraction to available P was maximum.

Key words: Labile P, soil tests, inorganic P forms, P fertilizers, organic manures

INTRODUCTION

Several extractants are being used to determine the labile P in soils and these are not consistent in extracting the available soil phosphate. Knowledge on the contribution of different inorganic P forms to labile P provides useful information in assessing the available P status of soils. The present investigation was made to study the labile P status as estimated by different extractants and its relationship with inorganic P forms under flooded condition as influenced by inorganic P fertilizers and organic manures.

MATERIALS AND METHODS

Two field experiments were conducted at Tamil Nadu Agricultural University, Coimbatore in neutral soil belonging to Madukkur series (Alfisol) with rice as test crop. The treatments consisted of three organic manures viz., Farmyard Manure (FYM) poultry manure (PM) and green leaf manure (GLM) @ 12.5 t ha⁻¹ and inorganic P sources viz., single super phosphate (SSP) and udaipur rock phosphate (URP) @ 0, 30 and 60 kg P₂O₅ ha⁻¹. The experiment was conducted in a randomized block design with three replications. The initial soil characteristics are presented in Table 1. After the harvest of the first crop, each plot was divided into two portions. For raising the second crop, one portion of the plot was fertilized (continuously fertilized plots) and the second portion was not fertilized (residual plots). Status of labile P was estimated by five different extractants as follows;

Table 1: Analytical values of initial soil

Properties	Values
Mechanical analysis	
Clay (Per cent)	21.92
Silt (Per cent)	8.23
Fine sand (Per cent)	42.78
Coarse sand (Per cent)	23.36
Chemical Constituents	
Organic carbon (Percent)	0.48
Available N (Kg ha ⁻¹)	146
Available P (Kg ha ⁻¹)	950
Available K (Kg ha ⁻¹)	250
Electro-Chemical Properties	
PH	7.30
Electrical conductivity (dSm ⁻¹)	0.24
Cation exchange capacity (C Mol (P ⁺) kg ⁻¹)	22.2

Extractant	Composition	Reference
Olsen	0.5 M NaHCO ₃ pH 8.5	Olsen <i>et al.</i> ^[10]
Bray No.1	0.025 M HCl + 0.03 M NH ₄ F; pH 2.5	Bray and Kurtz ^[11]
Morgan I	0.73 M CH ₃ COO Na + 0.52 M CH ₃ COOH; pH 4.8	Morgan ^[7]
Truog	0.002 M H ₂ SO ₄ buffered with (NH ₄) ₂ SO ₄ pH 3.0	Murphy and Riley ^[8]
Mehlich I	0.05 N HCl and 0.025 N H ₂ SO ₄ in equal proportions	Murphy and Riley ^[8]

The soils were analyzed for different inorganic P forms viz., Saloid, - P, Al-P, Fe-P and Ca-P ^[11]. Simple correlation coefficients and stepwise multiple regression analysis were calculated to evaluate the relationship between inorganic P forms and the P extracted by the different extractants.

RESULTS AND DISCUSSIONS

Labile P Status: The range of labile P as estimated by different extractants was found to be 4.7 to 7.2 kg ha⁻¹ (Olsen-P), 30.4 to 62.4 kg ha⁻¹ (Bray P) 3.8 to 5.9 kg ha⁻¹

Table 2: Available P (mg kg⁻¹) by different extractants

Treatments	Olsen			Bray			Morgan			Truog			Mehlich I		
	I crop	II crop (F)	II crop (R)	I crop	II crop (F)	II crop (R)	I crop	II crop (F)	II crop (R)	I crop	II crop (F)	II crop (R)	I crop	II crop (F)	II crop (R)
Organic Sources															
No Manure	4.7	12.4	10.1	30.4	39.5	35.9	3.8	9.0	7.3	28.8	35.7	32.8	60.0	64.8	62.6
FYM @ 12.5 t ha ⁻¹	6.1	14.3	9.5	57.5	64.0	60.4	4.8	10.3	9.3	35.8	40.1	37.1	70.8	76.9	74.1
PM @ 12.5 t ha ⁻¹	5.0	13.0	9.9	53.4	59.3	56.3	4.3	8.5	8.3	31.7	36.3	33.8	66.7	72.4	69.3
GLM @ 12.5 t ha ⁻¹	7.2	17.3	14.8	62.4	68.2	63.1	5.9	11.5	10.0	40.8	44.2	41.9	88.3	99.0	96.3
Inorganic – P															
SSP ₀	5.3	12.1	9.3	46.1	52.2	49.4	4.0	8.4	7.9	28.8	33.5	31.1	57.5	67.5	64.8
SSP ₃₀	6.5	14.8	12.9	54.7	61.5	57.5	5.3	10.4	8.1	37.5	42.6	39.5	75.0	86.4	83.4
SSP ₆₀	8.0	17.1	14.4	59.8	66.3	61.5	7.0	12.0	10.6	42.5	46.8	43.4	90.0	93.9	91.4
URP ₀	4.6	12.0	9.4	43.8	49.1	46.5	3.7	8.1	7.4	27.5	32.3	30.4	53.8	60.8	58.4
URP ₃₀	5.4	13.9	10.9	48.8	56.4	52.0	4.5	9.3	8.4	31.9	36.9	34.4	72.5	77.1	74.9
URP ₆₀	6.0	15.8	13.0	52.7	61.0	56.6	6.3	10.7	9.9	37.5	42.3	39.8	80.0	84.0	80.8
CD (P=0.05)															
Manure	0.34	0.79	0.63	1.10	1.01	0.75	0.22	0.61	0.51	0.89	1.19	1.34	1.45	1.38	1.07
P Sources	0.24	0.56	0.45	0.78	0.71	0.53	0.15	0.43	0.36	0.63	0.84	0.95	1.03	0.98	0.76
P Levels	0.29	0.68	0.55	0.96	0.87	0.65	0.19	0.53	0.44	0.77	1.03	1.16	1.26	1.20	0.93

(F)-Fertilized (R)-Residual

Table 3: Correlation coefficients [r] between soil inorganic P forms and available P

Soil Test Methods	I Crop				II Crop – Fertilized				II Crop -Residual			
	Saloid-P	Ca-P**	Fe-P	Al-P	Saloid-P	Ca-P	Fe-P	Al-P	Saloid-P	Ca-P	Fe-P	Al-P
Olsen	0.89**	0.56**	0.90**	NS	0.85**	0.46*	0.71**	NS	0.42*	NS	0.70**	NS
Bray	0.63**	0.54**	0.82**	0.71**	0.69**	0.77**	0.67**	0.65**	0.41*	0.78**	0.68**	0.55**
Mehlich I	0.84**	0.54**	0.83**	0.45*	0.84**	0.51**	0.66**	NS	0.47*	0.47*	0.63**	NS
Morgan	0.76**	0.64**	0.83**	NS	0.77**	NS	0.77**	NS	0.43*	0.54**	0.73**	NS
Truog	0.77**	0.55**	0.85**	0.44*	0.74**	0.46*	0.66*	NS	NS	0.47**	0.69**	NS

* and ** represent 5 and 1% level of significance

Table 4: Stepwise multiple regressions (R²) between soil inorganic P forms and available – P

Inorganic P forms	Soil Test Methods					
	I Crop	Olsen	Bray I	Truog	Morgan	Mehlich I
Fe-P + Al-P+ Saloid-P + Ca-P		0.938**	0.883**	0.894**	0.912**	0.907**
II Crop-Fertilized						
Fe-P + Al-P+ Saloid-P + Ca-P		0.894**	0.912**	0.831**	0.872**	0.889**
II Crop-Residual						
Fe-P + Al-P+ Saloid-P + Ca-P		0.744**	0.877**	0.735**	0.779**	0.739**

(Morgan-P), 27.5 to 42.5 kg ha⁻¹ (Truog-P) and 53.8 to 90.0 kg ha⁻¹ (Mehlich I – P). (Table.2).The P extracting power of different extractant was in the following Mehlich – I > Bray I > Truog > Olsen > Morgan. The relative superiority of Mehlich in extracting higher quantum of P from the soil owing to the strong extractants viz., HCl and H₂SO₄.

The differential behaviour of different extractants could be due to their selectivity in solubilizing specific fractions of P [3]. The Olsen's extractant removed lesser P than Bray I and Mehlich I extractants due to its mild alkaline nature which displaces P from the surface of Ca, Al and Fe phosphates by decreasing Ca activity and repression of Al³⁺ and Fe³⁺ activities respectively [4]. The

Table 5: Values of regression line characteristics showing the extent of relationship between indices of phosphorus availability

Extractants	Slope	Intercept	R ²	F ratio
Olsen Vs Bray I	0.08	1.67	0.624**	36.43
Olsen Vs Morgan	1.22	0.05	0.29**	287.20
Olsen Vs Truog	0.185	-0.618	0.940**	345.00
Olsen Vs Mehlich I	0.07	0.129	0.949**	416.90
Bray I Vs Morgan	9.87	4.92	0.622**	36.12
Bray I Vs Truog	1.50	-0.712	0.635**	38.20
Bray I Vs Mehlich I	0.617	5.96	0.625**	36.62
Morgan Vs Truog	0.145	-0.321	0.926**	274.60
Morgan Vs Mehlich I	0.059	0.331	0.908**	217.30
Truog Vs Mehlich I	0.396	5.51	0.916**	238.30

results revealed that irrespective of the method employed, green leaf manuring increased the Olsen's P considerably. This could be due to the gradual and steady decomposition of GLM which release organic acids and CO₂ that increase the solubility of Ca-P compounds such as octa calcium phosphate, tricalcium phosphate, hydroxyapatite and fluorapatite by complexing Ca²⁺ ions and thereby disturbing the solubility equalibria of Ca-P. Between FYM and PM, FYM performed better than PM. This could be due to the higher CaCO₃ content (10 per cent) of PM which neutralizes the organic acids produced during decomposition there by limiting the availability of acids for P dissolution [6].

Correlations: The correlation co-efficient (r) values [2] and stepwise multiple regressions (R²) between soil P fractions and available P as estimated by different extractants are presented in tables 3 and 4.

Bray-P, Mehlich I-P, Truog-P with all P forms Olsen -P and Morgan -P (except with Al-P) has shown highly positive and significant correlations. The correlation of available P as estimated by Olsen and Morgan extractants was not significant with Al-P. Among the inorganic P forms, Fe-P and saloid-P are the major contributors to available P as estimated by different extractants and Al-P contributes very little to the P extracted (except Bray I - P). These findings are similar to those reported [5]. The contribution of Fe-P fraction to available P was maximum. This could due to the Fe rich characteristics of the experimental soil (Madukkur series - Alfisol). Similar contribution in Alfisol was reported [9].

Stepwise multiple regression analyses (Table 4) showed that inorganic P forms viz., saloid-P, Fe-P, Al-P and Ca-P jointly contributed to 94 per cent of the variations in Olsen-P, 88 per cent of the variations in Bray I-P, 89 per cent of the variations in Truog-P and 91 per cent variation in Mehlich I - P. The characteristics of regression lines showing the extent of relationship between indices of P availability revealed that Olsen and Mehlich I were strongly correlated (Table 5). The values of a ratio indicated optimum degree of fit of equations. The relationship between Olsen and Mehlich I was very close as evident by the slope and intercept values.

The highly significant and positive correlation observed between Olsen-P and different forms of P shows the suitability of this extractant to the soils studied. The relative proportion of the contribution of inorganic P forms to the labile pool depends mainly on the solubility of the several phosphatic compounds as influenced by the relevant soil characteristics. Hence a soil test method for estimating the available P must be chosen based on the relative proportions of soil inorganic P forms and their stability as governed by physico-chemical properties of the soils.

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