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Short Note

Evaluation of Soil Phosphorus Tests and its Relation to Inorganic Phosphorus Forms in Flooded Soils

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Field experiments were conducted with rice under flooded condition to evaluate the efficacy of various soil tests for available P. 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. Among different indices of P availability, Olsen's soil test was found to be the most suitable method. 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. Iron-P was the dominant inorganic P fraction followed by Ca-P,Al-P and saloid-P. Available P in this rice soil depends on the concentration of Fe-P and saloid-P .

Key words: Labile P, Soil tests, Inorganic P forms, P fertilizers, Organic manures.

Inorganic phosphate in soil occurs as saloid-P, Al-P, Fe-P and Ca-P. Aluminium bound phosphate governs P availability, particularly in uplands, whereas, ferric and reductant soluble phosphates are available to plants under reduced conditions (Mandal and Mandal, 1973). Several extractants are being used to determine the labile P in soils and these are not consistent in extracting the available soil phosphate. (Rahman *et al.* 1995).The suitability of a soil test varies to a great extent depending on soil, crop and climatic conditions. During decomposition of organic manures, labile P in soil increased through complexation of cations. (Tolanur and Badanur, 2003). The objectives of the present investigation were to evaluate existing soil testing methods for available P in Madukkur soil series of Tamil Nadu, under flooded condition and to study the relationship with inorganic P forms as influenced by P fertilizers and organic manures.

Materials and Methods

Two field experiments were conducted in neutral soil (pH: 7.3) belonging to Madukkur series (Alfisol) with rice as test crop. The treatments consisted of three organic manures viz., Farm Yard 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 P_2O_5 ha^{-1}. The experiment was conducted in a randomized block design with three replications. 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 viz., Olsen (0.5 M $NaHCO_3$ pH 8.5) (Olsen et al. 1954) Bray No.1 (0.025 M HCl + 0.03 M NH_4F; pH 2.5) (Bray and Kurtz, 1945), Morgan I buffered (0.73 M CH_3COO Na + 0.52 M CH_3COOH; pH 4.8) Truog. (0.002 M H_2SO_4 with $(NH_4)_2SO_4$ pH 3.0) and Mehlich I (0.05 N HCl and 0.025 N H_2SO_4 in equal proportions) (Murphy and Riley, 1962) . The soils were analysed for different inorganic P forms viz., Saloid, - P, Al-P, Fe-P and Ca-P (Peterson and Corey, 1966). Simple correlation coefficients were calculated to evaluate the relationship between inorganic P forms and the P extracted by the different extractants.

Results and Discussion

The initial soil characteristics of the experimental site was as follows: sandy clay loam texture, neutral in soil reaction (pH:7.3),EC (0.24 dSm^{-1}) and CEC (22.2 C mol (p+)kg^{-1}.The organic carbon content was low (0.48 per cent), available N (146 kg ha^{-1}), Olsen–P (9.5 kg ha^{-1}) were low and available K content was high(450 kg ha^{-1}).Total Fe and alumina contents were 6.56 per cent and 4.24 per cent respectively.

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 I P) 3.8 to 5.9 kg ha^{-1} (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 1). The P extracting power of different extractants 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

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extractants viz., HCl and H_2SO_4.The differential behaviour of different extractants could be due to their selectivity in solubilizing specific fractions of P (Dhillon *et al.,* 1998). 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 Al^{3+} and Fe^{3+} activities respectively (Jackson, 1973). The 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 CO_2 that increase the solubility of Ca-P compounds such as octa calcium phosphate, tri calcium phosphate, hydroxyapatite and fluorapatite by complexing Ca^{2+} ions and thereby disturbing the solubility equalibria of Ca-P. Increase in Olsen- P was observed in FYM treated plots as compared with poultry manure treated plots. This could be due to the higher $CaCO_3$ content (10 per cent) of poultry manure which neutralize the organic acids produced during decomposition there by limiting the availability of acids for P dissolution (Mahimairaja et al., 1995). Bray-P, Mehlich I-P, Truog-P with all P forms Olsen-P and Morgan-P (except with Al-P) have shown highly positive and significant correlations. The correlation of available P as estimated by Olsen and Morgan extractants was not significant with Al-P. (Table 2).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). Contribution of Fe-P fraction to available P was the maximum. This could be due to the Fe rich characteristics of the experimental soil (Madukkur series – Alfisol). Similar contribution in Alfisol was reported by Nagendra Rao and Chakrabarthy (1994).

Table 1. Available P (mg kg^{-1}) by different extractants

Treatment	I Crop					II Crop – Fertilized					II Crop – Residual				
	Ol-P	Br-P	Mo-P	Tr-P	Meh -P	Ol-P	Br-P	Mo-P	Tr-P	Meh -P	Ol-P	Br-P	Mo-P	Tr-P	Meh -P
Organic Source															
No Manure	4.7	30.4	3.8	28.8	60.0	12.4	39.5	9.0	35.7	64.8	10.1	35.9	7.3	32.8	62.6
FYM	6.1	57.5	4.8	35.8	70.8	14.3	64.0	10.3	40.1	76.9	9.5	60.4	9.3	37.1	74.1
PM	5.0	53.4	4.3	31.7	66.7	13.0	59.3	8.5	36.3	72.4	9.9	56.3	8.3	33.8	69.3
GLM	7.2	62.4	5.9	40.8	88.3	17.3	68.2	11.5	44.2	99.0	14.8	63.1	10.0	41.9	96.3
Inorganic – P															
SSP_0	5.3	46.1	4.0	28.8	57.5	12.1	52.2	8.4	33.5	675	9.3	49.4	7.9	31.1	64.8
SSP_{30}	6.5	54.7	5.3	37.5	75.0	14.8	61.5	10.4	42.6	86.4	12.9	57.5	8.1	39.5	83.4
SSP_{60}	8.0	59.8	7.0	42.5	90.0	17.1	66.3	12.0	46.8	93.9	14.4	61.5	10.6	43.4	91.4
URP_0	4.6	43.8	3.7	27.5	53.8	12.0	49.1	8.1	32.3	60.8	9.4	46.5	7.4	30.4	58.4
URP_{30}	5.4	48.8	4.5	31.9	72.5	13.9	56.4	9.3	36.9	77.1	10.9	52.0	8.4	34.4	74.9
URP_{60}	6.0	52.7	6.3	37.5	80.0	15.8	61.0	10.7	42.3	84.0	13.0	56.6	9.9	39.8	80.8
CD (P=0.05)															
Manure	0.3	1.1	0.2	0.8	1.4	0.7	1.0	0.6	1.1	1.3	0.6	0.7	0.5	1.3	1.0
P Sources	0.2	0.7	0.1	0.6	1.0	0.5	0.7	0.4	0.8	0.9	0.4	0.5	0.3	0.9	0.7
P Levels	0.2	0.9	0.1	0.7	1.2	0.6	0.8	0.5	1.0	1.2	0.5	0.6	0.4	1.1	0.9

(FYM: Farm Yard Manure; PM: Poultry manure; GLM : Green Leaf Manure; SSP: Single Super Phosphate; URP: Udaipur Rock Phosphate; Ol-P: Olsen-P; Br-P: Bray-P; Mo-P: Morgan-P; Tr-P: Truog-P; Mehlich-P)

Table 2 . Correlation coefficients [r] between soil inorganic P forms and available P

Methods	I Crop				II Crop - Fertilized				II Crop -Residual			
	Sal-P	Ca-P	Fe-P	Al-P	Sal-P	Ca-P	Fe-P	Al-P	Sal-P	Ca-P	Fe-P	Al-P
Olsen	0.885**	0.557**	0.902**	NS	0.847**	0.465*	0.713**	NS	0.415*	NS	0.700**	NS
Bray	0.632**	0.539**	0.817**	0.709**	0.694**	0.766**	0.670**	0.645**	0.408*	0.784**	0.680**	0.550**
Mehlich I	0.843**	0.536**	0.829**	0.451*	0.837**	0.507**	0.660**	NS	0.465*	0.472*	0.626**	NS
Morgan	0.758**	0.644**	0.832**	NS	0.768	NS	0.774**	NS	0.433*	0.539**	0.725**	NS
Truog	0.771**	0.553**	0.852**	0.437*	0.740**	0.456*	0.660*	NS	NS	0.470**	0.693**	NS

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

Conclusions

The study revealed that 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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