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Utility of Soil Test Methods to Predict the Phosphorus Availability in Rice Soils Under Field Capacity and Flooded Moisture Conditions

By

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ABSTRACT

The study revealed that the phosphorus availability in rice soils was intimately connected with moisture regimes. Under flooded conditions the Fe.-P. underwent dynamic changes and ultimately influenced the higher concentration of available P, while no such realisation was felt in field capacity due to the liberal diffusion of oxygen and low redox conditions. Among the existing methods for the available P estimation, Olsen's and phosphate potential methods were found valid when the soils under test were preflooded for 15 days.

INTRODUCTION

Phosphorus nutrition of low land rice differs from upland rice in at least two important respects: (i) The rice plant can absorb an adequate amount of P from a soil solution with a low concentration of P and (ii) Water-logging releases P from fixed forms to the solution as a result of dynamism in oxidation reduction conditions.

The poor correlation between extractable P by the existing soil testing methods and response to phosphate fertilizers is apparently the result of the rice plant being able to utilize fractions of the soil P other than those attacked by the chemical extractants. And more complicated the situation is in rice farming where due to the utility of different moisture regimes many transformations of chemical components take place with different intensities. Owing to the above reasons, the soil test methods developed to assess the fertility of soil in relation to P have failed to be of universal application. Hence all these factors lead to the necessity of a good soil test method to assess the P availability applicable under all circumstances. With the above points in view the present study was undertaken on the utility of soil test methods in practice to predict the P availability in rice soils under field capacity and flooded moisture conditions and to evolve an ideal soil test for P availability.

MATERIALS AND METHODS

A pot culture experiment using eleven representative soils of Tamil Nadu was laid out with two moisture treatments *viz.*, field capacity and flooding moisture conditions. The test crop used was 'Karuna' (Co 33), a hybrid derivative short duration variety. The pots under flooded condition were

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irrigated daily and 5 cm depth of water was constantly maintained. The pots under field capacity were added calculated quantity of water (60 per cent water-holding capacity) and the soils mixed thoroughly. They were weighed soon after transplanting and thereafter irrigation was given on alternate days by finding the difference in weight of pots.

Collection of samples was done in three stages *viz.*, 15th day, 35th day (tillering) and 55th day (flowering) from the day of transplanting. Immediately after collection the soil samples were stored in a refrigerator and the extraction completed on the same day itself. The moisture in the wet samples were estimated separately. The samples were analysed for the available P by Olsen's method (Olsen *et. al.*, 1954), Bray's 2 (Bray and Kurtz, 1945) and by measuring phosphate potential using 0.01M $CaCl_2$ (Asyltng, 1954).

Soil samples from 15th day and 55th day were fractionated into different fractions of inorganic phosphorus as a Al-P, Ca-P, Fe-P and reductant soluble iron phosphate by the method of Chang and Jackson (1957) except for reductant soluble Fe-P which was analysed by a slightly modified method of Jackson (1967).

The crop was harvested and the grain and straw were separately analysed for the P content. Total uptake of P by the plant was calculated from the value of P obtained from the grain and straw. The experimental data collected were subjected to statistical scrutiny and the uptake of P was correlated with different soil tests for available P and different fractions of P and based on this conclusions were drawn.

RESULTS AND DISCUSSION

(i) Available phosphorus by Olsen's method: The available P concentration in the air-dried soils was found to be low but the concentration increased to 2 or 3 fold when these soils were subjected to flooding (Table 1). The concentration of P extracted was more when the soils were flooded for 15 days and thereafter there was a gradual decrease in the availability indicating the maximum uptake of P by plant during these stages *viz.*, tillering and flowering. In the field capacity condition there was no such significant increase of available P. This may be attributed to the liberal diffusion of oxygen under low moisture status which enhanced the fixation of P and reduce diffusivity of ions, while higher moisture status was conducive to solubilization of P and rapid circulation of ions under anaerobic condition developed in the submerged soils.

In the I and II stages of analysis, flooded condition was found to be superior in the availability of P than field capacity owing to the higher solubilization of P under reduced conditions. Though the flooded condition maintained a higher concentration of phosphate ion in the I and II stages than the field capacity, in the III stage both the moisture conditions were on par. This may be due to the higher uptake of P by the plants maintained under flooded conditions than the field capacity and thus were on par.

TABLE 1. Changes of available phosphorus with stages by Olsen's method.

(a) Comparison of moisture conditions:

Moisture condition	M_1	M_2	SE	CD
Mean	14.47	25.68	0.463	1.28

M_1 = Field capacity: M_2 = Flooding

(b) Comparison of stages:

Stages:	I	II	III	SE	CD
Mean	39.437	11.94	8.85	0.568	1.58

I = 15 days after transplanting

II = 35 days after transplanting

III = 55 days after transplanting

(ii) Available phosphorus by Bray No. 2: The same trend was observed in the case of Bray No. 2 extractant also. Here also the available concentration in the air dried soils was found to be low but the concentration increased when these soils were subjected to submergence. The available P of soils was found maximum in the I stage of analysis and at later stages there was gradual decrease.

All the above facts give a conclusive proof that before completion of I stage (before 15 days) the soils subjected to submergence undergo sufficient transformation to produce a high concentration of P in the available stage. Thereafter the crop begins to take up the nutrient vigorously causing depletion during later stages eventhough the slow transformation of insoluble form of P into the soluble form is still on the increasing state. That is the reason why the flooded condition proved its superio[illegible]er field capacity in the I stage in[illegible]s, and in the II and III stages on account of its fast removal of P by plant all the soils maintained an almost equal concentration of phosphorus under both moisture treatment. Hence it is evident that the transformations undergoing under flooded conditions influence the P availability to plant.

(iii) Phosphate potential: The chemical potential of P in soil solution estimates the free energy on the available energy which is the measure of the escaping tendency of the ion. The free energy concept was introduced to eliminate the soil factors interacting with the solubility of an ion. In the present investigation phosphate potentials of soils at different stages were estimated and the values calculated using the equation of Schofield (1955).

Phosphate potential

$$= \frac{1}{2} p\,Ca + pH_2PO_4$$

Uptake of phosphorus: Increase in the concentration of phosphate ion in the soil solution is an important factor in the acceleration of ion uptake. The uptake of P by rice which was significantly greater under flooded conditions than field capacity clearly indicated that under flooded conditions, the P availability was more in all the soils. This was in conformity with the result of Raymond and Shapire (1958), Halm (1967) and Chang (1961). In the case of field capacity no marked difference in uptake was realised.

When all the soils irrespective of treatment were pooled and correlations worked out between soil test and phosphorus uptake by plant, none of the soil tests studied were significantly related (Table 2). This reveals that the existing soil tests cannot be valid universally for all the soil conditions and moisture regimes.

When the moisture regime was separated, there were few significant

TABLE 2. Results of statistical analysis for correlation

Relationship between x	Relationship between y	Correlation coefficient (r)	Regression equation	No. of pairs of values
Available P by Olsen's method (air dried)	Uptake of P under flooded condition	0.806**	Y=2.42× + 7.54	22
Available P by Bray II method I Stage	do	0.369*	Y=0.270× + 39.61	44
Available P by Olsen's method I Stage	do	0.791**	Y=0.697× + 15.56	44
Available P by Olsen's method II Stage	do	0.796**	Y=1.70 × + 26.56	44
Phosphate potential I Stage	do	0.684**	Y=29.48× —125.14	22
Phosphate potential II Stage	do	0.773**	Y=35.95× —163.00	22
Iron phosphate (air dried sample)	do	0.458**	Y=0.251× + 35.77	22
Iron phosphate I Stage	do	0.442**	Y=0.162× + 34.62	44
Iron phosphate II Stage	do	0.426**	Y=1.169× + 32.22	44

*Significant at 5%

**Significant at 1%

correlations. Olsen's P of initial air dried samples after flooding with water for 15 days and 35 days had high correlation with uptake of P. Phosphate potential values of the soil sample collected after flooding for 15 days to

35 days correlated well with the uptake in flooded soils. None of the methods were correlated with the P uptake in soils maintained at field capacity. Since all the significant relations were obtained only in flooded soils, it is crystal clear that the availability of P is closely linked with the moisture level. Fe-P in air dried sample, sample after flooding for 15 days and 55 days correlated well with the uptake of P in flooded soils.

The results prove that among the existing methods, Olsen's available P method and phosphate potential estimation become valid under certain circumstances when the soils were flooded the soil environment was changed from an oxidizing to a reducing one; the transformations occurred in about 15 days. Many workers like Chang (1963), Shapiro (1958) and Davide (1960) have also established the marked increase in the availability of native and added phosphate in flooded soil as compared to well drained soils. This increase is attributted to the reduction of ferric phosphate to the more soluble ferrous form and the hydrolysis of phosphate compounds. Hence under these circumstances only the Olsen's available P and the phosphate potential methods available or predict fully the phosphate fertility when the soils are preflooded for 15 days and will fully account for the dynamical changes occurring in flooded soils.

Any soil test which is to be of ideal for rice soil should be able to evaluate fully the dynamic changes occurring in water logged conditions so as to predict the exact amount of P that becomes available. Based on the findings of the present investigation a simple soil test method is suggested for available phosphorus estimation for rice soils by evaluating the concentration either by Olsen's method or by estimating the phosphate potentials after flooding the samples under test for about 15 days.

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