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Buffering Capacity of Black Soils in Relation to Phosphorus Availability to Rice under Different Moisture Regimes

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The current methods of predicting P availability in rice soils need reconsideration. Anaerobic conditions due to submergence of the soil creates problems of assessment of this nutrient element. A pot experiment using three soils of Tamil Nadu and IR 22 rice as the test crop was conducted. Soils equilibrated with diammonium phosphate at the rate of 100 kg/ha were transplanted with rice. The moisture levels, viz., submergence, field capacity and wetting and drying were maintained. Soil samples were drawn at stages and analysed for available phosphorus by Olsen's, Bray's No. 1, 0.01M $CaCl_2$ and water extraction methods. Phosphate potential ($1/2\ pCa + pH_2PO_4$) was calculated for these soil samples and all these values were correlated with phosphorus uptake and yield of the crop. In assessing the phosphorus availability under different moisture regimes, the suitability of buffer curves was indicated and discussed.

Soil test procedures in vogue are always specific to a particular soil or crop or for a fraction of a nutrient in relation to crop growth. None of them has universal application in predicting phosphorus availability (Al Abbas and Barber, 1964). This is more so in the case of rice grown under varying moisture regimes on different types of soils. As thermodynamic approach appeared to be a better way to indicate the capacity of the soil to supply and replenish the nutrient to crop growth the present work was undertaken to apply the concept of buffering capacity along with common methods currently in use, to estimate the phosphorus availability in soils under varying moisture regimes with rice cultivation.

MATERIALS AND METHODS

Black soils from three major soil series of Tamil Nadu were collected and used in a greenhouse study. Six kg of soil from each type was kept in earthern pot and six pots under each type were treated with diammonium phosphate at 100 kg/ha and equilibrated for a month. Then 30 days-old IR 22 rice seedlings were transplanted at the rate of four per pot. Moisture levels as submergence at 5 cm depth, near field capacity and alternate wetting and drying were adopted and replicated twice. A similar set of pots without phosphorus maintained at different moisture levels were taken as control. Soil samples were drawn before trans-

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planting, at tillering and at flowering stages, air-dried and analysed for available phosphorus using the following methods: (i) Olsen's, (ii) Bray's No. 1 extractant, (iii) 0.08M $CaCl_2$ and (iv) water (Von Diest, 1963). Phosphate potential was estimated using the following extractants:

(a) 0.01 M $CaCl_2$+0.05 M KH_2PO_4 (50 ml each)

(b) 0.01 M $CaCl_2$ + 0.02 M KH_2PO_4 (50 ml each)

(c) 0.01 M $CaCl_2$ + 0.01M KH_2PO_4 (50 ml each)

A 5 g soil sample was shaken for 24 hours with each set of extractants, filtered and the filtrate was analysed for phosphorus, calcium and pH and the phosphate potential calculated from the equation:

1/2 pCa+pH_2PO_4 (white and Beckett, 1964).

Plants were harvested after maturity, digested by wet oxidation method and phosphorus was estimated by vanodomolybate method.

RESULTS AND DISCUSSION

The soil from Kovilpatti series was higher in clay, CaO (1.84 per cent) exchangeable calcium (13.9 meq/100 g) and cation exchange capacity (31.6 me/100g) than the rest. It had 1.22 per cent

TABLE I. Available - P in black soils under different moisture regimes (ppm)

Extractants used	Kovilpatti series			Pilamedu series			P.N. Palayam series		
	S	FC	WD	S	FC	WD	S	FC	WD
1. Olsen's									
I	11.88	15.00	12.50	10.63	3.75	5.63	26.88	20.63	25.00
T	10.00	18.75	17.50	5.00	10.00	11.88	14.00	16.88	23.75
F	11.75	8.00	8.63	9.88	5.00	13.88	13.00	13.25	21.50
2. Bray's									
I	51.75	48.00	59.75	55.50	55.50	41.25	44.00	55.50	43.50
T	7.50	6.75	4 88	3.75	4.50	4.13	3.75	3.75	4.50
F	12.00	8.10	8.10	11.40	4.20	4.80	1.35	2.40	1.65
3. 0.01M $CaCl_2$									
I	0.38	0.25	0.88	0.44	0.28	0.44	1.45	0.00	1.20
T	0.62	0.95	0.62	0.62	0.95	1.00	1.55	2.00	1.10
F	1.83	2.00	1.82	1.03	1.93	1.38	1.00	1.00	1.00
4. Water									
I	6.00	6.75	8.25	6.00	7.00	7.49	5.86	6.63	6.13
T	5.63	2.50	4.73	2.50	6.88	6.25	13.13	15.38	18.44
F	1.38	4.73	3.40	1.25	6.25	2.00	1.25	18.44	1.88

(I = Initial; T = Tillering and F = Final stage sample
S = submergence; FC = Field capacity and WD = wetting and drying)

of total P_2O_5 and 4 ppm of available phosphorus. The values of pH, available iron and available manganese remained almost uniform for all the soils.

Bray's No. 1 extractant indicated a higher availability of soil phosphorus for Kovilpatti series under all the moisture levels. Phosphorus extracted with distilled water was more in the case of Perianaickenpalayam series under the various moisture regimes (Table I).

The yield of dry matter was the same for all the three soils under submergence, but the grain yield for the Pilamedu and Perianaickenpalayam series were uniformly higher than that of Kovilpatti series. The same trend was seen in the other two moisture regimes.

Estimation of P under submerged conditions become more complex due to anerobic condition and the presence of reduction products that affect the nutrient uptake. In the present study, submerged soils with 5 cm standing water had yielded the maximum in terms of grain and straw than the other moisture levels. Chang (1965) reported a similar observation. Workers like Nephade and Gildhayal (1971) have also indicated clearly that flooding is necessary or essential during certain physiological stages of the plant.

The availability of phosphorus just before transplantation was high by all the soil test methods. It decreased after a stage of maximum availability. This might be due to changes in the form of applied phosphate.

The different extractants used removed varying amounts of phosphorus from different soils and also under different moisture levels. Among them, Bray-1 reagent extracted the maximum amount of phosphorus. (Table I).

Various methods tried in this study did not correlate either with phosphorus uptake or yield, indicating that the methods were not suitable for accurately predicting the phosphorus availability in rice soils.

In the thermodynamic approach, two different aspects of the measurement of the labile ion in the soil could

TABLE II. Buffering capacity of black soils at different moisture regimes

Particulars	Kovilpatti series			Pilamedu series			P.N. Palayam series		
	S	FC	WD	S	FC	WD	S	FC	WD
P atoms/1 x 10^{-4}	7.7	8.6	10.1	6.8	7.3	7.4	6.7	7.4	6.4
pH	5.6	5.6	5.6	5.8	5.7	5.7	5.8	5.5	5.7
1/2pCa	1.34	1.30	1.37	1.31	1.33	1.29	1.28	1.28	1.30
Phosphate potential	7.75	7.96	7.98	8.08	8.20	8.16	7.97	7.93	7.99

(S = Submergence; FC = Field capacity and WD = Wetting and drying) be made out, namely, (a) the potential of the system which determine the concentration and (b) the total quantity of ions which take part in the equilibria of the labile system. This is otherwise called "buffering capacity".

The buffering capacity of the soils under different moisture regimes are presented in Table II.

The buffering capacity values had correlated significantly with yield. When the soils under submergence alone were considered. Further, buffering capacity did not correlate with uptake of phosphorus. This indicated the limitation in using phosphate potential as a measure of phosphorus availability to rice soils.

Buffer curves were drawn by relating the phosphate potential (I) to the concentration (Q) taken as P atoms/litre. The slope of curve varied widely among soils indicating their differential behaviour due to the variation in soil moisture status. The present study clearly revealed that neither the concentration of nutrients measured (Q) nor the potential of the ion (I) could function as an ideal measure of nutrient availability individually.

However, the buffer curves obtained indicated the dynamic nature of rice soils and this parameter is fully depended on soil moisture regimes and stages of plant growth. Though they may be highly empirical, still they were held valid. Further detailed studies are necessary to ascertain the utility of such curves in soil fertility management and also for the quantification of buffering capacity of rice soils.

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