https://doi.org/10.29321/MAJ.10.A03998

A critical examination of the usefulness of Schofield's Phosphate Potential as an index of P availability in Soils *

by

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Synopsis: Some of the limitations in the method of determination of Schofield's phosphate potential are discussed. It does not seem to be a suitable index of available P for paddy and wheat crops in the soils studied.

Introduction: Considerable clarification of our ideas on phosphate availability in soils, owes its origin to the thermodynamic approach on this aspect proposed by Schofield (1955). According to his hypothesis, the availability of soil phosphate is mainly determined by the appropriate chemical potential and by its rate of decrease with phosphate withdrawal. He advocated the determination of the phosphate potential ($\frac{1}{2}$ p Ca + pH_2PO_4) in a standard salt solution such as 0·01 M $CaCl_2$. Aslyng (1954) in studies on lime and phosphate potentials in soils and availability of phosphate, observed that the crop yield in P deficient soil was correlated with total P concentration in 10^{-2}M extract. Talibudeen (1957) pointed out that Schofield's concept of using the free energy of the mono-calcium phosphate as the index of the phosphate status of the soils was incomplete in some respects. Availability of a nutrient is a function of both intensity and capacity factors while the phosphate potential is only an intensity factor. It is important to know, how soon desorption processes in soil could replenish the equilibrium phosphate level in the soil solution; for how long the adsorbed phosphate reserve could maintain this level and when that level falls so low that the nutrient ions cannot be utilised by the plant.

For any index of available nutrient to be satisfactory, there are two considerations. Firstly, it must correlate closely with crop responses to the addition of that nutrient and secondly, the measurement of that index must be practicable. This paper gives an account of an investigation intended to see how far Schofield's phosphate potential satisfies these two conditions.

Experimental methods: Seventeen soils from the control plots in the agronomic trials conducted by the Indian Agricultural Research Institute, in collaboration with the T.C.M., were taken up for the determination of Schofield's phosphate potential. The Schofield - Aslyng method is the one described by Moser *et al* (1959).

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* Part of work done at Indian Agricultural Research Institute in 1958—1959. (Received for publication on 14—8—1962).

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40 and 80 gm. lots of soils were shaken with 100 ccs. of 0.01M $CaCl_2$ for 30 minutes. The clear filtered solution is analysed for pH by Beckman pH meter and P colorimetrically. The concentration of phosphorus in the extracts is plotted against the reciprocal of the quantity of soil employed. The straight line passing through the experimental points is extrapolated to zero dilution. From the pH value, the calcium ion activity in the 0·01 M $CaCl_2$ solution and the P concentration at zero dilution, the "phosphate potential" is calculated.

Two other ratios of soil to solution were used and the filtered solutions were analysed for Ca and Mg. by titration with standard versenate (U.S. Salinity Laboratory Staff, 1954), pH with a Beckman pH meter and P colorimetrically.

Results and Discussion: The data of calcium and phosphorus in the $Cacl_2$ extracts at different soil to solution ratios are presented in tables I and II.

TABLE I.

Phosphate and Calcium at different soil : solution ratios

Soil	Soil Group	Textural classification	1 : 2·5			1 : 1·25		
			pH	Ca mols×10^{-2} / litre	P Microatoms / litre	pH	Ca mols×10^{-2} / litre	P microatoms / litre
Aduthurai	Alluvium	Clay	5·6	1·08	2·096	5·7	1·38	2·508
Karjat	Medium black	Clay loam	6·3	0·60	0·807	6·3	0·60	1·613
Hiragachi	Recent alluvium	,,	5·6	0·80	0·645	5·7	0·80	1·452
Sahaspur	,,	,,	6·0	0·70	0·726	5·6	0·63	0·896
Mankhand	,,	Silty clay	5·6	0·60	1·129	6·1	0·58	1·613
Trivandrum	Laterite	Silty clay loam	6·3	0·85	0·484	6·3	0·90	1·371
Raipur	Red & Yellow	Clay loam	5·2	0·85	0·645	5·4	0·79	0·887
Sabour	Alluvium	Silty loam	5·5	0·83	0·565	5·6	0·81	0·887
Bagwai	Medium black	Clay	6·2	0·73	1·152	6·4	0·50	0·726
Obeidulla ganj	Medium black	Clay	6·3	1·04	0·726	6·6	0·96	0·907
Powarkhera	Deep black	,,	6·7	0·90	0·968	6·8	0·98	1·512
Bichpuri	Semi arid alluvial	Loam	6·7	0·73	1·210	6·6	0·68	1·210
Varanasi	Indo-Gangetic alluvium Grey & Brown	,,	6·1	0·81	1·129	6·2	0·78	1·936
Nasirpur	Grey & Brown	Silty loam	6·9	0·85	1·613	6·6	0·81	2·339
Pura Farm	Grey & Brown Indo-Gangetic alluvium	Loam	6·5	0·75	1·290	6·2	0·83	2·258
Ujjain	Medium black	Clay	6·6	0·83	2·016	6·7	0·83	2·419
Lakmapur	Medium black	Clay	7·1	0·76	1·613	7·0	0·85	2·116

TABLE II.

P and Ca at different soil : solution ratios

Soil	1 : 10			1 : 0·8		
	pH	Ca mols/$_l$ ×10^{-2}	P atom×10^{-6}/1	pH	Ca mols/$_l$ ×10^{-2}	P atoms/1×10^{-6}
Aduthurai	5·3	0·82	1·55	5·6	2·10	2·067
Karjat	6·0	0·65	2·28			
Hiragachi	5·2	0·83	1·45	5·0	1·40	1·654
Saharpur	5·2	0·80	1·24	4·9	0·73	1·447
Mankhand	5·9	0·71	1·24	5·6	0·63	1·447
Trivandrum	5·6	0·92	1·03	5·3	0·93	1·034
Raipur	5·7	0·87	0·83	5·3	0·85	1·034
Sabour	5·6	0·84	1·03	5·8	0·85	0·827
Bagwar	6·3	0·76	1·03	6·2	0.88	0·827
Obeidulla ganj	6·5	0·90	1·24	6·8	1·03	1·241
Powarkhera	6·3	0·90	1·03	6·8	1·15	0·827
Bichpuri	6·5	0.84	1·24	6·4	0.70	1·447
Varanasi	6·5	0·83	1·03	6·3	0·70	1·034
Nasirpur	6·6	0·90	2·69	6·3	1·00	1·654
Pura Farm	6·0	0·90	2·69	7·1	0·95	2·687
Ujjain	7·8	0·87	0·62	6·7	1·00	1·034
Lakmapur	6·7	0·82	0·83	6·1	0·85	1·654

The soils in this investigation belong to varying soil groups and range from loam to clay in texture. One of the assumptions in Schofield's phosphate potential is the constancy of calcium. It is seen from the above table that when soils differing in their physico-chemical characteristics are considered, this constancy of calcium is not kept up. The second assumption is the linearity in the extrapolation of P concentration to zero dilution. The plot of the phosphorus concentration against the solution : soil ratios show a non-linear increase in P concentration, as the ratio of solution to soil narrows, except in soils from Hiragachi, Raipur and Pura farm.

In Table III are presented $\frac{1}{2}$ p Ca + pH_2PO_4 values at different soil to 0·01 M $CaCl_2$ solution ratios.

The phosphorus concentration in the extracts is often very small, causing considerable difficulty in the estimation. According to Wild (1959) the method is to some extent empirical, since both the soil solution ratios and extraction time are rather arbitrary. This seems to be borne out from the data in Table III. Consistent decrease in phosphate potential values with decrease in soil : solution ratios are observed in some soils while it does not seem to be the case in others.

TABLE III.

Schofield's phosphate potential values at different soil solution ratios

Soil	$\frac{1}{2}$ p Ca + pH_2PO_4 1 : 0·8	1 : 2·50	1 : 1·25	1 : 10
Aduthurai	7·097	7·045	6·986	7·116
Karjat	—	7·630	7·333	7·048
Hiragachi	7·070	7·551	7·219	7·127
Saharpur	7·193	7·573	7·458	7·202
Mankhand	7·247	7·366	7·284	7·279
Trivandrum	7·295	7·770	7·315	7·272
Raipur	7·313	7·517	7·398	7·366
Sabour	7·451	7·590	7·406	7·291
Bagwai	7·522	7·652	7·531	7·427
Obeidulla ganj	7·528	7·555	7·586	7·378
Powarkhera	7·706	7·617	7·459	7·392
Bichpuri	7·390	7·565	7·530	7·393
Varanasi	7·208	7·555	7·158	7·473
Nasirpur	7·472	7·522	7·172	7·081
Pura Farm	7·178	7·428	7·096	6·909
Ujjain	7·547	7·243	7·219	6·607
Lakmapur	7·409	7·635	7·471	7·659

$\frac{1}{2}$ P Ca + pH_2PO_4 values were calculated from Ca and H_2PO_4 ion activities.

The data on Schofield's phosphate potential and paddy and wheat crop responses to phosphatic fertilisation at 30 lb. P_2O_5 per acre in the complex manurial experiments (1958–59) are given in Table IV. Response for 30 lb. refer to the average of that for 20 and 40 lb. P_2O_5 per acre (Experiment 2 for paddy and 8 for wheat).

TABLE IV.

Schofield's phosphate potential and yield responses of paddy and wheat crops to P fertilisation

Soil	P (micro atoms/l) at zero dilution	pH_2PO_4	$\frac{1}{2}$ p Ca+pH_2PO_4	Paddy crop per cent response to 30 lb. P_2O_5 per acre
Aduthurai	2·93	5·642	6·812	8·2
Karjat	2·40	5·827	6·997	−3·5
Hiragachi	2·24	5·746	6·916	19·0
Saharpur	1·07	6·067	7·237	5·2
Mankhand	2·07	5·799	6·969	17·2
Trivandrum	2·24	5·755	6·925	...
Raipur	1·12	6·056	7·226	17·9
Sabour	1·25	6·012	7·182	13·0
Bagwai	1·58	5·981	7·151	27·8

$r = 0·16$

TABLE IV. *(Contd.)*

	P (micro atom/l) at zero dilution	pH_2PO_4	$\frac{1}{2}$ p Ca+pH_2PO_4	Per cent response of wheat crop to 30 lb P_2O_5 per acre
Obeidulla ganj	1·10	6·699	7·869	8·3
Powerkhera	2·07	6·073	7·243	19·3
Bickpuri	1·21	6·182	7·252	4·1
Varanasi	2·74	5·729	6·899	4·7
Nasirpur	3·15	5·736	6·906	6·2
Pura Farm	3·20	5·703	6·873	19·3
Ujjain	2·80	5·818	6·988	1·6
Lakmapur	2·65	5·842	7·012	17·9

$r = + 0·09$

The coefficients of correlation of Schofield's phosphate potential with both paddy and wheat crop responses are 0·16 and 0·09 respectively which are quite low and not statistically significant. Though the concept of Schofield in respect of phosphate potential is admirable in some respects, it has not proved to be a satisfactory index of P availability in the soils studied and for the two crops, paddy and wheat. This is also in agreement with the findings of Ramamoorthy and Subramanian (1960) who reported low coefficients of correlations of Schofield's phosphate potential with paddy crop responses. This may perhaps be due to the fact that Schofield's phosphate potential is not an equilibrium value and represents one of a soil disturbed as regards its phosphate potential on the surface. The P availability does not also seem to depend on the P concentration under artificial conditions of calcium constancy as in his method. Further, as Talibudeen (*loc cit*) has rightly pointed out, Schofield's phosphate potential seems to neglect the interaction of phosphate with organic matter and organisms which may be quite important, perhaps in crops like paddy, which are grown mainly under water-logged conditions. It is in this context that the equilibrium phosphate potential, as suggested by Ramamoorthy and Subramanian (*loc cit*) seems to hold promise, as it seems to take care of the various limitations discussed.

Summary: A study of the method of determination of the phosphate potential, as proposed by Schofield, has shown that in many respects, it is somewhat empirical. The two assumptions of constancy of calcium and linearity in respect of extrapolation to zero dilution do not seem to be valid in many of the soils studied. Schofield's phosphate potential does not seem to reflect the available P status in the soils studied and with respect to the two crops, paddy and wheat, as indicated by its low coefficient of correlation with crop responses.

Acknowledgment: The author is thankful to Dr. Ramamoorthy, Physical Chemist, Indian Agricultural Research Institute, for his valuable guidance.

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Book Review

1. **"Manures and Fertilizers"** *by K. S. Yawalkar and J. P. Agarwal* — Agri. Horticultural Publishing House, Nagpur — Price Rs. 8/- — Printed in India in 1962 by Kapur Art Press, New Delhi-5.

The Book embodies some of the facts and figures obtained throughout India in the use of manures and fertilizers in the different Research stations and State Departments of Agriculture in the country. Dr. K. S. Yawalkar who was for some time in charge of the statistical lay out and interpretation of the results of the Model Agronomic Experiments and simple cultivators' field trials done through out India, has had access to all the data available in these trials at the Indian Agricultural Research Institute, New Delhi and has made a good review of the response to N, P and K in different parts of India. With this background knowledge he has prepared a fairly comprehensive text book on manures and fertilizers which should come in handy for students of Agriculture. It is priced fairly low and should be within the reach of every B. Sc. (Ag.) Degree student.

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2. **"Commercial Fertilisers in India—Some recommendations for efficient use"** *by K. S. Yawalkar, P. N. Jakate and M. M. P. Srivastava* — Agri. Horticultural Publishing house, Nagpur. Price Rs. 3/- Printed in India in 1962 by Citizen Press, 11 A/12 W E A., New Delhi. 5.

This is a good compendium of inorganic fertilizers in India. It gives the composition of the major plant nutrients present in each fertilizer and the doses in which they should be used. Besides, it has brought in all the fertilizer recommendations made in the different states in India for the various crops grown in the state. It should be a good reference book for fertilizer mixing firms, their agents and salesmen.

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