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Assessment of Soil Fertility Level — I.
Rapid Tests for available Phosphorus

by

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Introduction: This study was undertaken with a view to obtain a quick assessment of plant nutrients in the soil by some of the well-known rapid methods and thus reduce the time involved in analysis of these nutrients by the routine time-consuming methods now in vogue in this laboratory. Phosphorus, representing as it does one of the "big three" in plant nutrients was first taken up for estimation by these rapid methods.

Phosphorus in soils is the key to our fertility problems and plays a major role in the physiology of the plant. The phosphorus that is of importance to plant nutrition is not the net total phosphorus present in the soil but it is the phosphorus which is soluble and easily accessible to plant roots, herein called "available phosphorus". From time immemorial, agricultural chemists have tried to devise ways and means of assessing this fraction of the phosphorus present in soils. Consequently many methods based on empirical presumptions were evolved. These methods put forth certain soil extractants of different compounds and of different pH according to the tentative assumptions made by the author of the method to simulate conditions prevailing at the root zone of the plant in nature. The time-consuming routine method so far used in this laboratory is the Dyer's 1% citric acid method (7). In this method 1% citric acid in the proportion of 1 : 10 soil to extractant was adjudged to simulate the extraction of P_2O_5 at the root zone of the plant. In the five rapid methods studied in the present work other extractants to simulate root absorption were employed as detailed under "Materials and Methods" below. In the Dyer's citric acid method the period of extraction was for 12 hours and the subsequent evaporation and ignition to destroy citric acid and remove silica by dehydratihg it were all very laborious and time-consuming. The rapid methods cut short the period of extraction and could be utilised for colorimetric estimation of P_2O_5 by Truog's method (2,6).

The comparison of methods of assessing the "available phosphorus" in soils was done in three stages. Experiment I was a straight comparison of the values obtained by the different

methods in the well-known soil types of the Madras State. Experiment II was to assess the presence or absence of interfering ions in colour development in the soil extracts obtained by the different methods and Experiment III was designed to obtain a correlation of the estimates made by the different methods with actual grain yield of the crop grown on the soils.

Materials and Methods. I. *Method of extraction:* Of the methods available in literature, the following five methods were taken up for study:—

	Name of method	Extractant	Duration of extraction	Ratio of soil to extractar
1.	Morgan's method (1)	Sodium acetate and acetic acid pH 4·8	2 hours	1 : 40 (2·5 g. to 100 ml.)
2.	Truog's method (2)	0.002N. H_2SO_4 buffered with $(NH_4)_2SO_4$ to pH 3	30 minutes	1 : 200 (1 g. to 200 ml.)
3.	William's method (3)	N/2 acetic acid pH 3	2 hours	1 : 40 (2·5 g. to 100 ml.)
4.	Burriel's method (4)	Acetic acid ÷ H_2SO_4 + $CaCO_3$ + $MgCO_3$ pH 3·25	5 minutes	1 : 100 (1 g. to 100 ml.)
5.	Olsen's method (5)	0·5 Molar $NaHCO_3$ adjusted to pH 8·5 with NaOH	30 minutes	1 : 20 (5 g. to 100 ml.)

These five rapid methods were compared with Dyer's 1% citric acid method.

II. *Method of estimation:* The P_2O_5 in the extracts obtained by the various rapid methods listed above were estimated colorimetrically by the Truog and Meyer method (6) using a Spekker Absorptiometer for measuring the colour developed with 4·0 ml. of ammonium molybdate sulphuric acid solution and 0·8 ml. of freshly prepared 1% stannous chloride in a suitable aliquot of the extract, made up to 100 ml. In the Dyer's 1% citric acid method alone the usual volumetric method of estimating P_2O_5 was followed.

Materials: The following surface soils representing typical soil types of the Madras State were utilised for the comparison of the various techniques:

	Type	No. of samples	Sample No. and location
1.	Black soils ...	3	2791, 2793. 2795/'52–'53 Siruguppa
2.	Alluvial soil ...	3	S. S. 543, 546, 542/'51–'52 Punavasal, Tanjore dt.
3.	Laterite soil ...	3	1374, 1380, 1408/'52–'53 Pattambi.
4.	Red soil ...	10	261 to 270/'53–'54 Coimbatore.
5.	Calcareous red soil	10	910 to 919/'52–'53 ,,

Experiment I: Comparison of estimates of available phosphorus :—

Procedure : The above soil samples were analysed for "available phosphorus" by the five rapid methods and the Dyer's 1% citric acid method.

Results : The results are presented in table I. From the results obtained it will be seen that no one rapid method can be recommended universally for all types of soils. A comparison of the values obtained by the different rapid methods with those of Dyer's shows, that while in the case of red and alluvial soils the latter method always gives higher values than the former, in the case of black and laterite soils Dyer's values are lower than those obtained by rapid methods. Considering the unsuitability of a universal application of Dyers' 1% citric acid method to all types of soils, the criterion of maximum extraction was found to be more helpful in fixing the best rapid method for a particular type of soil and has also enabled us to bring the various soil types under two broad groups viz. calcareous and non-calcareous. For calcareous red and black soils, William's N/2 acetic acid method at pH 3·0 or Morgan's N/2 acetic acid at pH 4·8 and for non-calcareous red soils, laterite soils and alluvial soils, Truog's 0·002 N. H_2SO_4, seem to be the best rapid methods of extraction of available P_2O_5.

Experiment II. Recovery of added phosphorus in soil extracts :—

Procedure : With a view to see that no interfering ions were present in the soil extracts obtained by the five rapid methods, known amounts of phosphate solution were added to the soil extract and the estimation done as before with the Spekker Absorptiometer.

Results : The results of analysis are presented in Table II. From the data presented therein, it will be clear, that in no case was there any interfering ion, which would mar or enhance the colour development in the colorimetric estimation of the soil extracts obtained by the rapid methods, as nearly 90 to 100% of the added phosphorus were estimated by the colorimetric method.

Experiment III: Rapid estimates of available phosphorus correlated with grain yield :—

Procedure : All the methods tested in this study were based on tentative assumptions which according to the author of the technique was said to simulate the natural conditions at the root zone. So, this experiment was initiated to compare the values obtained by the various rapid methods with the soils of the old and

now permanent manurial plots at the Central Farm, Coimbatore. The fertility status of these soils was known definitely, having the same type of manurial treatment for more than two decades. The average grain yield from the last five crop seasons were computed.

Results: These grain yields with the "available P_2O_5" estimated by the different methods are presented in Table III and the same brought out graphically in plates 1 and 2. From the data it will be clear, that in the case of red soils as in the old and new permanent manurials, the rapid methods of estimating available P_2O_5 except that of Olsen's (5) reflect the fertility status of the soil.

Summary and conclusions: 1. This study was undertaken to try out some of the rapid methods of estimating "Available Phosphorus" in soils.

2. From the first stage of the study detailed under Experiment I, it was seen that there is no one rapid method capable of adoption for all types of soil. The N/2 acetic acid method either of Williams at pH 4·8 or of Morgan's at pH 4·8 was good for calcareous soils and the Truog's 0·002 NH_2SO_4 method was suitable for non-calcareous soils.

3. All the soil extracts obtained by the different methods were studied for the presence or absence of interfering ions in colour development in the colorimetric estimation. As 90 to 100% of the added phosphates were recovered in the colorimetric estimation it was concluded that the soil extracts obtained by the different methods did not have anything which would interfere with the colorimetric estimation.

4. In the case of red soils, a comparison of the estimates of the available phosphorus with actual grain yield of the crops raised on the soil was made and was found to agree closely in four out of the five rapid methods studied.

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PLATE I

GRAIN YIELDS OF O.P.M. COMPARED WITH ESTIMATED AVAILABLE P_2O_5

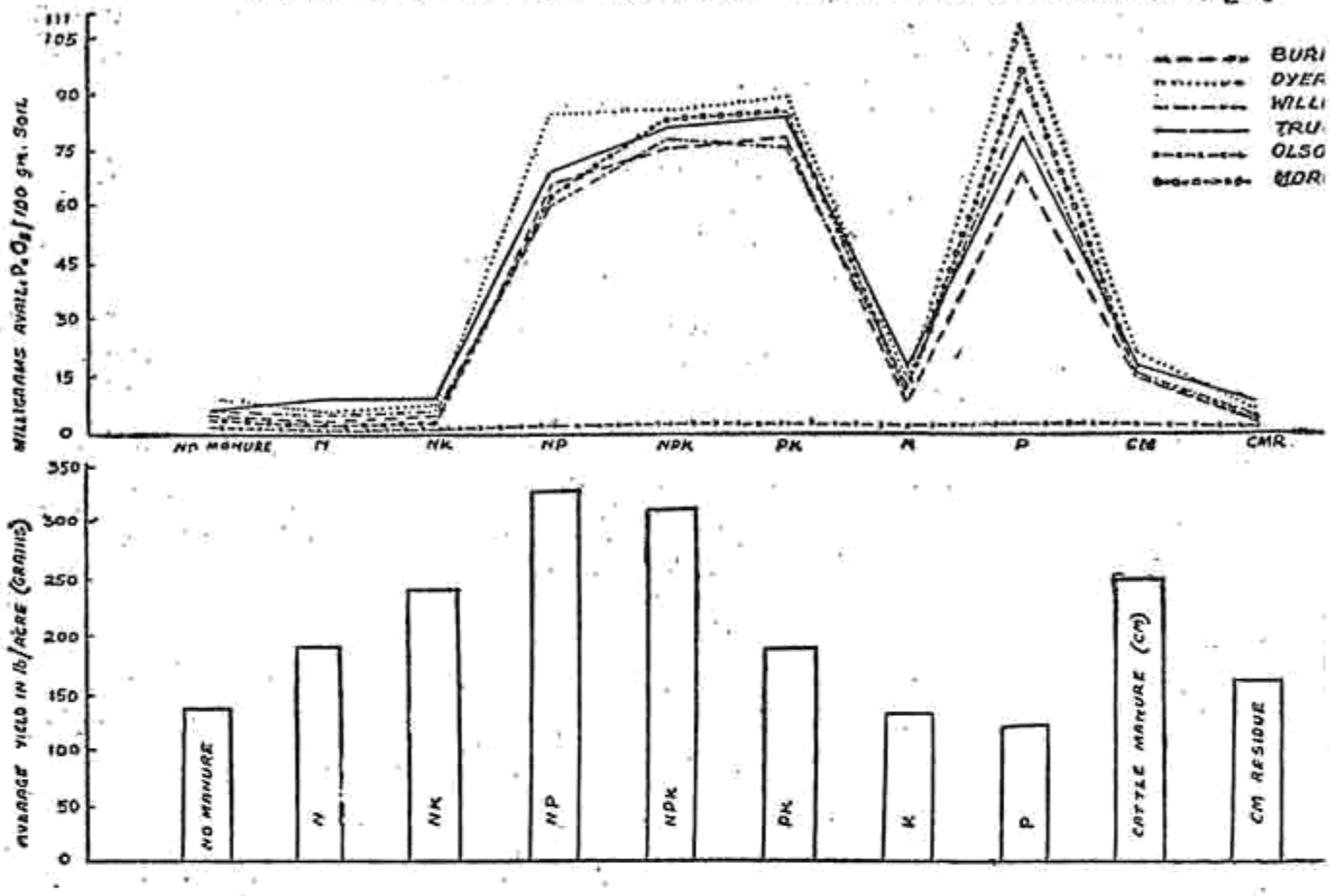
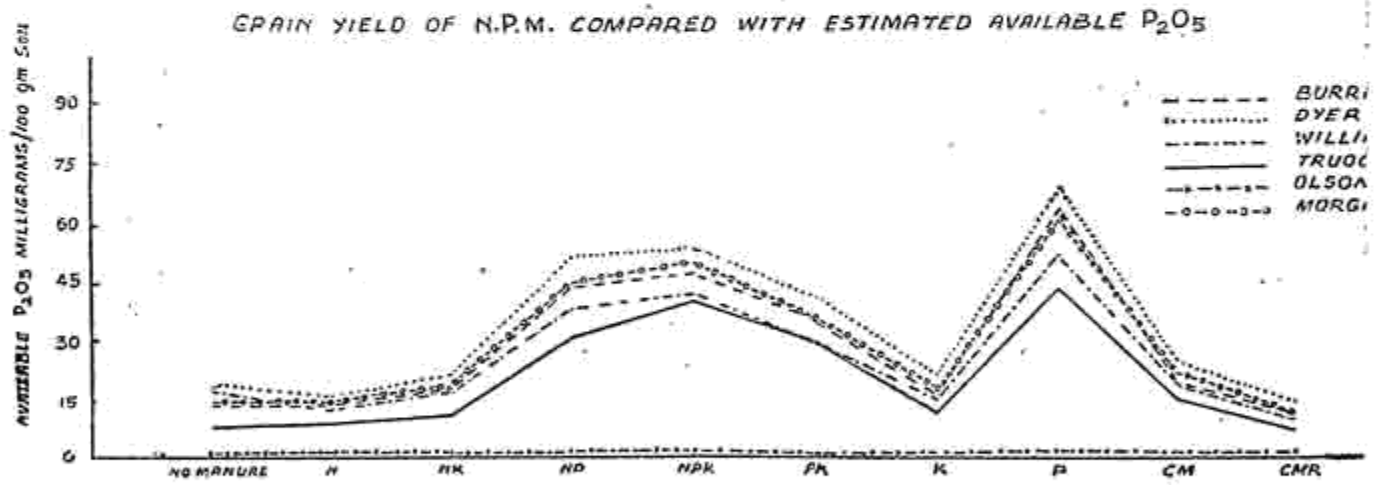


PLATE II

GRAIN YIELD OF N.P.M. COMPARED WITH ESTIMATED AVAILABLE P_2O_5



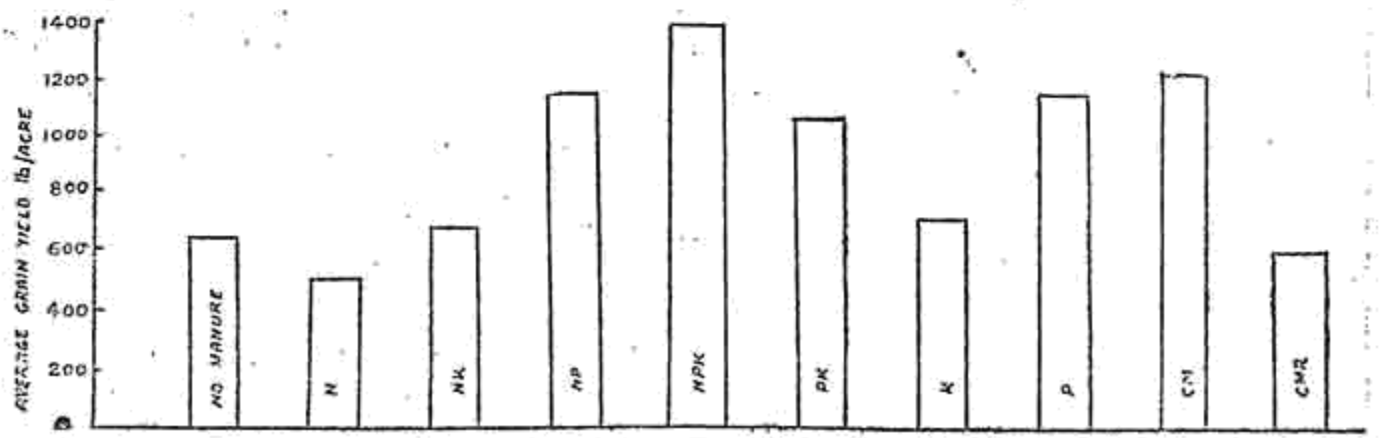


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TABLE I

Showing the available P_2O_5 in different soil types as estimated by different rapid methods and Dyer's method

(Milligrams P_2O_5/100 gram air dry soil)

S. No.	Lab. No.	Truog's method	William's method	Burriel's method	Morgan's method	Olsen's method	Dyer's method
	Black soil from Siruguppa:						
1	2791/52-53 ..	3·2	9·0	6·3	6·2	0·8	3·4
2	2793/52-53 ..	2·8	9·5	6·5	6·6	0·9	3·5
3	2795/52-53 ..	3·0	9·1	6·6	5·0	1·3	5·4
	Alluvial soils of Tanjore dela:						
1	543/51-52 ..	2·0	0·6	0·55	1·2	0·8	3·3
2	546/51-52 ..	1·7	Nil	0·55	0·8	0·8	3·5
3	549/51-52 ..	1·5	Nil	0·20	0·8	0·4	1·2
	Laterite soils from Patlambi:						
1	1374/52-53 ..	5·6	0·6	2·3	2·4	5·6	1·8
2	1380/52-53 ..	4·0	0·5	1·3	2·0	3·3	2·3
3	1408/52-53 ..	2·8	0·5	0·75	1·2	2·3	4·9
	Red soils from Coimbatore:						
1	261/53-54 ..	5·4	5·4	4·6	4·6	0·6	9·3
2	262/ ,, ..	7 3	4·4	4·0	3·4	0·2	6·4
3	263/ ,, ..	8·4	4·8	5·3	4·2	0·6	7·9
1	913/52-53 ..	8·0	16·5	14·5	14·6	0·7	18·4
2	911/ ,, ..	9 2	11 9	12·7	12·8	0·7	16·7
3	912/ ,, ..	11·1	16·5	16·5	17·6	0·7	20·8

TABLE II.

Showing the percentage of Recovery of Phosphate added to the Soil Extracts obtained using Different Extractants.

S. No.	Lab. No.	Truog's	Average	William's	Average	Burriel's	Average	Morgan's	Average	Olsen's	Average
1.	Red Soil O. P. M. 263/54–'54.	98·8	99·4	95·5	97·8	96·7	92·7	100·0	100·0	78·9	90·4
2.	do. 278/ ,,	100·0		100·0		88·7		100·0		101·8	
3.	do. N. P. M. 912/52–'53.	100 0	100 0	97·0	97·05	95·4	95·55	94·3	94·1	93·2	94·0
4.	do. ,, 917/53–'50.	100·0		97 1		95·9		93·9		94·7	
5.	Black Soil, Siruguppa	93·6	96·8	100 0	100·0	99·2	98·6	95·2	95·05	100·0	92·7
6.	do. Anuppapatti	100·0		100·0		98·0		94·9		85·4	
7.	Laterite Soil, Pattambi	90·5	95·25	82·8	85·4	85·1	93·4	91·8	93·8	93·6	93·2
8.	do. ,,	100·0		88·0		101·6		95·7		92·8	
9.	Delta Soil, Punavasal	93·0	96·15	88·9	94·1	87·2	98.8	87·5	92·85	100·0	94·9
10.	do. Mayavaram	99·3		99·3		96·4		98·2		89·8	

TABLE III

Showing the average grain yields in the old and new permanen manurials as compared with the available P_2O_5 in the soil estimated by different methods

	Available P_2O_5 Milligrams/100 gm. soil						Average yield of grain lb/acre	Remarks
	Truog's	William's	Burriels	Morgan's	Olsen's	Dyer's		
Old Permanent Manurial Soils:								
Lab. No. 261/53-54.	5·4	5·4	4·6	4·6	0·6	9·3	140·5	Unirrigated
,, 262 ,,	7 3	4·4	4·0	3·4	0·2	6 4	190 9	
,, 263 ,,	8·4	4 8	5·3	4·2	0·6	7·9	238 3	
,, 264 ,,	70·0	60 6	63·5	62 0	2 0	83 3	332·2	
,, 265 ,,	80·3	77 0	73·5	77·5	1·8	85·3	308·1	
,, 266 ,,	84·3	76·0	78·5	78·5	2·8	89·5	186 5	
,, 267 ,,	17·3	10·7	9·9	10·2	0·7	14·1	133·4	
,, 268 ,,	84·0	91·2	78·5	94·5	2·8	106·8	128·0	
,, 269 ,,	19·0	16·0	15·4	16·2	1·1	21·0	251·4	
,, 270 ,,	8·0	4·4	4·9	4·2	0·6	7·4	160·2	
New Permanent Manurial Soils:								
Lab. No. 910/51-52.	8·0	16·5	14·5	14·6	0·7	18·4	639·6	Irrigated
,, 911 ,,	9·2	11·9	12·3	12·8	0·7	16·7	513·2	
,, 912 ,,	11·1	16·5	16·5	17·6	0·7	20·8	672·2	
,, 913 ,,	31·0	38·0	43·0	43·5	1·5	52 0	1,158·8	
,, 914 ,,	41·0	42·0	47 0	50·0	1·5	53·0	1,395·6	
,, 915 ,,	30 0	30·0	36·0	35·0	1·3	43·0	1,071·4	
,, 916 ,,	13·2	16 0	15 7	16·2	0·7	20·9	692·6	
,, 917 ,,	43 0	52·0	62·5	60·0	1·9	68·8	1,148·2	
,, 918 ,,	14·8	19·0	18·9	20·8	1·3	24·6	1,210·2	
,, 919 ,,	8·6	10·0	10·7	10·8	0·7	14·7	548·6	

ERRATUM

Vol. XL. No. 12 1953 P. 550. para 2. line 10 from above for 4% DNOC read 40% DNOC.