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Streamlining Soil Test Recommendations in Madras State — Correlation Studies Suggest the Way

by

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Introduction: Soil test crop response correlation studies is recognised as the best way to select soil tests for a region in the estimation of available nutrients. In Madras State, Olsen's method is used for the estimation of available P as a result of correlation studies conducted at the Indian Agricultural Research Institute, on an All-India basis. However, region-wise detailed correlation studies need be conducted in large States like Madras with widely varying soils, such as alluvial, red, black and laterite.

Review of Literature: Russell (1962) is of the opinion that inherent in the basis of each method of soil test is the assumption that crops need the same amount of available phosphorus for good growth in all soils-an assumption that is certainly incorrect if soils of widely different genetic types are considered, but is reasonably valid for soils of the same genetic type. Long and Seatz (1953) have suggested that the reliability of predictions based on soil tests for phosphorus can be improved by a more thorough characterisation of the soil, such as texture, pH, internal drainage and clay mineral type. Miller (1960) working on the chemical methods of determining available P and K in Maryland soils has stated that the soil type determined to a large extent the correlation between yield and P extraction.

Materials and Methods: 1. *Soils:* (i) 1961—62 SEASON: Twelve soils representing the major soil groups of Madras State, *viz.*, alluvial, red, grey, brown and black were used. The soils covered a pH range of 5·8 to 6·7, texture of sand to clay, cation exchange capacity of 8·8 to 83·7 m. e. per 100 g. clay.

(ii) 1962—'63: Eight soils representing major soil groups *i. e.*, alluvial, red, black and lateritic covering a range of pH of 4·2 to 7·9, texture of sand to clay, cation exchange capacity of 25 to 96 m. e. per 100 g. clay were used.

(iii) 1963—'64: Ten red soils of Coimbatore covering a range of pH of 7·3 to 8·6, texture of sandy loam to sandy clay, cation exchange capacity of 47 to 95 m. e. per 100 g. clay were used.

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2. *Crop :* Pot experiments to evaluate response to added P were conducted.

(i) 1962—'63: Paddy strain Co. 30 (duration 110 days) was used.

(ii) 1962—'63: *Ragi* strain K2 (duration 135 days) was used.

(iii) 1963—'64: *Ragi* strain K2 was used.

3. *Treatments :* (i) 1962—'63 (PADDY CROP): The treatments were P_0, P_1 and P_2 at 0, 20 and 40 lb. P_2O_5 per acre respectively applied as monocalcium phosphate before planting. Nitrogen and potash were common to all at 45 lb. N per acre as ammonium sulphate in three split doses and 30 lb. K_2O per acre as potassium sulphate applied at 15 lb. basallv and 15 lb. as top dress. The experiment was run in duplicate.

(ii) 1962—'63 (*Ragi* CROP): The treatments were NKP_0 and NKP, phosphorus was applied basally as monocalcium phosphate at 0 and 40 lb. P_2O_5 per acre. Nitrogen and potash were common to both treatments—N at 45 lb. per acre as ammonium sulphate applied in three split doses and potash at 40 lb. per acre supplied before planting. The experiment was run in duplicate.

(iii) 1963—'64 (*Ragi* CROP): The treatments were NP_0K, NP_1K, NP_2K, and NP_3K with four replications. Phosphorus was applied at 0, 40, 80 and 120 lb. P_2O_5 per acre as super, basally. Nitrogen and potash were common to all treatments, the former at 60 lb. N per acre as ammonium sulphate in three split doses and the later at 60 lb. K_2O per acre as potassium chloride basally.

4. *Methods of analysis for estimating available P :*

1. Bray I (Dickman, and Bray, 1940)
2. Bray II (Bray, and Kurtz, 1945).
3. Truog (Truog, 1930).
4. Olsen (Olsen, Cole, Watenabe and Dean, 1954).
5. Dyer (Dyer, 1894).
6. CO_2 water (McGeorge and Pearson, 1947).

In addition, Saunder's method (1956) was tried in *ragi* experiment of 1963—'64.

5. *Collection and interpretation of data :* Data on the yield of grain and straw were expressed as per cent yield as suggested by Bray (1948) as follows:

$$100 \times \frac{\text{Yield without added nutrient}}{\text{Maximum yield}}$$

The percentage yield of grain was used as a response index of soils for P application.

The soil test values for available phosphorus were correlated with per cent yield.

Results: The correlation co-efficients between soil test values for available P and per cent yield values for the different soils and crops are given (Tables 1, 2 and 3).

TABLE 1. *Correlation coefficients of soil tests for available phosphorus with per cent yield — Paddy crop (1962'-63)*

Soil test methods	All soils	Alluvial soils N = 4		Red, black grey, grey brown soils N = 6	
		Soil test *vs* yield	Log soil test *vs* yield	Soil test *vs* yield	Log soil test *vs* yield
Olsen	0·36	0·524	0·538	0·154	0·017
Bray I	0·44	0·954*	0·995†	0·682	0·936*
Bray II	0·26	0·718	0·741	0·506	0·428
Truog	0·46	0·911	0·801	0·715	0·905*
Dyer	0·48	0·611	0·468	0·745	0·797
CO_2–water	0·41	0·438	0·426	0·429	0·236

* Significant at 5 per cent level

† Significant at 1 per cent level

TABLE 2. *Correlation coefficients of soil test for available phosphorus with per cent yield – Ragi (1962–'63)*

Soil test method	All soils	5 soils of medium C. E. C.	4 soils of medium C. E. C.
Olsen	0·566	0·919*	
Bray I	— 0·115	0·212	960*
Bray II	— 0·100	0·854	
Truog	0·548	0·150	
Dyer	0·190	0·130	
CO_2–water	0·218	0·210	

* Significant at 5 per cent level

TABLE 3. *Correlation coefficient of soil test for phosphorus with response of Ragi to added P. ('r' values)*

Soil test method	Soils of C. E. C. 47 to 95·2 m. e./ 100 g. clay (10 soils)	Soils of C. E. C. 72 to 95·2 m. e./ 100 g. clay (8 soils)	Soils of C. E. C. 72 to 95 m. e./ 100 g. clay (7 soils) £
Olsen	+ 0·02	+ 0·07	...
Bray I	+ 0·06	+ 0·66	+ 0·747@
Bray II	+ 0·44	+ 0·64	...
Truog	+ 0·35	+ 0·65	+ 0·757* ¶
Dyer	+ 0·20	+ 0·36	+ 0·916† ¶
Saunder	— 0·30	— 0·28	...
CO_2-water	— 0·24	— 0·26	...

£ Values for tests which showed further improvement over the previous column alone are given.

† Significant at 5 per cent level.

* Significant at 1 per cent level.

@ Very near Significance at 5 per cent (0·754 *vs.* 0·747)

¶ Differences are not statistically significant.

The results in Table 1. shows that for paddy, the correlation for Bray I method was highly significant for alluvial soils of medium cation exchange capacity (on clay basis) and Bray I and Truog's method for red, black, grey and grey brown soils of higher cation exchange capacity (*vide* Table 1). When the two groups are taken together the correlations were not significant.

Tables 2 and 3 give correlation co-efficients with *ragi* as test crop. For medium cation exchange capacity soils (Table 2) Olsen's or Bray I method gave significant correlations, while for high cation exchange capacity soils, Dyer and Truog have given significant correlation (Table 3) while Bray I was promising, the 'r' value falling only slightly short of 5 per cent (0. 754 *vs.* 0·747). Table 4. summarises the relationships between Bray I values and the per cent yield values of untreated soils.

Discussion: For soils with clay of medium and high cation exchange capacity, Bray I method is best suited for estimating available P for paddy crop, while it is quite promising for *ragi* crop. The soil test values by this method, therefore, can be used to compare the different soil groups with reference to response to added phosphorus. When the relations of Bray I soil test values are plotted on a graph against per cent yield values on 'y' axis clear indications are obtained as to how the relationship varies with different soils and for different crops.

The per cent yield value suggested by Bray is an index of response and directly gives the level at which the soil is producing as per cent of maximum yield possible when P in sufficient amount is applied. For the alluvial soils a cent per cent yield was obtained when soil test value was 8·4 lb. per acre while for a similar yield in the case of higher cation exchange capacity soils, the soil test value was about 72·9 lb. P per acre (*vide* Table 4). This means that while recommending fertilizers based on soil tests, phosphate may be recommended for alluvial soils testing up to about 8·4 lb. P per acre while for the other group of soils up to the value of 72·9. Similarly for a given soil group, *ragi* crop showed higher values of soil tests upto which fertilizer can be recommended, compared to paddy.

TABLE 4. *Relation between soil test for available P in lb./acre by Bray I method and per cent yield*

	Paddy		*Ragi*	
	Soil test for 75 % yield	Soil test for 100 % yield	Soil test for 75 % yield	Soil test for 100 % yield
Soils of low C. E. C. (clay basis)	...	...	...	...
Soils of medium C. E. C. (clay basis)	1·5	8·4	13·5	26·5
Soils of high C. E. C. (clay basis)	16·0	72·9	48·0	114·0

Remarks: 1. Soil testing a higher amount of P than the values given under 100 per cent yield will not respond to phosphate.

2. Suggested values for 75 per cent yield and for 100 per cent yield are drawn from actual data or from trend of results (from graphs) for the purpose of illustration. This has to be confirmed by further study.

The criterion used for differentiating soil groups is the cation exchange capacity calculated for 100 g. clay. The cation exchange capacity value of clay is used to characterise the clay mineral make up of soil, low values indicating soils predominantly kaolinitic, higher values indicating illitic and still higher values the montmorillonitic. The classification of soils on the basis of cation exchange capacity values of their clays in general, synchronises with the major soil groups of Madras State such as black soils (high cation exchange capacity clays), alluvial soils (generally medium cation exchange capacity clays), calcareous red soils (high cation exchange capacity clays) and non-calcareous red soils (lateritic, low pH, low cation exchange capacity clays). Since determination of cation exchange capacity (being a time consuming process) is not suited for soil test services, the broad groupings as alluvial *etc.*, listed above may be used. Soils falling on the border between the two groups or behaving as exceptions to the general classification may present a problem in which case other characteristics as pH may also have to be considered. This aspect needs further study.

Nelson, Mehlich and Winters (1953) have stated that improvements in the interpretation of the tests are possible when properties as pH, soil texture, fixing power of soil for P and type of clay mineral are considered. The cation/anion exchange capacity ratio was found useful for indentifying the type of clay mineral and it was found that the amounts of P extracted with 0·05 N Hcl + 0·025 NH_2SO_4 corresponding to optimum growth increases with increasing C/A ratio. Hence if the method is to be used successfully, different levels of sufficiency must be established for different soils. These authors also have stressed that crop differences must be taken into consideration in making recommendation for P based on soil tests. They have cited the work of Krantz, Nelson, Welch and Hall (1949) in which for a soil testing 58 lb. P_2O_5 with corn as crop there was no response to phosphate while with cotton as the crop 70 per cent increase in yield was obtained.

Suggested classification of soil test values for different soils and crops reported in Table 4. has been given to illustrate the possible approach in streamlining the soil test recommendations. These values, although drawn from actual data or from trends of graphs, are to be confirmed by further detailed studies on each soil group and crop and may need slight alterations. The classification of soil test values for different soils and crops has suggested the way for differential recommendations for different soils and crops for improving soil test recommendations.

Summary and Conclusions: The paper summarises the results of correlation studies of soil test for available phosphorus with response of *ragi* and paddy crops to added phosphorus and examines the possibility of having a chemical test which will be useful in differentiating the different soils and crops of Madras State for recommending phosphatic fertilizers. The response to added P was determined in pot trials and expressed as per cent yield as suggested by Bray.

Soils were tested for available phosphorus by different methods used in laboratories elsewhere and the soil test values were correlated with per cent yield values.

From the results of these studies, a criterion for classifying different soils has been suggested. The soils of Madras State can be grouped as low, medium and high, with respect to cation exchange capacity of their clays. This classification roughly coincides with the natural groups into which the Madras soils fall *viz.*, alluvial (medium cation exchange capacity), red calcareous soils (high cation exchange capacity), red lateritic soils (low cation exchange capacity) and black soils (high cation exchange capacity). The study has also suggested that Bray I method can probably be adopted to estimate available phosphorus on all these soils and for *ragi* and pady crops.

Using the relationship of Bray I values of available P and per cent yield values, it has been illustrated how the soil test values differ for different soils and crops for a given per cent yield and for maximum yield, showing thereby the need to take into consideration the nature of the soil and crop in giving recommendations for fertilizer use based on soil tests. Further detailed studies are needed to confirm these findings.

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