

EDTA EXTRACTABLE PHOSPHORUS IN SOILS AS RELATED TO
AVAILABLE AND INORGANIC PHOSPHORUS FORMS

Key words: EDTA-P, available P, inorganic P, ammonium molybdate-stannous chloride, Alfisols, vertisols

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ABSTRACT

Twenty surface soil samples, representing two major soil orders alfisols and vertisols were extracted with 0.01N Na₂ EDTA solution (pH 4.8) at a soil/solution ratio of 1:25. Phosphorus in the extract was determined following ammonium molybdate-stannous chloride colorimetric method. The EDTA extractable P showed significant positive correlations with extractable P according to the Olsen, Morgan, Bray 1 and 2 and also with inorganic phosphorus fractions associated with Al, Ca and Fe.

INTRODUCTION

A major portion of inorganic P in soils occurs as relatively insoluble compounds of Al, Ca and Fe. Though several chemical and microbiological factors govern the solubilization and availability of these insoluble phosphates, however, the role of certain organic

chelating agents like EDTA, which can bind with the metallic cations and release P seems important in relation to extraction of available P from soils²⁻⁴.

When a large number of soil samples are to be handled for available P it sometimes becomes necessary to store the extracts for 2-3 days before these could be analysed for P. While using Olsen's extracting procedure (0.5 M NaHCO₃, pH 8.5) for available P with the Institute farm soils, it has been observed by the author that erroneous results for available P were sometimes obtained if the extracts were stored for 2 to 3 days before analysis. The purpose of the work reported in this paper was to evaluate EDTA extractable phosphorus (EDTA-P) in relation to available and inorganic P forms in soils. The stability of EDTA extracts of soils in relation to phosphate-P extracted was also studied.

MATERIALS AND METHODS

The soils used were surface (0-15 cm) samples from the experimental farm of ICRISAT, Hyderabad and belong to soils orders alfisols and vertisols. These soils represent the major agricultural soils of the Deccan Plateau of India in the Semi-arid tropical region.

A large area of the ICRISAT farm was sampled and 20 soil samples, 10 from each soil order were selected to provide a wide range in pH, organic carbon, clay content, extractable P according to Olsen, Morgan, Bray 1 and 2 and inorganic phosphorus forms (Table 1). Most of the area selected for soil sampling had not received P fertilizers. The soil samples were air dried and ground to pass a 2 mm sieve before use.

TABLE 1
Analysis of soils used

Soil characteristic	Alfisols	Vertisols
pH (1:1)	5.5 - 6.8	7.2 - 8.7
Organic C (%)	0.18 - 0.29	0.30 - 0.38
Clay content (%)	20 - 35	40 - 56
P tests (ppm of soil)		
Olsen-P	0.8 - 4.8	2.0 - 15.5
Morgan-P	0.3 - 2.8	0.8 - 7.0
Bray 1-P	1.5 - 6.0	3.0 - 10.5
Bray 2-P	2.8 - 7.2	4.9 - 18.6
EDTA-P	1.0 - 5.8	3.3 - 14.9
Fe-P	19 - 36	21 - 41
Ca-P	18 - 27	42 - 93
Al-P	11 - 19	17 - 35

Na₂ EDTA (ethylenethiaminetetraacetic acid, disodium salt) solution with a normality of 0.01 N buffered at pH 4.8 was used as an extractant for extracting P from soils. The 0.01 N EDTA salt solution had a pH of 4.6, which was adjusted to 4.8 with dilute NaOH solution.

The following was the final procedure followed for extraction and determination of P from soil samples. Four g of soil samples were shaken with 100 ml of Na₂ EDTA solution for one hour on a

Burrell wrist action shaker. About 0.25 g of activated charcoal was also added for clarification of the soil extract. The soil suspension was filtered through Whatman No. 42 filter paper.

Phosphate in the extract was determined following ammonium molybdate stannous chloride blue colour method⁵.

EDTA-P was compared with those evaluated by other extraction procedures⁶⁻⁸ and also with inorganic phosphorus forms⁹ in soils and correlations worked out.

RESULTS AND DISCUSSION

In preliminary experiments an EDTA concentration of 0.01 N was found to be optimum. To check whether the reagent at this concentration interfered or not with the colour development in the estimation of P, recovery determinations by adding known amounts of phosphate-P (from KH_2PO_4 solution) in the range of 1 to 20 μg to 10 or 20 ml aliquots of EDTA solution were carried out. It was found that the recovery of the added $\text{PO}_4\text{-P}$ to EDTA solution was quantitative (99.2 to 99.8%) and the reagent did not interfere with the colour development and absorbance measurement at 660 nm with a spectrophotometer.

Preliminary work also showed that an EDTA solution pH of 4.8 was necessary to extract P from the soil samples to represent available fraction. The neutral pH of the reagent extracted considerably less amounts of P from alfisols and there was no added advantage for lower reactions of the reagent.

The shaking time for extraction with EDTA salt solution was chosen one hour because there was little increase in the amount of P extracted when the shaking time was increased further particularly at a soil to solution ratio of 1:25, which was found to be optimum.

The lower soil to solution ratios of EDTA extracted considerably less amounts of P and the increase in extraction time further increased the amounts of P extracted even beyond one hour. So the wider soil/solution ratio of 1:25 was chosen to maintain the rapidity of the method with one hour extraction time instead of increasing the extraction time by adopting a lower soil to extractant ratio to achieve the similar results for EDTA-P.

The correlations of EDTA-P with other soil parameters are shown in Table 2, which reveal that P extracted by the reagent has a high positive significant correlation coefficients (significant at the 1% level) not only with extractable P according to the Olsen, Morgan, Bray 1 and 2 but also with Al, Ca and Fe-P fractions for the soils used.

TABLE 2

Correlations between 0.01 N Na₂ EDTA extractable phosphorus and other soil parameters.

Parameter compared	Correlation coefficient (r)
Olsen-P	0.90**
Morgan-P	0.92**
Bray 1-P	0.90**
Bray 2-P	0.95**
Al-P	0.94**
Ca-P	0.90**
Fe-P	0.97**

** = significant at the 1% level.

It is important to note that EDTA-P showed significant positive correlations with all the three forms of inorganic P, indicating that the reagent possibly binds with all cations Al, Ca and Fe and derives P. Alexander and Robertson¹⁰ also reported that EDTA extractable P in soils showed significant positive correlations with Al-P and Fe-P but it was not significantly correlated with Ca-P. However, this study shows a significant positive correlations between EDTA-P and Ca-P in addition to with Al-P and Fe-P.

Storage of several of the EDTA extracts of the soils used in this study showed that the extracts of the reagent were quite stable and the amount of phosphate-P did not change even after storage at room temperature ($27 \pm 3^{\circ}\text{C}$) for 7 days when kept after filtration. These results also indicated that no hydrolysis of the extracted organic phosphates from soils would occur during storage and the results for available phosphate-P will thus be not influenced even if some organic phosphates are extracted by the reagent. Recently, Nnadi, Tabatabai and Han way¹¹ have also shown that the storage of the EDTA extracts of some Iowa soils for 5 days at 25°C did not result in any hydrolysis of the organic phosphate, which are supportive of the observation made in the present study. However, it is suggested that if storage of the extracts are required beyond 24 hours it should be stored in a refrigerator after filtration.

The results of this study indicate that EDTA method for extracting available P from soils might have advantages over the other extracting solutions because of the ability of the reagent to derive P from all the three inorganic P forms. The stability of the EDTA-extracts of soils during storage with respect to phosphate-P

should be an additional advantage accompanying this method and can be an important consideration when large number of soils samples have to be handled for available P.

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REFERENCES

1. Present address: Soil Chemistry Department, International Rice Research Institute, Los Baños, Philippines (Mail address: P.O. Box 933, Manila, Philippines).
2. J. S. Kanwar, Aust. Conf. Soil Sci., Adelaide 1:3 (1953).
3. P. J. Viro, Soil Sci. 79:459-465 (1955a).
4. P. J. Viro, Soil Sci. 80:69-74 (1955b).
5. M. L. Jackson, Soil Chemical Analysis, Prentice-Hall (India), New Delhi (1967).
6. R. H. Bray and L. T. Kurtz, Soil Sci. 59:39-45 (1945).
7. M. F. Morgan, Connect. Agric. Expt. Sta. Bull. 450 (1941).
8. S. R. Olsen, C. V. Cole, F. S. Watanabe and L. A. Dean, U. S. Dept. Agric. Circ. 939 (1954).
9. R. C. Glenn, P. H. Hsu, M. L. Jackson and R. B. Corey, Agron. Abstr. pp. 9 (1959).
10. T. G. Alexander and J. A. Robertson, Soil Sci. 114:69-72 (1972).
11. L. A. Nnadi, M. A. Tabatabai and J. J. Hanway, Soil Sci. 119:203-209 (1975).