CHARACTERIZATION OF KERALA SOILS INTO FERTILITY CLASSES WITH RESPECT TO AVAILABLE P AND K EXTRACTED BY A COMMON EXTRACTANT

By

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THESIS

Submitted in partial fulfilment of the
requirements for the degree of

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Soil Science and Agricultural Chemistry
COLLEGE OF HORTICULTURE
Vellanikkara, Trichur

1988

DECLARATION

I hereby declare that this thesis entitled "Characterization of Kerala soils into fertility classes with respect to available P and K extracted by a common extractant" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

Vellanikkara,
3rd September, 1988.

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CERTIFICATE

Certified that this thesis entitled "Characterization of Kerala soils into fertility classes with respect to available P and K extracted by a common extractant" is a record of research work done independently by Smt.P.V.Kamalam under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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CERTIFICATE

We, the undersigned members of the Advisory Committee of Smt.P.V.Kamalam, a candidate for the degree of Master of Science in Agriculture with major in Soil Science and Agricultural Chemistry, agree that the thesis entitled "Characterisation of Kerala soils into fertility classes with respect to available P and K extracted by a common extractant" may be submitted by Smt.P.V.Kamalam, in partial fulfilment of the requirement for the degree.

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ACKNOWLEDGEMENTS

I gratefully acknowledge the directions and help rendered by Dr.A.I.Jose, Professor and Head, Department of Soil Science and Agricultural Chemistry, College of Horticulture, Vellanikkara and Chairman of my Advisory Committee in completing this investigation. His critical evaluation of the work is notably conspicous for which I am highly indebted to him.

The valuable guidance and suggestions offered by Dr.R.Vikraman Nair (Professor, Department of Agronomy), Dr.V.K.Venugopal (Associate Professor, Department of Soil Science and Agricultural Chemistry) and Sri.V.K.G.Unnithan (Associate Professor, Department of Agricultural Statistics) helped me in completing this investigation.

I am thankful to Dr.C.Sreedharan, Associate Dean for providing the necessary facilities required for this investigation.

I place on record my deep sense of gratitude to Dr.P.Padmaja, Professor Project Co-ordinator (Soils and Agronomy) for her constant guidance and immense academic interest bestowed on me.

I specially thank the members of staff of the Department of Soil Science and Agricultural Chemistry, College of Horticulture, Vellanikkara for their sincere help in completing this work.

I acknowledge my indebtedness and gratitude to my friends P.Seema, P.V.Shylaja, and N.K.Padmam from whom I received immense help. Their abiding co-operation and companionship made possible the completion of this work in time.

Finally I thank the Kerala Agricultural University for awarding me the KAU Merit Scholarship.

Vellanikkara,
September, 1988.

P.V.KAMALAM

CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Introduction

INTRODUCTION

The supply of N, P and K in soil at adequate amounts for plant growth is often met through fertilisation. Of the major plant nutrients in soil, P and K undergo a set of transformations. They occur in fixed, exchangeable and soluble forms. The available portion of nutrients is determined by soil testing which refers to the quantity of nutrient that is taken up by plants. The selection and adoption of a chemical procedure and its interpretation have to take into consideration various factors and processes that are involved in plant growth. Attempts made by different scientists to screen a suitable extractant for assessing P and K supply of soil have led to the development of a large number of extracting solutions like water, alkalies, acids, buffered and neutral salt solutions. Probably, the first fertiliser recommendation based on a soil test by using 1 per cent citric acid as the extracting solution was that of Dyer (1894). At present P and K extractions are carried out individually with Bray 1 and neutral N NH_4OAc respectively in the soil testing laboratories of the state. Simultaneous extraction of both available P and K in the soil can make considerable savings of time, materials and labour. The development of a common extractant will therefore be appreciated. A large number of chemical extractants has been tested for this purpose. Organic acids when employed along with mineral acids can act as chelates and can effectively prevent resorption of P brought into solution by the mineral acid. Devi (1986) screened various chemical agents for simultaneous extraction of available P and K. She suggested Mathew's triacid extractant (0.06 N H_2SO_4 + 0.06 N HCl + 0.05 N oxalic acid) as the best extractant for combined P and K determination based on plant uptake values. The use of a common extractant can definitely intensify the soil testing activities of the state. However, the suitability of the triacid for the combined extraction of P and K has to be confirmed on a larger number of soil samples collected from all over the state. The ten fertility classes now followed in the soil testing laboratories are based on the Bray-1 P and NH_4OAc K values. The triacid extractant can be recommended for routine soil testing work only if the fertility class intervals are redefined in terms of the triacid P and triacid K values. Therefore it becomes necessary to work out the class intervals based on the test values estimated by the common extractant for the purpose of fertiliser recommendation.

This study was therefore conducted with the following objectives in view.

1. To confirm the suitability of Mathew's triacid extractant for combined estimation of available P and K on a large number of soil samples.

2. To establish precise relationship between the available P and K extracted by the common extractant (triacid) evolved by the KAU and the available P and K extracted by the methods now followed in the soil testing laboratories of Kerala.

3. To classify the soils of Kerala into the various fertility classes for providing fertiliser recommendation based on available P and K values estimated using the common extractant.

Review of Literature

REVIEW OF LITERATURE

Several chemical techniques have been studied to ascertain the soils need for supply of P and K in adequate quantities for plant growth. An accurate method has yet to be developed since no single extractant is found universally suited under a wide diversity of soil conditions. The increased importance of these nutrients in crop growth paves the need for a more rapid and easy chemical tool to be adopted in soil testing procedures.

1. Chemical methods for available P and K

The most common and still widely used chemical extractant for P and K is based on the individual estimation of these nutrients. The Bray 1 (Bray and Kurtz, 1945) and neutral normal NH_4OAc (Hanway and Heidal, 1952) are the most widely used chemical extractants for determination of available P and K respectively. Under flooded soil conditions, Olsen's extractant (Olsen et al., 1954; Webber and Mattingly, 1970; Walmsley and Cornforth, 1973; Matar and Samman, 1975; Barrow and Shaw, 1976a, 1976b; Bowman and Cole, 1978) gives a reliable estimate of P requirement of rice crop (Biddappa and Sarkunan, 1981). The anion exchange resin (Amer et al., 1955) and isotopic dilution techniques (Fried, 1964; Larsen, 1967) were reported to give high correlation with P uptake by ragi plants (Jose, 1972).

Selection of an extractant for assessing the availability of a particular nutrient in soil is usually based on correlation studies with crop uptake. The principle involved is that the extractant is capable of dissolving a fraction of soil P that is considered available to plants Acidic soils could be assessed for available P status more successfully using strong acid extractants (Bingham, 1975).

2. Acid extractants used for the extraction of available P and K

2.1 Earlier proposals

Various proposals put forward by previous authors have been considered in this context. Extractants used for the estimation of available P include both organic and inorganic. Organic acids employed are 1 per cent citric acid (Dyer, 1894); 0.5 N acetic acid (Suetov, 1968), oxalic acid (Gachon, 1966), 2.5 per cent acetic acid containing 8-hydroxy quinoline (Williams, 1950), 0.07 N EDTA and 0.005 N oxalic acid (Borlan and Bordeiasu, 1968). Acid extractants like carbonic acid (Mc George, 1939; Stanberry, 1949; Sen Gupta and Cornfield, 1963; Abbott, 1978), 0.314*N* HCl (Baver and Bruner, 1939), 0.7 *N* HCl (Olsen, 1946), 0.2 *N* HNO_3 (Fraps, 1909), 0.01 *N* HNO_3 (Von Sigmond, 1929), 0.01 *N* H_2SO_4 (Kerr and Von Steights, 1938), 0.05 *N* H_2SO_4 (Beater, 1949), 0.2 *N* H_2SO_4 (Bandroff, 1952), 0.5*N* H_2SO_4 (Bittencourt *et al*., 1978) 0.05 *N* HCl + 0.025 *N* H_2SO_4 (Nelson *et al*., 1953; Fitts, 1956; Pritchett, 1976), 0.002 *N* H_2SO_4 buffered to pH 3 with $(NH_4)_2SO_4$ (Truog, 1930), sodium acetate - acetic acid (Morgan, 1937), 0.02 *N* calcium lactate in 0.01 *N* HCl, pH 3.5 (Egner, 1941); 0.1 *M* ammonium lactate in 0.4 *M* acetic acid (Egner *et al*., 1960); 0.1 *M* calcium lactate and 0.1 *M* calcium acetate in 0.3 *M* acetic acid (Schuller, 1969), boric acid and borax buffered to pH 7.6 (Sik, 1964), 1 *N* HCl (Puri and Swarnakar, 1969), 0.5 *N* NH_4F and 0.1 *N* HCl (Bray and Kurtz, 1945) and 0.03 *N* NH_4F and 0.025 *N* HCl (Dupuis, 1950) have been suggested.

As in the case of P, various extractants have been proposed for the estimation of available K in soil. The amount of nutrient present in soil solution and change in its concentration that occurs during crop growth should be known for a good interpretation of plant nutrient requirement. Weak extractants remove K only from soil solution while stronger extractants (lactate or NH_4OAc solutions) extract larger quantities including those from unavailable sources. The correlation between K uptake of plants and K test values is therefore unsatisfactory.

The different extractants suggested by several workers include dilute HCl (Garman, 1957; Harada and Sinohara, 1968; Mishra et al., 1970), 0.7 N HCl (Baumgardner and Barbier, 1956), HCl under reflux (Singh et al., 1983), 1.38 N H_2SO_4 (Hunter and Pratt, 1957), 6 N H_2SO_4 (Wang and Tseng, 1962), boiling 0.5 N HCl + 0.025 N H_2SO_4 (Wang and Tseng, 1962), boiling 0.5 N HNO_3 (Oommen and Iswaran, 1962; Mirchaev, 1966); shaking with 0.5 N HNO_3 (Oommen and Iswaran, 1962; Weber and Caldwell, 1965; Eagle, 1967), boiling 1 N HNO_3 (Nelson, 1959; Boyd and Fracter, 1967), 1 N HNO_3 (Wood and De Turk, 1941), 1 per cent citric acid (Dyer, 1894; Sen et al., 1949), 0.5 N acetic acid (Sen et al., 1949; Russell, 1967), neutral N NH_4OAc (Hanway and Heidal, 1952; Van Diest, 1963; Datta and Kalbande, 1967; Mishra et al., 1970; Chiriac, 1964), sodium acetate + acetic acid + HCl (Carpenter, 1953) and 43.65 per cent sodium acetate and 15 per cent HNO_3 (Bray, 1932).

Common extractant for more than one nutrient is attractive in routine soil testing because of savings in time and labour. The most widely known multiple extractants have been the Morgan's solution, Mehlich's double acid and the Egner's extractant (Egner et al., 1960). Extractants such as Bray 1, water and NH_4OAc used for testing individual nutrients are also sometimes used for simultaneous extraction of P and K.

Sodium acetate and acetic acid, pH 4.8 (Morgan, 1937), 0.130 N HCl (Spurway, 1935), 0.125 N NaOH and 0.167 N acetic acid, pH 5.0 (Mester, 1934), 0.3 N HCl (Warren and Cooke, 1962), 1 per cent citric acid (Warren and Cooke, 1962) and Mehlich II 0.2 N NH_4Cl + 0.015 N NH_4F + 0.2 N acetic acid + 0.012 N HCl (Mehlich, 1978) have been suggested as extractants for combined estimation of P and K.

2.2 Recent proposals

Maida (1978) indicated that the P test levels obtained by the method of Olsen, Bray, Williams and Stewart, Morgan, Aslyng, anion exchange resin, Saunder, Dyer and North Carolina were all significantly inter-related. He noted that the Al-P fraction extracted by these methods was in decreasing order of Dyer, North Carolina, 0.1 M NaOH, 0.5 M acetic acid, Olsen, Bray and anion exchange resin. Fe-P was the second most important variable contributing to the total variation in 0.1 N NaOH, Olsen P, North Carolina, anion exchange resin and Dyer P values.

Mathew (1979) evaluated the available P reserve of soil by chemical methods and indicated that Bray 1 is not an efficient extractant for the estimation of available P reserve of soil and recommended the extractant 0.06 N H_2SO_4

and 0.06 N HCl in 0.05 N oxalic acid with an equilibration period of 30 min and soil solution ratio 1:10 as a better method for estimating the total available P reserve of the soil (Ra-value).

Giroux and Tran (1985) evaluated the different available P extraction methods using Bray 1, Bray 2, new Mehlich, North Carolina DA-4, DA-10, Olsen and two anion exchange resin (F^- and HCO_3^-) and found DA-4, DA-10, new Mehlich and HCO_3^- resin methods to show the best correlation with oat yield and plant P uptake. The Bray 1 and Bray 2 were the most affected by soil properties especially the oxalate extractable Al.

Tran and Giroux (1985) studied the influence of the chemical and physical properties of soil on the extractable P with Bray 1, Bray 2, new Mehlich, North Carolina double acid, DA-4 and DA-10 extractants and two anion exchange resin methods. The Bray 2, DA-4 and DA-10 methods were reported to extract more P from soils high in Ca-P. Bray 1 solution was found to be more affected by the presence of free carbonates and was also found to be the most consistent over a wide range of soil textures.

Buckley *et al*. (1986) suggested citric acid as a better extractant in comparison with $NaHCO_3$ for determining available P in the acid sandy soils measuring more than 8 ppm P.

Swami and Lal (1970) in a comparative study with six extractants for available K ranked the extractants based on their extraction ability in the order of 1 N HNO_3, IN NH_4OAc, 1.38 N H_2SO_4, 2.0 per cent acetic acid, Morgan's extractant (3 per cent acetic acid with 100 g of NaOAc/litre buffered to pH 4.8) and water.

Nambiar (1972) compared the K extracting efficiency of different methods by estimating the K uptake by ragi seedlings (Neubauer technique) and ranked those methods as to their suitability for extraction of K in the following descending order of IN HNO_3 (Wood and De Turk, 1941), 6 N H_2SO_4 (Hunter and Pratt, 1957), 0.5 N HNO_3 with heating (Oommen and Iswaran, 1962), 1.38 N H_2SO_4 (Hunter and Pratt, 1957), neutral 1 N NH_4OAc (Hanway and Heidal, 1952, 0.5 N HNO_3 with shaking (Oommen and Iswaran, 1962), 1 per cent citric acid (Dyer), 1 per cent ammonium carbonate, 43.65 per cent sodium acetate and 15 per cent HNO_3 (Bray, 1932), 0.05 N HCl + 0.025 N H_2SO_4 (North Carolina), Neubauer method (modified), 0.1 N EDTA, 10 per cent sodium acetate with 3 per cent acetic acid (Morgan, 1941), 0.5 N NaCl, 0.05 N EDTA and water. Available K measured by each of these extractants was correlated with that of NH_4OAc or Neubauer technique.

Ahmed et al. (1973) reported that NH_4OAc and cold H_2SO_4 gave the best estimate of available K and were least influenced by changes in soil properties. The acetic acid extract in general was the least effective.

Ramanathan (1978) studied the correlation between the different methods of K estimation and K uptake by ragi and reported N HNO_3 as the most promising extractant. He arranged the extractants according to their suitability for predicting K availability in the order of N HNO_3, non-exchangeable K, N NH_4OAc, 0.5 N HCl, 6 N H_2SO_4, 0.01 M $CaCl_2$ and water soluble.

Chatterjee and Maji (1984) showed that 0.1 N cold H_2SO_4 and 0.05 M sodium tetraphenyl boron gave high positive significant correlation with dry matter yield of barley (*Hordeum vulgare*) and Neubauer K. Boiling 1 N HNO_3 extracted more K than other extractants but was found to give no correlation with dry matter yield. Potassium extracted by different reagents was related with the organic matter content of soil.

Lierop and Tran (1985) made a comparative study of the removal of K by electro-ultrafiltration (EUF) and some chemical extractants and indicated that K removed by EUF procedure and chemical extraction were closely related. However, EUF was found to be less efficient in soils with higher proportions of clay than NH_4OAc, the new Mehlich solution or the double acid mixture failed to give soil fertility information.

Devi (1986) recommended Mathew's tri-acid extractant as a common extractant for both available P and available K. This could save considerable time and materials in soil testing.

3. An appraisal of chemical soil testing for available P and K in acid soils of Kerala

The conventional method of estimating soil available P with Bray 1 need not necessarily give a reliable estimate for assessing the need of P application. This method is based on the correlation between values estimated by them with that of a test crop grown. However, to assess the P supplying power of soil on a long term basis it is necessary to gain information on the phosphate supplying power of soil. For this, plants have to be grown successively in the soil till a stage is reached when P deficiency symptoms are observed. The total P removed by the plant has to be then correlated with the amount of P extracted by chemical methods.

A study was therefore conducted in the lateritic soils of Kerala by Mathew (1979) to evolve a suitable laboratory chemical method for estimation of 'Ra-value' of soil. In his study the soil samples used showed wide variations in P status and other properties associated with P fixation and availability. Available P was determined by employing Bray 1, Bray 2, Bray 4, Olsen's and Truog's extractants. The total plant removable P content of the soil was determined by pot culture experiments using rice as the test crop. Screening of a suitable chemical extractant for determining the 'Ra value' of soil was done by employing mineral and organic acids at their varying strengths and combinations with different periods of equilibration (5, 10, 15, 30, 45 and 60 min) and a single soil solution ratio of 1:10. Mineral acids, HCl and H_2SO_4 were selected based on the assumption that they will suit the acid laterite soils in their ability to extract soil P without drastically affecting the chemical nature of soil. Hydrochloric acid at 0.06 N was found to extract the maximum amount of P but its performance was poor when compared with Bray 1. Sulphuric acid extracted higher quantities when compared with HCl. Phosphorus extracted at various concentrations of H_2SO_4 was found to be correlated with the cumulative P uptake at the end of the sixth crop. A combination of both these acids extracted much higher quantities than the individual acids, with a profound influence at lower concentrations.

With various combinations of mineral acids tried, P extracted by the combination of 0.06 N H_2SO_4 in 0.06 N HCl and 0.06 N H_2SO_4 in 0.08 N HCl possessed the highest degree of correlation with the 'Ra-value'.

Mathew (1979) further found that organic acids acted as chelates and prevented the resorption of P from solution. Thus organic acids when employed along with mineral acids increased the amount of P extracted by mineral acids. Oxalic acid (0.05 N) was found to be more effective than acetic and citric acids employed for the study. An equilibration period of 30 min was found to be optimum for a combination of mineral acid and organic acid. Phosphorus extracted by Bray 1 was not significantly correlated with P uptake by crops in soil groups in which the percentage P content of plants went below 0.025, 0.05 and 0.20, whereas a significant correlation was obtained with that extracted by the triacid extractant (0.06 N H_2SO_4 + 0.06 N HCl + 0.05 N oxalic acid). This gave a clear indication that Bray 1 is not suitable for estimation of 'Ra-value' of soil. The extractant 0.06 N H_2SO_4 + 0.06 N HCl + 0.05 N oxalic acid was found superior to all other combinations of acids and gave better correlations with the 'Ra-values' of the soil. So he recommended the above extractant with an equilibration period of 30 min and a soil solution ratio of 1:10 to be used for a better estimate of the 'Ra-value' of soil.

Devi (1986) undertook a study with the objective of evolving a single extractant suitable for extracting both available P and available K. A single extractant could simplify the work load in soil testing laboratories where estimation of P and K is still followed by the conventional methods of extracting with Bray 1 and neutral 1N NH_4OAc for P and K respectively. Screening of chemical extractants was done on the acid laterite soils of Kerala and was based on laboratory studies and Neubauer seedling technique. Eighteen extractants were tried of which nine were NH_4F-DTPA combinations in a preliminary study so as to fix an approximate range of the concentration of the reagents. The values obtained by the different methods were correlated with those extracted by Bray 1 for available P and with neutral 1N NH_4OAc for available K. A soil solution ratio of 1:10 and two equilibration periods of 30 and 60 min were employed in this study using a single soil. Based on this preliminary study, Devi (1986) then screened 15 extractants using nine soils with five equilibration periods viz., 5, 10, 15, 30 and 60 min at a soil solution ratio of 1:10. Extractants with suitable equilibration periods were selected based on the correlation between the amount of P and K extracted by the various extractants and P and K uptake by rice. For the final selection of a common extractant, ten extractants with suitable equilibration periods and a soil solution ratio 1:10 were employed on 87 soils. Correlation coefficients were worked out between the amounts of P and K extracted by the various extractants and the amount of P and K extracted by Bray 1 and M neutral NH_4OAc respectively.

Considering all the soils taken, the extraction efficiency of the various extractants for available P were listed in the decreasing order of 0.1 M NH_4F + 0.003 M DTPA (88.21 ppm), 0.3 M NH_4F + 0.001 M DTPA (43.43 ppm), 0.1 M NH_4F + 0.001 M DTPA (31.56 ppm), 0.5 M NH_4F + 0.005 M DTPA (31.45 ppm), Bray 1 (30.67 ppm), 0.05 M NH_4F + 0.05 M acetic acid (28.56 ppm); Mathew's triacid extractant (27.31 ppm), Bray 1 + 0.005 M DTPA (22.67 ppm), Olsen's extractant (19.75 ppm) and neutral M NH_4OAc (7.16 ppm).

Available K was estimated by the various extractants in the decreasing order of NH_4OAc (119.1 ppm), Bray 1 + 0.005 M DTPA (111.0 ppm) Mathew's triacid extractant (110.7 ppm), NH_4OAc standard (107.4 ppm), Bray 1 (101.4 ppm), Olsen's extractant (100.8 ppm), 0.05 M NH_4F + 0.05 M acetic acid (94.1 ppm) 0.1 M NH_4F + 0.003 M DTPA (88.4 ppm), 0.1 M

NH_4F + 0.001 M DTPA (88.1 ppm), 0.3 M NH_4F + 0.001 M DTPA (83.6 ppm) and 0.5 M NH_4F + 0.005 M DTPA (62.0 ppm).

The correlation coefficients with Bray 1 P extracted by the various extractants were in the order of 0.5 M NH_4F + 0.005 M DTPA (0.9294**), 0.05 M NH_4F + 0.05 M acetic acid (0.9168**), NH_4OAc (0.9014**), Olsen (0.8977**), Mathew's triacid (0.8913**), Bray 1 + 0.005 M DTPA (0.8887**), 0.3 M NH_4F + 0.001 M DTPA (0.8868**), 0.1 M NH_4F + 0.001 M DTPA (0.8046**) and 0.1 M NH_4F + 0.003 M DTPA (0.4080**).

All the extractants did not give a significant positive correlation with neutral N NH_4OAc K. Only Mathew's triacid (0.6436**), 0.1 M NH_4F + 0.001 M DTPA (0.4009**) and Olsen's extractant (0.2503**) was found to give significant positive correlation. Thus Mathew's triacid extractant was found to give a better correlation with Bray 1 P and NH_4OAc K when used as a common extractant with 1:10 soil solution ratio and an equilibration period of 30 min. She therefore recommended that Mathew's triacid can be employed as a common extractant for the estimation of available P and K of Kerala soil.

Materials and Methods

MATERIALS AND METHODS

1. Collection of soil samples

Five hundred and eleven surface soil (0-15 cm) samples were collected from all over state so as to represent the entire state of Kerala and to ascertain wide variations in the analytical results of the samples collected. The samples were dried in shade, powdered and passed through a 2 mm sieve and stored for chemical analysis.

2. Analytical methods

The soils were analysed for pH, EC, organic carbon, available P and available K.

2.1 pH and EC

pH of the soil was determined with pH meter using a soil water suspension ratio of 1: 2.5. Electrical conductivity of the supernatant liquid of 1: 2.5 soil water suspension was measured with direct reading conductivity meter.

2.2 Organic carbon

Organic carbon was determined by Walkley and Black procedure as given by Jackson (1958) in which the soil was digested with a known amount of standard $K_2Cr_2O_7$ and concentrated sulphuric acid, the excess unreacted chromic acid being determined by back titration with standard ferrous sulphate using ferroin as the indicator.

2.3 Available phosphorus

The soil was extracted for available phosphorus with Bray No.1 solution (0.03 N NH_4F + 0.025 N HCl) at 1:10 soil solution ratio with an equilibration period of 5 min. The phosphorus in the extract was determined colorimetrically by the chlorostannous reduced molybdophosphoric blue colour method in hydrochloric acid system using a Klett-Summerson photoelectric colorimeter.

2.4 Available potassium

The available potassium status of soil was determined by extraction with 1 N neutral NH_4OAc using a soil solution ratio of 1:5 with an equilibration period of 5 min. The potassium extracted was determined using an EEL flame photometer.

2.5 Combined extraction of available phosphorus and potassium

Combined extraction of available phosphorus and potassium of soil was done by extracting the soil with

0.06 N H_2SO_4 + 0.06 N HCl + 0.05 N oxalic acid at 1:10 soil extractant ratio with an equilibration period of 30 min. Phosphorus in the extract was then determined colorimetrically by the chlorostannous reduced molybdophosphoric blue colour method in HCl system and K was determined flame photometrically.

3. Statistical analysis

Simple correlation and regression were established between the various parameters of soil determined as per the methods of Snedecor and Cochran (1967).

Results and Discussion

RESULTS AND DISCUSSION

The amounts of available P and K present in soil are usually estimated by extracting the soil with suitable chemical agents for a specified period of time. This is on the assumption that the amount of nutrient extracted by these chemical extractants will correlate with the amount of nutrient that can be readily taken up by a crop. A large number of extractants has been screened for their suitability to extract available P and available K from the soils of Kerala by different workers (Mathew, 1979; Devi, 1986). In general, most of these studies indicated the suitability of Bray 1 extractant for the estimation of available P and neutral NH_4OAc for the extraction of available K in the acid soils of this state. Accordingly, Bray 1 and 1 N neutral NH_4OAc are adopted as the standard chemical agents for the estimation of available P and K in the soil testing laboratories of the state. While studying the efficiency of different chemical methods in estimating P availability in soils, Mathew (1979) observed that a combination of three acids namely 0.06 N H_2SO_4 + 0.06 N HCl and 0.05 N oxalic acid served as a better index of phosphate availability as compared to Bray 1. The extraction procedure for the estimations of available P and available K can be simplified if a single extractant suitable for extracting both available P and available K is evolved. The use of sophisticated laboratory equipment that are capable of analysing a solution for different elements simultaneously is becoming widespread. The advantages of such moddrn instruments can be fully realized only if a single soil extract can provide the information on several soil nutrients. With these objectives Devi (1986) screened various chemical agents including acids, neutral salts and chelating agents in various combinations for the simultaneous extraction of available P and available K. Considering the degree of correlation between P and K extracted by the chemical agent and the amount of these nutrients taken up by the test crop (rice), she suggested Mathew's triacid as the best extrectant for the simultaneous extraction of available P and K from soil. She attributed good reproducibility as well as easy workability to this method as compared to the methods currently followed for the estimation of available P and K. She also observed that the amount of available P extracted by the triacid well correlated with the amount of P extracted by Bray 1. Similarly, the K extracted by the triacid showed significant positive correlation with the amount of K brought into solution by

1 *N* neutral NH_4OAc. Therefore, it was suggested that the triacid can be employed as a common extractant for the combined extraction of available P and K in place of Bray 1 and neutral NH_4OAc as individual extractants. This study was undertaken in order to confirm the suitability of the triacid extractant for the combined estimation of available P and K using a large number of soils collected from all over the state.

The soil testing laboratories of Kerala now classify soils into ten fertility classes ranging from 0 to 9 based on the content of available P and K for the purpose of giving fertiliser recommendations. In the case of available P, 100 per cent of the general fertilizer recommendation is given to a soil containing 4.46 ppm (10 kg/ha) when extracted with Bray 1 extractant. A soil containing available P more than this critical value will receive a correspondingly decreased fertiliser recommendation with respect to P. Similarly, if the value is less than 4.46 ppm it will receive a correspondingly higher fertiliser recommendation for P. The class intervals for different fertility classes are made based on this concept. Similarly, class intervals for fertility classes with respect to available K are formed taking 51.34 ppm (115 kg/ha) as the value to receive 100 per cent of the fertiliser recommendation. At present the soil testing laboratories make use of the values of available P and K as estimated by Bray 1 and NH_4OAc respectively for classifying the soil into appropriate fertility classes.

After confirming the suitability of the triacid extractant for the combined extraction of P and K, it is necessary to redefine the fertility class intervals with respect to available P and K extracted by this common extractant for the ten fertility classes followed in soil testing laboratories of the state. Therefore, coefficients of correlation and regression were worked out for P and K extracted by the triacid and those by Bray 1 and neutral $\underline{N}$ NH_4OAc. The results of the study are discussed here.

1. Physico-chemical properties of soil

The physico-chemical properties of the soils selected for the study are presented in Table 1 and the relationships between soil properties are given in Table 2. In order to involve maximum variation in the physico-chemical properties of soil especially with respect to those governing the fixation and availability of P and K, large number of surface soil samples were collected from all over the state. These soils belonged to various soil groups of Kerala namely

Table 1. Physico-chemical properties of soils selected for the study

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
1	2	3	4	5	6	7	8	9	10
<u>**Kasargod and Cannanore**</u>									
1	Kasargod	5.3	0.086	3.06	7.82	5.52	77.0	28.0	Clay loam
2	Mambram	5.4	0.004	1.41	14.72	7.36	300.0	125.0	Clay loam
3		5.5	0.006	2.48	11.50	7.36	112.5	39.0	Sandy clay loam
4	Kolayad	5.6	0.004	0.96	12.88	8.51	54.0	24.0	Sandy loam
5	Chalodu	4.9	0.015	2.04	8.05	12.30	64.0	24.0	Sandy clay
6		5.5	0.012	3.21	5.75	3.22	84.0	30.0	Clay loam
7		4.7	0.027	1.77	4.60	2.76	79.0	30.0	Clay loam
8		5.5	0.004	0.93	6.21	2.53	39.0	14.0	Sandy clay loam
9	Iritti	5.1	0.004	1.62	7.13	2.76	74.0	29.0	Sandy clay
10		5.1	0.006	1.29	5.78	2.76	86.0	31.0	Sandy clay loam
11		4.4	0.004	2.34	43.70	27.83	98.0	44.0	Clay loam
12	Anjarakandi	5.1	0.018	2.34	10.35	10.12	137.5	59.0	Sandy clay loam
13		5.2	0.009	1.29	10.35	21.85	162.5	62.0	Sandy clay
14		5.0	0.012	0.78	19.55	18.40	76.0	33.0	Sandy clay loam
15	Ulikkal	5.2	0.067	2.58	9.66	6.90	32.0	13.0	Clay loam
16	Mathil	5.1	0.009	1.11	40.25	24.61	58.0	23.0	Sand
17		5.1	0.011	2.82	7.13	6.90	46.0	20.0	Clay loam
18	Pilathara	4.9	0.009	1.65	6.44	7.13	48.0	22.0	Sandy clay loam
19		5.0	0.014	0.87	8.74	5.06	73.0	35.0	Sandy loam
20	Karikottakkari	6.0	0.088	1.92	12.65	18.86	425.0	150.0	Sandy clay

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
21	Karihottakkari	5.7	0.006	1.77	10.58	22.17	60.0	150.0	Sandy clay loam
22	Mattannur	5.7	0.029	2.97	6.21	5.52	125.0	54.0	Clay loam
23		5.0	0.008	0.78	17.71	10.81	54.0	20.0	Clay loam
24		5.7	0.017	1.25	12.42	9.20	75.0	38.0	Sandy clay loam
25	Kilakam	5.2	0.038	1.83	16.56	8.51	112.5	44.0	Clay loam
26	Panoor	5.1	0.010	0.78	11.96	6.90	46.0	16.0	Clay loam
27		5.7	0.012	0.51	11.96	9.20	84.0	44.0	Sandy clay loam
28		6.1	0.009	0.72	12.65	9.43	48.0	30.0	Sandy loam
29	Payyannur	5.1	0.009	1.14	8.28	18.86	12.5	48.0	Clay loam
30		5.4	0.010	1.95	8.74	5.29	43.0	16.0	Sandy clay
31	Chokli	6.1	0.010	0.81	20.01	23.69	175.0	75.0	Clay loam
32		4.5	0.022	1.20	14.95	16.33	82.0	37.0	Clay loam
33		5.6	0.005	0.40	8.74	6.21	18.0	8.0	Sandy loam
34	Mayyil	4.9	0.024	2.67	3.22	1.61	150.0	63.0	Sandy clay loam
	<u>Calicut and Wynad</u>								
35	Nadakkavu	5.4	0.014	0.70	54.05	54.05	100.0	62.5	Sand
36		5.2	0.014	1.94	19.09	13.57	82.0	32.0	Clay loam
37		5.7	0.008	1.85	21.16	16.10	95.0	42.0	Sandy loam
38		6.0	0.013	2.03	23.23	20.24	175.0	67.0	Clay loam
39	Mavoor	5.3	0.019	0.82	69.00	42.55	100.0	50.0	Sandy loam
40		5.1	0.011	1.71	26.22	57.50	150.0	50.0	Clay loam

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
41	Mankav	6.1	0.046	1.97	8.97	14.26	225.0	92.0	Sandy clay loam
42		5.3	0.018	0.82	8.28	4.00	92.0	40.0	Sand
43		5.2	0.022	0.79	50.60	41.30	162.5	52.0	Clay loam
44		5.3	0.015	0.82	48.30	37.95	125.0	43.0	Sandy loam
45		6.6	0.014	0.69	108.10	124.20	88.0	42.0	Sand
46		5.4	0.007	2.75	44.62	48.63	125.0	57.0	Sand
47	Elathur	5.3	0.007	0.56	62.10	54.73	50.0	18.0	Sandy clay loam
48		7.0	0.011	1.04	35.65	52.14	100.0	48.0	Sandy loam
49		5.4	0.030	0.93	47.15	53.60	76.0	34.0	Sandy loam
50	Naduvannur	5.4	0.004	0.81	35.65	23.40	125.0	46.0	Sandy clay loam
51		6.3	0.021	0.42	48.55	39.80	52.0	26.0	Sandy loam
52		5.4	0.007	1.09	12.36	47.20	62.0	11.0	Clay
53	Mukkom	5.7	0.009	1.29	12.65	18.50	98.0	44.0	Clay
54		5.2	0.008	1.60	40.25	22.30	80.0	22.0	Sandy loam
55		5.5	0.004	1.44	40.71	38.50	58.0	20.0	Clay
56		5.7	0.008	1.29	36.34	29.80	72.0	28.0	Clay loam
57		5.7	0.007	1.35	41.40	38.25	100.0	46.0	Clay loam
58		5.5	0.008	1.11	38.64	34.88	76.0	30.0	Clay loam
59		5.8	0.008	1.50	44.16	42.87	74.0	32.0	Sandy clay loam
60	Atholi	6.7	0.010	0.17	6.90	5.80	40.0	14.0	Sand

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
61	Atholi	7.9	0.025	1.20	10.58	21.20	125.0	60.0	Sandy loam
62		5.8	0.007	1.38	43.47	56.80	50.0	16.0	Clay
63		5.4	0.007	0.30	20.70	17.80	37.0	10.0	Sand
64		5.3	0.008	1.10	41.40	37.80	38.0	12.0	Sandy loam
65		5.2	0.039	0.33	50.37	43.20	96.0	38.0	Sandy clay loam
66		5.4	0.026	0.96	57.50	56.60	162.5	60.0	Sandy clay loam
67		5.9	0.120	0.42	4.83	11.20	150.0	64.0	Clay
68		5.7	0.006	0.36	45.31	47.20	36.0	11.0	Clay
69	Unnikulam	6.2	0.520	1.14	51.29	49.80	96.0	42.0	Sandy clay loam
70		6.2	0.010	1.02	77.05	118.02	212.5	74.0	Clay
71		5.1	0.020	4.41	40.71	62.80	62.5	22.0	Clay
72		5.8	0.017	0.51	30.74	50.61	55.0	34.0	Clay
73		5.5	0.004	1.94	57.50	64.40	162.5	75.0	Sandy clay loam
74		5.7	0.010	1.86	51.75	69.20	162.5	70.0	Sandy loam
75		5.4	0.008	1.67	51.29	62.64	43.0	52.0	Sandy clay loam
76		6.0	0.011	1.29	44.85	76.34	43.0	20.0	Sandy clay loam
77		5.8	0.010	1.29	37.03	32.60	52.0	22.0	Sandy loam
78		4.1	0.011	1.74	51.29	46.64	68.0	28.0	Sandy clay loam
79	Kuruvattoor	5.1	0.008	1.26	8.74	7.23	15.0	6.0	Sandy loam
80		5.3	0.038	1.17	49.91	38.10	162.5	62.0	Clay

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
81	Kuruvattoor	6.0	0.007	0.78	44.85	45.45	48.0	15.0	Clay
82	Kalachi	5.8	0.010	1.17	92.00	71.50	112.5	51.0	Sandy clay loam
83	Arikulam	5.7	0.007	0.12	108.10	98.00	31.0	10.0	Sand
84		5.4	0.007	1.05	36.57	34.80	34.0	12.0	Sandy loam
85		5.4	0.008	1.38	38.64	35.23	91.0	38.0	Clay loam
86	Karassery	5.4	0.021	0.72	43.01	38.21	82.0	30.0	Clay loam
87		6.1	0.035	0.39	51.75	92.03	96.0	48.0	Sandy loam
88	Thikkoti	5.4	0.038	0.57	46.69	32.20	125.0	58.0	Sand
89		5.1	0.019	0.42	45.77	48.20	28.0	11.0	Clay
90		5.4	0.150	0.84	74.75	82.60	75.0	33.0	Sand
91		5.8	0.010	1.77	39.10	42.60	16.0	9.0	Sand
92	Cheruvannur	5.1	0.015	0.36	17.39	15.09	98.0	36.0	Clay
93		5.5	0.014	1.08	40.25	38.90	94.0	45.0	Sandy loam
94		5.2	0.006	1.14	44.16	38.62	54.0	24.0	Clay loam
95		5.4	0.014	1.59	50.83	64.61	87.5	43.0	Sandy clay loam
96	Perambra	5.6	0.030	0.39	10.81	7.60	88.0	48.0	Clay
97		4.8	0.005	1.26	39.10	28.60	41.0	14.0	Sandy clay loam
98		5.4	0.011	2.60	43.24	36.90	58.0	20.0	Sandy loam
99		5.3	0.016	2.40	26.91	18.10	100.0	42.0	Sandy clay loam
100		6.2	0.012	0.24	32.20	17.60	20.0	9.0	Sand

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
101	Perambra	5.1	0.009	2.12	33.58	29.99	51.0	20.0	Clay
102		5.1	0.009	2.01	39.10	37.63	53.0	20.0	Clay loam
103		5.6	0.039	2.27	35.65	44.68	275.0	125.0	Clay
104		5.3	0.011	1.28	48.07	39.80	84.0	35.0	Clay loam
105	Kunnummal	5.4	0.005	1.02	44.85	42.60	30.0	11.0	Clay
106		5.5	0.011	0.81	44.39	41.37	32.0	12.0	Clay
107		5.4	0.021	1.01	50.37	48.62	82.0	36.0	Clay loam
108		5.5	0.008	0.87	51.29	47.25	37.0	12.0	Sandy clay loam
109	Chorode	5.2	0.150	0.42	20.93	13.20	80.0	36.0	Sandy clay loam
110		5.3	0.150	0.72	104.65	108.34	79.0	37.0	Clay
111		4.8	0.017	1.76	38.18	29.90	100.0	42.0	Clay loam
112		5.3	0.015	0.09	47.61	23.45	21.0	9.0	Sand
113		5.5	0.160	0.93	108.10	136.43	79.0	32.0	Sand
114		5.5	0.021	0.29	57.27	42.38	29.0	12.0	Sand
115		5.4	0.190	0.60	49.91	37.53	38.0	19.0	Loam
116	Kurachundu	5.6	0.070	1.38	43.70	52.10	154.0	67.0	Clay
117		5.3	0.009	0.18	44.16	22.01	18.0	6.0	Clay
118		5.4	0.008	1.59	34.10	42.60	112.5	46.0	Sandy clay loam
119		5.4	0.007	1.10	33.35	26.72	100.0	42.0	Sandy clay loam
120	Koduvally	6.5	0.010	1.80	113.25	128.10	100.0	60.0	Sandy clay loam

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
121	Purameni	4.5	0.023	0.48	41.40	32.10	48.0	30.0	Clay loam
122	Kunnamangalam	5.7	0.007	0.63	43.47	54.80	55.0	20.0	Sandy loam
123		5.6	0.013	1.23	40.25	38.62	88.0	43.0	Sandy loam
124		6.3	0.005	0.96	41.86	61.23	84.0	35.0	Sandy loam
125	Thiruvambadi	5.6	0.024	1.17	46.69	48.15	150.0	46.0	Clay
126		5.5	0.009	2.04	46.00	49.23	137.5	54.0	Sandy loam
127		5.4	0.150	0.96	97.75	82.03	75.0	32.0	Sand
128		6.7	0.160	0.96	52.90	53.75	54.0	23.0	Clay loam
129		5.7	0.017	0.84	26.91	18.89	63.0	24.0	Clay loam
130	Wynad	5.9	0.013	0.87	36.57	28.37	14.0	18.0	Loam
	<u>Malappuram</u>								
131	Kottakkal	5.6	0.007	0.96	14.03	15.18	212.0	80.0	Clay
132		5.6	0.031	0.81	34.50	60.95	150.0	66.0	Sandy clay loam
133		4.4	0.012	0.97	19.95	13.57	84.0	33.0	Clay
134	Mampad	5.9	0.005	0.81	94.30	123.05	34.0	13.0	Clay loam
135	Chungathara	4.5	0.023	1.89	77.05	80.50	237.5	83.0	Clay loam
136		5.7	0.016	1.47	19.32	25.99	125.0	64.0	Sandy clay loam
137	Manjery	5.8	0.029	0.99	23.46	14.95	212.5	77.0	Clay loam
138		5.6	0.012	0.42	35.42	15.98	98.0	46.0	Sandy clay
139		5.9	0.016	1.41	29.21	44.85	90.0	35.0	Sandy clay loam
140		6.0	0.008	3.41	43.70	43.70	250.0	100.0	Sandy clay loam

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
141	Manjery	5.5	0.012	1.56	73.60	117.60	150.0	64.0	Sandy clay loam
142		6.6	0.011	0.73	90.85	138.34	250.0	112.0	Clay
143	Valiyora	5.2	0.008	1.89	21.85	12.65	52.0	19.0	Clay loam
144		5.0	0.008	0.66	20.93	12.65	34.0	12.0	Sandy loam
145	Areakod	5.1	0.021	1.77	28.63	19.98	75.0	35.0	Sandy clay loam
146	Pommala	5.0	0.034	1.35	17.71	9.20	88.0	37.0	Sandy clay loam
147	Edappal	4.9	0.045	0.63	21.15	45.08	225.0	86.0	Sandy clay loam
148		5.3	0.007	0.96	39.10	39.21	76.0	29.0	Sandy clay loam
149	Pookottumpadam	5.4	0.010	2.04	13.24	9.20	44.0	16.0	Loam
150		5.1	0.016	0.78	32.66	47.15	86.0	32.0	Sandy loam
151	Edakkara	6.2	0.017	0.43	19.09	37.03	187.5	79.0	Sandy loam
152		5.4	0.008	0.48	81.65	102.35	162.5	50.0	Sandy clay loam
153		4.6	0.030	1.18	21.62	24.61	44.0	17.0	Sand
154	Edavannapara	6.5	0.007	0.39	98.90	135.70	92.0	50.0	Loam
155		5.8	0.021	1.29	40.71	81.65	200.0	86.0	Sandy clay loam
156		6.1	0.012	0.75	21.39	15.41	58.0	22.0	Sandy loam
157	Kalpakanchery	5.5	0.010	1.32	69.00	100.05	162.5	62.0	Sandy clay loam
158		5.3	0.009	1.38	62.10	96.60	162.5	62.0	Sandy clay loam
159		5.3	0.007	1.38	30.59	38.87	187.5	71.0	Sandy loam
160		5.7	0.020	1.17	80.50	96.60	94.0	44.0	Sandy loam

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
161	Thirurangadi	6.5	0.010	1.71	72.45	85.37	96.0	42.0	Sandy clay loam
162		5.8	0.009	1.04	89.70	76.41	85.0	33.0	Sandy clay loam
163	Morayur	5.6	0.016	0.30	21.39	15.41	58.0	22.0	Sandy clay loam
164		5.0	0.009	0.82	28.75	30.59	84.0	31.0	Sandy clay loam
165	Thavanoor	5.1	0.006	0.45	22.31	19.09	84.0	35.0	Sand
166		6.6	0.031	0.18	14.72	17.02	62.0	25.0	Sandy loam
167		4.5	0.030	0.99	14.72	20.47	65.0	24.0	Sandy loam
168	Maranchery	4.5	0.018	0.81	50.83	75.40	187.5	80.0	Sandy clay loam
169		5.0	0.020	0.70	21.16	18.86	88.0	37.0	Clay loam
170		5.1	0.008	1.30	29.67	50.60	64.0	25.0	Sandy clay loam
171		5.2	0.009	1.24	18.86	16.56	70.0	28.0	Sandy clay loam
	<u>Palghat</u>								
172	Alathur	6.4	0.023	1.19	26.22	27.14	137.5	55.0	Sandy clay loam
173		6.0	0.023	1.19	45.30	48.01	11.0	4.0	Sand
174		5.6	0.015	0.24	16.10	11.96	60.0	24.0	Clay loam
175		5.7	0.006	0.79	20.70	13.80	175.0	58.0	Clay loam
176		6.6	0.010	0.76	174.80	152.95	44.0	26.0	Sand
177		4.8	0.011	1.08	7.36	12.42	63.0	24.0	Loam
178		5.3	0.008	0.93	15.18	19.78	41.0	16.0	Sandy clay loam
179		5.3	0.016	0.86	11.50	19.55	90.0	42.0	Sandy loam
180		5.7	0.010	1.19	9.66	11.73	88.0	31.0	Sandy clay loam

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
181	Agali	5.5	0.005	1.54	18.86	13.11	38.0	16.0	Clay loam
182	Chittoor	5.4	0.043	1.33	14.72	19.32	62.0	24.0	Loam
183		7.3	0.020	0.82	18.63	27.37	80.0	35.0	Sandy clay loam
184		7.2	0.015	0.61	62.10	52.90	77.0	35.0	Sandy clay loam
185		5.4	0.008	1.13	31.51	51.29	78.0	30.0	Sandy clay loam
186		7.1	0.032	1.88	64.40	78.20	250.0	87.0	Sandy clay loam
187		6.2	0.013	0.93	11.50	21.85	225.0	84.0	Sandy clay loam
188	Cherpulachery	5.6	0.026	0.82	20.01	14.49	162.5	57.0	Sandy clay loam
189		5.6	0.014	0.76	18.17	12.65	150.0	46.0	Sandy clay loam
190		6.1	0.015	0.99	13.80	31.74	200.0	74.0	Sandy clay loam
191		6.2	0.015	0.84	20.70	40.48	225.0	84.0	Sandy loam
192	Pattambi	6.3	0.055	0.38	62.10	69.00	212.5	78.0	Sand
193	Rajapuram	5.2	0.030	0.96	15.87	10.81	88.0	42.0	Sand
194	Koodallur	6.2	0.010	0.44	25.76	40.48	67.0	34.0	Loam
195		5.5	0.018	0.44	19.55	36.11	47.0	25.0	Loam
196	Koppam	4.1	0.009	1.59	45.77	13.11	375.0	147.0	Clay
197		5.3	0.010	0.86	25.99	42.78	100.0	43.0	Sand
198		4.7	0.024	1.85	15.41	26.91	69.0	26.0	Sandy clay loam
199		7.1	0.011	0.64	119.60	136.85	90.0	39.0	Loam
200	Mannarghat	7.1	0.017	0.44	6.67	5.80	72.0	36.0	Sand
201		6.0	0.006	0.73	7.59	13.57	125.0	42.0	Sand

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
	<u>Trichur</u>								
202	Kadukutty	5.2	0.016	0.96	29.67	22.00	70.0	26.0	Sandy loam
203		5.0	0.027	1.13	39.79	48.07	75.0	36.0	Sandy clay loam
204		5.5	0.007	0.93	77.94	23.00	74.0	16.0	Loam
205		5.1	0.010	1.08	32.20	34.96	76.0	36.0	Sandy clay loam
206		4.6	0.017	1.13	20.93	23.46	86.0	44.0	Sand
207		4.7	0.010	0.93	43.47	55.89	75.0	36.0	Sand
208		5.8	0.011	0.93	29.21	54.51	98.0	48.0	Sandy clay loam
209	Kadavallur	6.3	0.023	1.98	7.36	9.20	275.0	100.0	Clay loam
210		6.2	0.017	1.44	17.94	40.71	225.0	79.0	Clay loam
211		6.0	0.015	1.26	8.28	6.90	137.5	59.0	Clay loam
212		5.9	0.050	1.02	9.89	7.13	175.0	76.0	Sandy loam
213	Padiyur	4.0	0.110	0.39	36.80	33.35	35.0	19.0	Sandy loam
214		5.6	0.011	1.14	27.84	24.61	225.0	90.0	Sandy loam
215		6.0	0.025	0.66	88.55	131.10	62.0	30.0	Sand
216		6.5	0.010	0.87	37.03	37.04	72.0	32.0	Sandy clay loam
217		4.0	0.100	0.44	34.50	63.71	32.0	23.0	Sandy loam
218	Cherpu	5.2	0.037	2.13	28.06	43.70	65.0	29.0	Sandy loam
219		5.2	0.028	1.82	27.37	28.06	46.0	18.0	Loamy sand
220		5.2	0.032	2.34	30.86	69.00	72.0	22.0	Sandy clay loam

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
221	Cherpu	5.1	0.039	1.77	31.74	54.28	68.0	13.0	Sandy loam
222		4.8	0.007	1.13	10.58	10.58	26.0	11.0	Sandy loam
223		5.3	0.008	1.74	21.85	19.55	54.0	14.0	Sandy loam
224	Mattathur	5.4	0.014	1.71	14.03	13.57	94.0	54.0	Sand
225		5.5	0.013	1.19	29.44	41.86	125.0	56.0	Sandy clay loam
226		5.1	0.008	0.97	14.72	27.83	38.0	20.0	Sandy clay loam
227		5.3	0.015	0.97	48.07	57.27	100.00	58.0	Sand
228		5.6	0.007	1.26	25.76	25.76	18.0	13.0	Sandy clay loam
229	Kodungalloor	6.9	0.010	2.49	171.35	228.85	40.0	24.0	Sand
230		6.2	0.006	0.48	10.35	8.28	17.0	9.0	Sand
231		6.2	0.004	0.42	77.05	109.24	16.0	8.0	Sand
232		6.2	0.020	1.74	86.25	115.00	98.0	48.0	Sandy clay loam
233		4.5	0.100	1.45	45.69	37.20	40.0	16.0	Sandy loam
234		6.1	0.013	1.28	67.85	67.39	98.0	34.0	Sandy loam
235		6.9	0.010	0.53	50.60	74.75	62.0	38.0	Sand
236		5.8	0.009	1.31	45.31	71.76	187.5	78.0	Clay loam
237	Vattanapilly	6.5	0.006	0.27	50.60	94.30	10.0	6.0	Sand
238		6.2	0.007	2.05	34.50	49.45	70.0	19.0	Sandy loam
239		5.4	0.010	0.93	44.85	300.15	175.0	260.0	Sandy loam
240		6.7	0.006	0.79	44.60	54.51	43.0	24.0	Loam

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
241	Vattanapilly	6.2	0.007	2.00	173.65	220.08	75.0	40.0	Sand
242		7.0	0.016	0.82	37.95	52.21	28.0	16.0	Sandy clay loam
243		7.2	0.022	0.59	43.47	70.61	30.0	19.0	Sandy clay loam
244		5.5	0.008	0.99	30.82	38.05	66.0	14.0	Sandy loam
245	Parappukkara	5.0	0.029	1.74	11.73	43.70	63.0	28.0	Sandy loam
246		5.3	0.016	1.31	41.86	59.57	89.0	33.0	Clay loam
247		6.5	0.013	1.13	30.59	42.09	58.0	18.0	Sandy loam
248		5.3	0.006	1.10	92.00	72.45	94.0	43.0	Sand
249		5.3	0.014	0.84	45.77	59.57	112.5	54.0	Sand
250		5.7	0.011	1.28	9.89	31.51	60.0	30.0	Clay loam
	<u>Ernakulam</u>								
251	Ankamali	5.5	0.028	0.90	58.65	52.33	116.0	33.0	Sandy clay loam
252		5.8	0.020	0.78	31.05	23.00	152.0	46.0	Clay
253		5.8	0.008	0.42	33.93	23.00	64.0	16.0	Sandy clay loam
254		5.2	0.014	0.84	56.93	61.53	74.0	19.0	Sandy clay loam
255		5.6	0.036	0.45	59.23	58.65	98.0	36.0	Sandy clay loam
256		4.7	0.022	0.84	43.70	59.23	96.0	24.0	Clay
257		4.8	0.013	1.20	31.63	10.35	146.0	56.0	Clay
258	Tripunithara	6.1	0.030	0.42	248.40	269.10	156.0	54.0	Sandy loam
259		7.1	0.029	0.39	370.30	441.60	154.0	47.0	Sandy loam
260		6.9	0.016	1.05	264.50	303.60	132.0	56.0	Sandy clay loam

Table 1.(Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH$_4$OAc K (ppm)	Triacid K (ppm)	Textural class
261	Tripunithara	6.2	0.086	1.23	110.40	141.20	140.0	49.0	Sandy clay loam
262		5.8	0.016	0.12	88.55	128.23	68.0	16.0	Sandy clay loam
263	Choornikkara	5.4	0.012	0.72	84.53	98.90	98.0	26.0	Sandy loam
264		4.6	0.220	1.05	35.65	22.43	98.0	40.0	Sandy clay loam
265		6.8	0.100	1.20	66.13	72.45	164.0	54.0	Clay
266		6.5	0.061	0.81	75.90	89.13	88.0	21.0	Clay
267		6.1	0.032	1.50	52.90	52.33	33.0	12.0	Clay
268	Alwaye	5.2	0.022	1.32	85.10	87.40	172.0	54.0	Sandy clay loam
269		5.2	0.053	0.84	37.95	43.13	148.0	58.0	Sand
270		6.0	0.018	1.83	35.08	58.08	160.0	68.0	Sandy clay loam
271		5.1	0.026	0.84	33.93	23.58	142.0	54.0	Sandy clay loam
272		5.7	0.013	1.14	77.63	68.43	72.0	20.0	Sandy clay loam
273		4.3	0.140	2.22	28.18	21.85	164.0	60.0	Clay
274		5.0	0.024	1.71	39.10	48.30	150.0	55.0	Clay
275		5.1	0.019	1.14	35.08	39.68	132.0	50.0	Sandy clay loam
276	Sree Moolanagaram	5.7	0.017	0.54	42.55	54.05	198.0	73.0	Sandy clay loam
277		6.2	0.016	1.50	53.48	66.70	114.0	32.0	Clay
278		5.4	0.009	0.90	36.23	31.05	80.0	23.0	Sandy clay loam
279		4.6	0.004	1.02	40.83	46.58	202.0	65.0	Sandy clay loam
280		5.4	0.038	1.47	44.28	80.50	124.0	40.0	Clay

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
281	Sree Moolanagaram	5.3	0.017	1.02	32.20	25.30	160.0	62.0	Sandy clay loam
282		7.7	0.049	1.52	49.45	44.85	144.0	52.0	Sand
283		4.7	0.013	1.55	96.60	97.75	64.0	42.0	Clay
284	Muvattupuzha	5.6	0.120	1.65	47.15	58.65	88.0	40.0	Sandy clay loam
285		4.5	0.096	1.39	36.80	29.90	42.0	26.0	Sandy clay loam
286		4.6	0.160	1.05	69.00	28.75	34.0	13.0	Sandy loam
287		5.4	0.019	1.35	98.90	63.25	100.0	48.0	Sandy clay loam
288	Kalamassery	7.5	0.024	1.85	112.13	130.20	26.0	10.0	Sandy clay loam
289		4.7	0.015	1.56	61.53	72.45	104.0	32.0	Clay
290		7.3	0.014	1.25	98.90	120.18	86.0	42.0	Sand
291		5.5	0.310	3.44	358.80	462.50	134.0	68.0	Sand
292	Palluruthy	7.6	0.027	1.20	121.33	99.00	192.0	90.0	Clay
293		7.3	0.034	0.66	48.30	87.98	84.0	29.0	Clay
294		3.8	0.350	2.22	26.45	48.88	128.0	67.0	Sandy loam
295		4.4	0.110	2.22	33.35	43.13	136.0	66.0	Sandy clay loam
296		2.8	1.000	3.45	13.80	12.65	20.0	16.0	Sand
297		2.9	0.770	3.51	19.55	15.53	16.0	23.0	Sand
298	Anchalpetty	5.6	0.015	1.26	39.68	34.50	168.0	60.0	Clay
299		5.1	0.011	1.36	34.50	21.85	148.0	54.0	Sandy clay loam
300		5.7	0.008	1.08	37.38	54.63	176.0	66.0	Clay

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
301	Kothamangalam	5.1	0.015	2.00	25.30	2.88	120.0	45.0	Sand
302		6.3	0.016	1.97	63.83	107.58	66.0	20.0	Sandy loam
303		5.0	0.120	1.35	46.00	25.30	92.0	50.0	Sandy loam
304		7.2	0.017	0.46	358.80	399.05	52.0	42.0	Sand
305		5.3	0.015	1.01	108.10	106.38	126.0	67.0	Sandy clay loam
306		5.6	0.021	0.77	111.55	128.23	98.0	42.0	Sand
	<u>Idukki</u>								
307	Vannapuram	6.7	0.016	2.24	52.90	62.10	162.5	55.0	Sandy loam
308		6.3	0.012	2.43	56.93	75.90	137.5	66.0	Sand
309		5.9	0.023	1.91	17.80	20.79	54.0	28.0	Sandy loam
310		6.5	0.014	1.88	48.30	55.78	150.0	62.0	Sand
311	Vathukudy	6.3	0.005	1.16	49.45	75.90	162.5	53.0	Sandy loam
312	Cheenikushi	5.6	0.007	1.28	1 .73	5.18	137.5	48.0	Clay loam
313		6.5	0.010	1.22	4.03	53.48	150.0	55.0	Clay loam
314	Muttom	5.5	0.006	2.52	50.60	94.30	94.0	36.0	Clay loam
315		5.6	0.005	1.45	0.46	1.73	100.0	36.0	Clay loam
316	Kodikulam	5.2	0.013	3.09	33.35	25.30	70.0	37.0	Sand
317		5.1	0.009	1.64	9.20	21.03	90.0	37.0	Clay loam
318	Karimannur	5.4	0.009	1.59	2.30	3.45	58.0	29.0	Clay loam
319		5.3	0.005	1.94	1.15	2.88	42.0	24.0	Sand
320		5.4	0.010	1.71	6.33	6.33	76.0	26.0	Sandy clay loam

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
321	Atakulam	5.2	0.009	3.32	1.73	3.45	97.0	46.0	Sandy clay loam
322		5.2	0.006	3.09	40.25	28.75	162.5	52.0	Sandy clay loam
323	Marykulam	5.4	0.013	2.03	18.98	14.38	162.5	78.0	Sandy clay loam
324		4.7	0.012	1.19	14.38	20.70	137.5	61.0	Sandy clay loam
325	Nedumkondam	5.6	0.015	1.25	32.78	23.00	90.0	36.0	Sand
326		5.3	0.024	1.20	51.75	35.65	150.0	44.0	Sand
327		5.3	0.022	1.16	60.95	33.93	137.5	44.0	Sand
328	Karimkunnam	5.6	0.007	1.94	23.58	16.68	175.0	89.0	Clay loam
329	Kumaramangalam	5.5	0.013	2.14	4.60	8.63	76.0	23.0	Sandy loam
330		5.7	0.004	1.25	48.30	38.53	32.0	26.0	Sandy clay loam
331	Alakode	6.4	0.056	2.28	56.35	56.35	162.5	68.0	Sandy clay loam
332	Kottayam Vaikom	5.6	0.016	0.53	37.95	63.25	137.5	72.0	Sand
333		6.1	0.019	1.68	40.25	32.60	150.0	80.0	Sand
334		5.6	0.017	0.50	15.75	12.65	150.0	73.0	Sand
335	Erumely	5.5	0.009	2.40	5.75	2.88	150.0	63.0	Clay loam
336		5.5	0.010	1.80	8.63	5.18	212.5	85.0	Clay loam
338	Marangoli	5.6	0.004	1.56	13.80	9.78	69.0	35.0	Clay loam
338	Chempu	7.1	0.030	0.71	36.20	54.05	112.5	62.0	Clay loam
339		6.4	0.017	0.68	115.00	161.00	71.0	48.0	Sand
340		4.4	0.036	0.65	115.00	141.20	89.0	47.0	Sand

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
341	Chempu	4.4	0.036	0.65	115.00	141.00	89.00	47.00	Sand
342		6.2	0.013	1.32	44.28	74.18	100.00	63.0	Sandy loam
343		5.1	0.018	1.08	8.05	10.93	125.0	65.0	Clay loam
344		6.3	0.075	2.97	120.75	94.63	300.0	144.0	Sand
345	Bharananganam	5.3	0.028	1.95	9.20	6.33	186.5	82.0	Sandy clay loam
346		5.4	0.260	2.07	10.35	6.33	175.0	70.0	Sandy clay loam
347		6.0	0.011	1.29	5.75	8.05	150.0	76.0	Sandy clay loam
348		6.4	0.030	2.55	31.63	40.25	350.0	148.0	Sandy clay loam
349		5.2	0.015	1.83	253.00	275.62	137.5	71.0	Sandy clay loam
350		5.6	0.019	1.93	19.55	16.63	162.5	71.0	Sandy clay loam
351	Uzhavoor	5.0	0.038	1.95	20.13	21.28	84.0	48.0	Sandy clay loam
352		6.5	0.017	1.23	43.70	34.50	250.0	104.0	Sandy clay loam
353	Arpookara	5.2	0.014	0.63	5.75	10.35	88.0	45.0	Sandy clay loam
354	Mulakkulam	4.9	0.017	0.86	25.30	50.03	37.0	30.0	Sandy clay loam
355		5.8	0.010	1.44	70.15	86.25	125.0	62.0	Sandy loam
356		7.2	0.047	1.26	25.88	48.30	225.0	86.0	Clay loam
357		5.1	0.010	1.53	8.63	10.93	95.0	52.0	Clay loam
358		5.3	0.014	2.28	43.70	47.73	65.0	41.0	Sandy loam
359	Kiolangoor	5.1	0.032	2.28	43.70	47.73	63.0	39.0	Sandy loam
360	Kangazha	5.5	0.004	2.61	7.48	5.75	66.0	39.0	Clay loam

ntd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
361	Kangazha	5.5	0.004	2.33	22.43	14.38	187.50	81.0	Sandy loam
362		5.8	0.090	1.93	7.48	5.75	162.50	70.0	Sand
363		5.4	0.020	2.31	34.50	92.00	125.00	74.0	Sand
364		5.5	0.012	2.13	22.43	48.88	325.0	126.0	Clay loam
365		5.5	0.012	2.37	12.60	24.73	225.0	89.0	Sand
366		5.7	0.012	1.92	6.90	12.08	250.0	116.0	Clay loam
367		5.5	0.029	2.07	57.50	69.41	187.5	99.0	Clay loam
368		5.4	0.053	2.17	20.70	11.50	225.0	100.0	Clay loam
369		5.6	0.013	1.83	304.75	288.95	125.0	62.0	Sandy clay loam
370		5.6	0.008	1.60	21.85	13.80	300.0	122.0	Sandy clay loam
371		5.9	0.018	2.01	40.25	114.43	300.0	124.0	Sand
372		5.7	0.022	2.35	18.98	13.80	162.5	72.0	Sand
373		5.7	0.007	2.20	44.85	33.93	162.5	88.0	Clay loam
374	Palai	5.5	0.015	1.59	8.63	5.75	48.0	26.0	Clay loam
375		6.6	0.013	2.47	58.65	110.40	250.0	102.0	Sandy clay loam
	<u>Alleppey</u>								
376	Kavalam	5.3	0.012	1.80	11.50	22.54	79.0	38.0	Sandy loam
377		5.2	0.027	1.47	11.27	10.12	72.0	46.0	Sand
378		5.1	0.028	1.71	10.12	9.89	70.0	40.0	Sandy loam
379		3.8	0.180	1.44	6.67	13.57	36.0	26.0	Sand
380		5.4	0.020	1.68	21.16	20.24	68.0	44.0	Sandy loam

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
381	Kavalam	4.6	0.064	2.16	22.08	17.71	125.0	64.0	Sandy loam
382		5.2	0.021	1.68	24.61	21.85	75.0	50.0	Sandy loam
383		5.5	0.011	1.42	23.69	19.55	61.0	48.0	Sandy loam
384		5.3	0.016	1.65	20.01	14.95	70.0	39.0	Sandy loam
385		5.3	0.016	1.62	22.77	17.71	75.0	75.0	Sandy loam
386		4.6	0.056	2.22	11.27	10.81	162.5	58.0	Sandy loam
387		5.4	0.014	1.59	16.79	12.19	59.0	34.0	Sandy loam
388		5.2	0.012	1.59	22.54	15.18	72.0	40.0	Sandy loam
389		5.3	0.017	1.53	20.24	23.23	69.0	37.0	Sandy loam
390		5.5	0.010	1.50	8.51	8.28	65.0	32.0	Sandy loam
391	Thiruvalla	3.7	0.290	2.04	5.75	2.99	99.0	55.0	Sand
392		5.4	0.036	1.95	20.24	35.19	162.5	68.0	Clay
393		4.3	0.023	1.65	8.05	7.82	58.0	38.0	Sandy loam
394		5.6	0.020	1.65	9.66	6.21	64.0	44.0	Sandy loam
395		8.2	0.022	0.23	32.20	37.95	28.0	26.0	Sandy loam
396		5.3	0.015	1.17	16.56	16.10	34.0	24.0	Sand
397		5.5	0.010	1.20	47.15	50.60	237.5	92.0	Sand
398		5.5	0.016	1.50	37.26	30.82	175.0	90.0	Sand
399		5.2	0.031	1.50	23.46	18.63	79.0	41.0	Sand
400		5.7	0.014	0.78	14.95	18.86	212.5	84.0	Sand

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
401	Thiruvalla	5.3	0.074	1.83	21.85	34.27	200.0	80.0	Sandy clay loam
402		5.7	0.012	1.86	32.66	31.05	175.0	63.0	Sandy clay loam
403		8.1	0.040	0.23	37.03	46.00	34.0	30.0	Sand
404	Shertallai	6.3	0.010	0.93	45.77	63.21	28.0	32.0	Sand
405		6.2	0.022	0.59	20.01	17.48	58.0	40.0	Sand
406		5.8	0.015	0.45	23.92	29.90	24.0	18.0	Sand
407		8.2	0.007	0.33	21.39	33.81	27.0	26.0	Sand
408		6.3	0.005	2.28	17.02	42.32	25.0	12.0	Sand
409		5.8	0.013	0.48	55.52	11.50	80.0	39.0	Sand
410		6.2	0.023	0.56	11.50	25.53	15.0	7.0	Sand
411		8.1	0.039	0.42	19.55	43.01	26.0	14.0	Sand
412		5.3	0.027	0.75	7.59	5.29	21.0	10.0	Sand
413		4.7	0.054	0.04	8.51	21.62	14.0	6.0	Sand
414		5.8	0.061	0.69	8.05	7.13	27.0	13.0	Sand
415		8.1	0.012	0.39	15.64	26.22	26.0	14.0	Sand
416		7.9	0.100	0.36	31.51	30.82	24.0	14.0	Sand
417		5.2	0.034	0.99	9.89	14.26	84.0	38.0	Sand
418		5.9	0.017	0.54	18.40	16.79	25.0	13.0	Sand
419		5.9	0.017	1.41	17.02	20.70	50.0	27.0	Sand
420		8.0	0.006	0.39	14.26	19.32	23.0	15.0	Sand

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
421	Mavelikkara	5.1	0.011	1.62	21.16	15.18	70.0	38.0	Sand
422		5.1	0.012	1.62	21.16	15.18	70.0	38.0	Sand
423		3.7	0.030	1.74	3.91	4.14	29.0	12.0	Sandy loam
424		5.2	0.019	1.71	18.86	11.27	58.0	30.0	Sandy loam
425		4.0	0.006	2.05	5.75	8.05	64.0	29.0	Sandy loam
426		3.6	0.027	2.02	1.38	5.06	20.0	9.0	Sand
427		3.6	0.003	1.80	0.92	3.45	38.0	17.0	Sand
428		3.6	0.029	1.91	1.61	3.91	31.0	16.0	Sandy loam
429		5.1	0.023	1.12	17.71	21.39	40.0	12.0	Sandy loam
430		6.2	0.018	1.74	27.37	36.11	100.0	57.0	Sandy loam
431		5.3	0.007	0.54	28.06	31.51	34.0	19.0	Sandy loam
432		5.8	0.011	1.43	4.60	15.41	46.0	18.0	Sandy loam
	<u>Pathanamthitta</u>								
433	Adoor	5.0	0.004	1.45	8.63	4.60	87.5	66.0	Sandy loam
434	Mannady	5.4	0.017	1.27	12.65	15.53	87.5	55.0	Sandy clay loam
435		5.4	0.011	1.19	14.38	17.83	82.5	57.0	Sandy clay loam
436		5.4	0.006	1.19	13.80	18.40	100.0	76.0	Sandy clay loam
	<u>Quilon</u>								
437	Perumkulam	6.7	0.005	0.96	100.63	101.78	125.0	44.0	Sand
438		7.4	0.007	1.01	18.40	25.88	200.0	82.0	Sandy clay loam
439	Poovattur	5.4	0.005	1.40	10.35	8.05	125.0	43.0	Sandy loam
440		5.1	0.017	2.33	13.23	9.78	96.0	45.0	Sandy loam

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH$_4$OAc K (ppm)	Triacid K (ppm)	Textural class
441	Poovattur	6.2	0.005	0.57	25.30	11.50	37.5	33.0	Sandy loam
442		5.6	0.006	1.86	19.98	43.70	125.0	60.0	Sandy clay loam
443		5.9	0.018	1.48	14.95	21.85	162.5	75.0	Sandy clay loam
444		5.5	0.023	1.12	19.55	38.53	87.5	47.0	Sandy loam
445	Pathanapuram	4.7	0.006	1.97	12.65	18.40	225.0	104.0	Sandy loam
446		4.8	0.010	2.34	8.63	19.55	137.5	77.0	Sandy clay loam
447		4.4	0.017	1.98	10.35	24.15	212.5	108.0	Sandy clay loam
448		4.5	0.017	1.94	9.20	21.85	200.0	24.0	Sandy clay loam
449		4.5	0.210	1.91	9.20	22.43	218.0	100.0	Sandy clay loam
450		4.5	0.017	2.20	9.78	20.70	212.5	100.0	Sandy clay loam
451		4.6	0.110	1.93	9.20	22.43	212.5	100.0	Sandy clay loam
452		4.6	0.200	1.94	10.35	23.00	212.5	100.0	Sandy clay loam
453		4.5	0.180	1.94	8.63	22.43	225.0	99.6	Sandy clay loam
454		4.5	0.170	1.20	9.20	20.13	212.5	98.0	Sandy clay loam
455	Chedayamangalam	5.5	0.009	1.77	10.60	14.60	137.5	68.0	Sandy clay loam
456		5.5	0.018	1.66	4.60	4.60	312.5	125.0	Sandy clay loam
457		5.0	0.005	2.23	11.50	14.50	312.5	125.0	Sandy clay loam
458		5.2	0.011	1.98	9.20	9.20	250.0	102.0	Sandy clay loam
459		5.7	0.030	1.78	5.75	6.80	262.5	116.0	Clay
460		5.3	0.009	1.47	6.33	9.88	100.0	63.0	Clay

Table 1 (Contd.)

Sl. No. 6	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
461	Punalur	5.5	0.009	1.99	6.33	13.80	187.5	84.0	Clay
462		5.2	0.008	1.85	6.90	17.83	52.0	42.0	Clay
463		5.1	0.019	1.96	5.75	12.65	88.0	55.0	Clay
464		5.2	0.037	0.94	6.90	9.20	44.0	20.0	Clay
465		5.8	0.022	1.65	5.75	9.78	46.0	35.0	Clay
466		5.7	0.023	1.77	6.90	14.95	137.5	72.0	Clay
467		5.2	0.009	0.96	6.90	12.08	46.0	31.0	Clay
468	Kundara	5.6	0.036	1.26	39.10	51.18	125.0	70.0	Clay
469		5.7	0.043	0.95	55.20	76.48	150.0	76.0	Sand
470		7.5	0.025	0.55	60.38	72.40	312.5	154.0	Sandy loam
471		6.2	0.040	0.44	8.63	10.35	73.0	32.0	Sand
472		8.8	0.033	0.96	48.88	78.20	286.0	104.0	Clay
473		5.7	0.051	0.74	37.38	41.98	175.0	83.0	Clay
474	Pooyapally	5.6	0.046	1.23	4.60	8.63	137.5	66.0	Clay
475		5.3	0.052	1.46	5.75	12.08	38.0	36.0	Clay loam
476		5.5	0.047	0.81	5.18	9.20	71.0	52.0	Clay
477		5.5	0.051	1.17	5.17	10.93	90.0	60.0	Clay
478		5.6	0.040	1.19	5.75	10.35	90.0	58.0	Clay
479		5.4	0.046	1.13	6.90	11.50	187.5	90.0	Clay
480		5.6	0.052	1.55	9.78	13.23	100.0	64.0	Clay

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
481	Pooyapally	5.5	0.006	0.79	5.18	8.05	74.0	48.0	Clay
	<u>Trivandrum</u>								
482	Kottukal	6.7	0.009	1.01	37.95	52.90	80.0	56.0	Sandy loam
483		5.4	0.019	1.04	20.70	26.45	67.0	47.0	Sandy clay loam
484		5.6	0.007	1.15	19.55	27.03	48.0	40.0	Sandy clay loam
485		6.4	0.015	1.17	32.20	38.53	79.0	53.0	Sandy loam
486		6.2	0.022	1.61	40.25	52.33	175.0	76.0	Clay loam
487		5.2	0.004	0.98	17.25	27.03	35.0	32.0	Clay loam
488		4.7	0.012	0.89	20.70	29.90	36.0	36.0	Clay loam
489		5.4	0.004	0.89	13.80	31.05	36.0	29.0	Clay loam
490		5.3	0.009	0.29	14.95	26.45	82.0	52.0	Clay loam
491		5.3	0.012	1.14	21.85	29.33	46.0	35.0	Clay loam
492		5.8	0.030	0.71	21.85	43.70	150.0	74.0	Sandy loam
493	Vellanadu	5.9	0.009	0.32	50.60	33.35	28.0	33.0	Clay loam
494		4.8	0.130	2.07	16.10	40.83	175.0	81.0	Clay loam
495		5.1	0.200	1.94	18.40	39.10	225.0	82.0	Clay loam
496		5.3	0.055	1.99	20.70	52.90	212.0	91.0	Clay loam
497		5.7	0.007	0.78	17.25	27.03	28.0	24.0	Clay loam
498		5.6	0.006	0.92	13.80	29.90	39.0	36.0	Clay loam
499		5.5	0.004	0.54	19.55	27.03	26.0	30.0	Clay loam
500		5.1	0.010	2.60	23.00	39.10	84.0	38.0	Clay loam

Table 1 (Contd.)

Sl. No.	Location	pH	EC (S/m)	Organic C (%)	Bray-1 P (ppm)	Triacid P (ppm)	NH_4OAc K (ppm)	Triacid K (ppm)	Textural class
501	Vellanadu	4.7	0.006	0.14	20.70	31.05	51.0	39.0	Sandy clay loam
502		4.5	0.006	1.02	19.55	27.03	42.0	31.0	Clay
503		4.3	0.019	0.23	21.85	27.60	200.0	72.0	Clay
504		4.5	0.023	0.28	23.00	37.95	200.0	76.0	Clay loam
505		5.6	0.022	2.04	38.41	37.26	162.5	76.0	Clay loam
506		4.9	0.022	1.11	40.25	38.24	125.0	65.0	Clay loam
507	Vengenoor	6.7	0.065	2.49	74.75	123.63	225.0	116.0	Sand
508		6.0	0.033	0.62	9.78	11.50	150.0	82.0	Clay loam
509		5.7	0.025	2.22	37.38	31.05	164.0	60.0	Clay
510		5.8	0.021	1.22	142.60	191.04	54.0	22.0	Sandy clay loam
511		5.4	0.012	0.64	4.37	10.81	62.0	24.0	Loam
Mean		5.5	0.032	1.34	36.82	42.38	105.23	46.45	
Range		2.8-	0.004-	0.04-	0.46-	1.73-	10.0-	4.0-	
		8.2	1 .000	4.41	370.30	462.50	425.0	154.0	

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Table 2. Relationships between physico-chemical properties of soils (n = 511)

Soil properties		Coefficient of correlation (r)	Regression equation
(x)	(y)		
EC	pH	-0.2994**	$y = -0.3131x + 5.639$
Organic C		-0.2353**	$y = -0.2301x + 5.845$
Bray-1 P		0.2697**	$y = 0.0050x + 5.363$
Triacid P		0.3047**	$y = 0.0046x + 5.343$
Triacid K		0.06047*	$y = 0.0016x + 5.463$
*Δ P		-0.2293**	$y = -0.0113x + 5.475$
Organic C	EC	0.2505**	$y = 0.2338x + 0.009$
NH_4OAc K	Organic C	0.2411**	$y = 0.0025x + 1.071$
Triacid K		0.2214**	$y = 0.0066x + 1.032$
*Δ K		0.1934**	$y = 0.0035x + 1.131$
Bray-1 P	Triacid P	0.9575**	$y = 1.1921x - 2.060$
*Δ P		-0.3283**	$y = -0.0918x + 31.74$
NH_4OAc K	Triacid P	0.0715*	$y = 0.0788x + 37.74$
Triacid K		0.0683*	$y = 0.1206x + 36.77$
Δ K		0.0670*	$y = 0.0626x + 34.72$
Δ P		-0.5802**	$y = 1.8972x + 31.90$
NH_4OAc K	Triacid K	0.9235**	$y = 0.4492x - 3.062$
Δ K		0.9704**	$y = 1.5380x + 14.69$
Δ P		-0.1222**	$y = -0.5384x + 102.2$
Δ K	Δ P	-0.0943*	$y = -0.2624x + 57.41$

*Δ P = Triacid P - Bray-1 P

*Δ K = NH_4OAc K - Triacid K

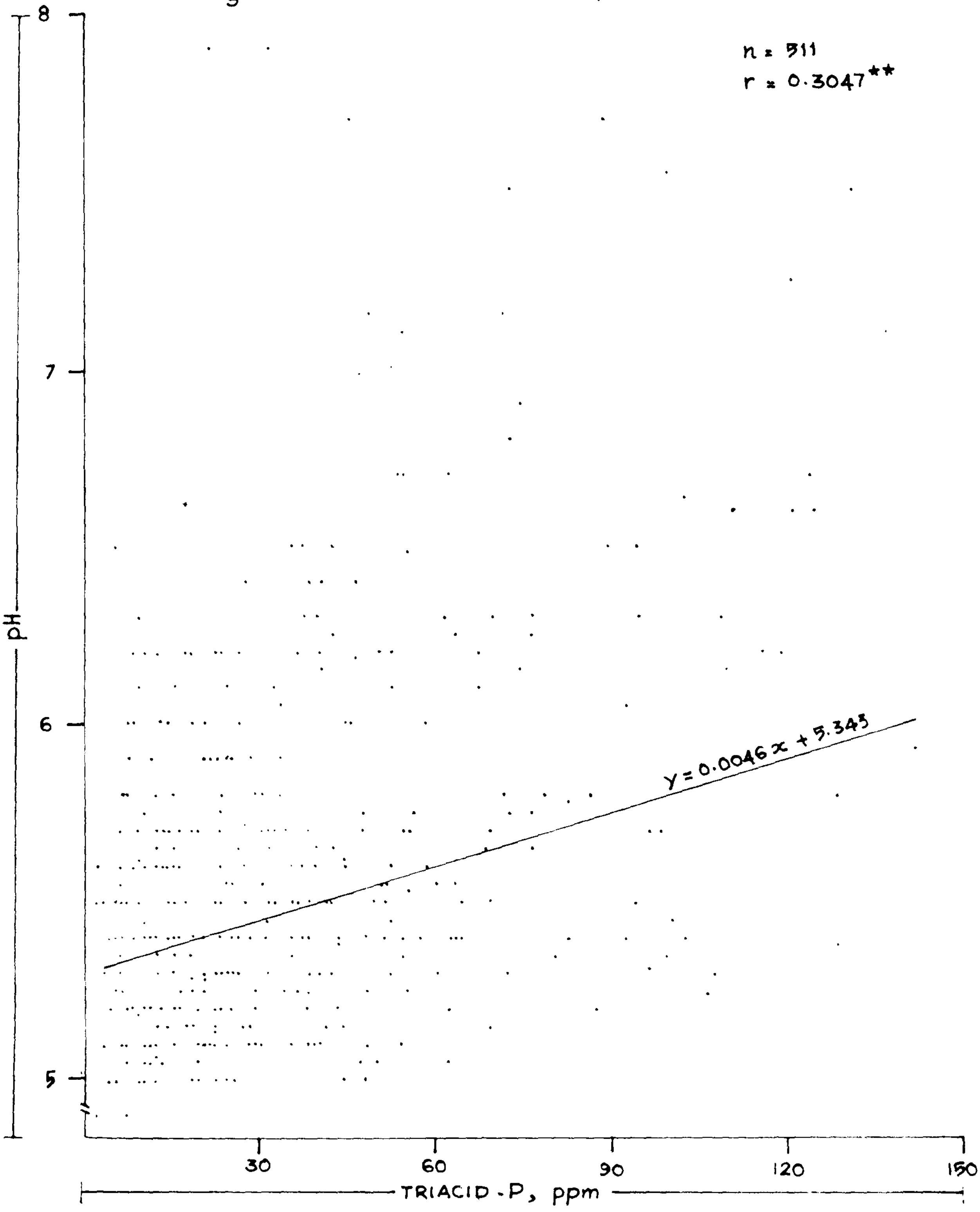
* Significant at 5% level

** Significant at 1% level

laterite, red loam, forest, coastal alluvium, riverine alluvium, brown hydromorphic, hydromorphic saline, acid saline and black soils. However, the characteristics of the soil groups, as such, are not considered in this investigation. The pH of the soil ranged from 2.8 to 8.2. In general, the soils of Kerala are acidic in nature except the neutral to weakly alkaline black cotton soil of Chittoor thaluk. Consequently, the mean pH of the soil collected for the study was 5.5. Most of the soils under investigation were non-saline and acidic in nature and therefore in most of the cases the electrical conductivity of the soil was either the contribution of H^+ ions or ions which became preponderant under the influence of increasing acidity. This was evidenced by the significant negative correlation ($r = -0.2994^{**}$) exhibited between pH and the electrical conductivity of the soil. The pH of the soil was also found to be negatively correlated with the content of organic matter in the soil ($r = -0.2353^{**}$). The contribution of organic acids towards soil acidity is two fold. Organic acids evolved as a result of decomposition of organic matter is a potential source of soil acidity. Moreover, the high cation exchange and buffering capacities of soil organic matter contribute to high reserve acidity under acidic soil conditions. A significant positive correlation existed between the available P content and pH of the soil irrespective of the extractant used for the estimation of available P. When the coefficient of linear correlation between pH and Bray-1 P was 0.2697** that between pH and triacid P was 0.3047**. The relationship between pH and triacid P is graphically represented in Fig.1. It is well established that the maximum availability of P in soil takes place at the neutral range, the availability being markedly reduced with increasing acidity of the soil due to the formation of insoluble Fe and Al phosphates. When the difference between the amount of P extracted by triacid and that by the Bray-1 P was worked out (△P) for the various soils, it was observed that this difference increased with increasing acidity of soil (r = -0.2293**). This may be attributed to the relatively higher efficiency of the triacid extractant to extract P from the soil presumably due its higher acid strength.

In general, the soils were non-saline, EC varying from 0.004 to 1.000 S/m with a mean of 0.032 S/m. As already mentioned, the EC of soil was significantly correlated with the acidity of the soil. The EC was also found to be correlated with the organic carbon (r = 0.2505**). The increased content of organic matter in soil causes increase

Fig-1 RELATIONSHIP BETWEEN pH AND TRIACID-P



in soil acidity which in turn causes an increase in EC of the soil. The significant negative correlation between pH and organic carbon strengthens the possibility of this indirect effect of organic matter in increasing the EC of acid soils.

Organic carbon content of the soil ranged from 0.04 per cent to 4.41 per cent with a mean value of 1.14 per cent. The soils were, in general, rich in organic matter. According to the fertility rating followed for the Kerala soils, a value of 0.3 per cent organic carbon in sandy soil and 0.5 per cent for clay or loam are considered to be the critical values to receive 100 per cent of the fertilizer recommendation with respect to N. Only twelve soils used for the study were below these critical values. A significant positive correlation was observed between the content of organic carbon and available K extracted by both the extractants (Table 2). This indicated that the soil organic matter significantly contributed to the pool of available K in soil but such a correlation was not observed in the case of available P. It is possible that the P released by mineralisation of organic matter is not held in available forms due to increased P fixation resulting from the increased acidity from soil.

Available phosphorus

The available P extracted by Bray 1 ranged from 0.46 to 370.30 ppm (829.47 kg/ha) the mean value being 36.82 ppm (1.03- 82.48 kg/ha). The soil selected for the study varied markedly in the content of available P. The number of soils in the ranges of 0-5, 6-10, 11-15, 16-20, 21-50, 51-100 and more than 100 ppm was 21, 82, 50, 50, 210, 71 and 27 respectively. As per the ratings followed in the soil testing laboratories, a soil containing 4.46 ppm (10 kg/ha) of available P is considered to be the medium and as per this rating, in general, there were more soils in the medium and high range groups than the low group. This pattern of distribution of the soil in respect of available P indicates that the present value of available P assigned for 100 per cent recommendation namely 4.46 ppm does not represent the mode when the distribution of available P in a large number of soil is examined. Similar observations have been made by other workers also. In eighteen soils selected for the study, Mathew (1979) observed that the mean value of Bray 1 available P of those soils was 19.94 ppm (44.67 kg/ha), while Devi (1986) observed a mean value of 72.18 ppm (161.68 kg/ha) in 87 soils studied by her. This situation warrants a revision in the level of available P to be taken as a medium value to receive 100 per cent of the fertilizer recommendation as per the package of practices followed in the state.

Suitability of Mathew's triacid extractant for the extraction of available soil phosphorus

In an earlier study Mathew (1979) formulated varying combinations of chemical agents in order to evolve a chemical extractant which can be employed for the estimation of the total available phosphorus reserve of the soil. He observed that a combination of two mineral acids namely 0.06 N H_2SO_4 + 0.06 N HCl extracted a fraction of soil P which well correlated with the available P reserve of the soil. He further observed that the incorporation of an organic acid namely oxalic acid considerably increased the reproducibility of the values due to the chelating power of the oxalate ions thereby preventing the readsorption of the extracted phosphate ions back to the soil surface. This triacid extractant gave better correlation with the cumulative values of P uptake by rice (Ra-value) as compared to that of Bray 1 extractant. Thus, he recommended this triacid extractant with an equilibration period of 30 min and a soil solution ratio of 1:10 for the estimation of available P reserve (Ra-value) of the soils of the state. In an attempt to find a suitable extractant which could extract available P as well as available

K from the soil, Devi (1986) noticed that the triacid extractant can be employed successfully for the simultaneous extraction of available P and K. Her studies revealed that P extracted by triacid was significantly correlated with the P extracted by Bray 1 and hence suggested that the triacid could conveniently replace Bray 1 for the estimation of available P in the soil testing laboratories of the state. She also observed that the uptake of P by the test crop was significantly correlated with available P extracted by the triacid.

The triacid extracted relatively larger amounts of available P from the soil as compared to that of Bray 1. It ranged from 1.73 - 462.50 ppm in the soils selected for the study. This is in conformity with the observations made by Mathew (1979) and Devi (1986). The combination of the two mineral acids in the presence of oxalate ions is capable of solubilising higher quantities of soil P than that could be done by the combination of HCl and NH_4F in Bray 1. The ability of triacid to extract more quantities of P from the soil and the probable mechanism of extraction have been discussed by the earlier workers. In the present study, values of Bray-1 P and triacid P were very closely correlated ($r = 0.9575^{**}$). The simple linear regression equation was found to be $y = 1.19x - 2.06$ where x and y were Bray-1 P and triacid P respectively (Fig.2). These relationships show that values of Bray-1 P can be predicted from triacid P or the vice-versa with an accuracy of 91.68 per cent. However since this regression equation carries a negative linear constant (-2.06), a value of 0 for Bray-1 P will correspond to a value of -2.06 for triacid P. In the fertility classes followed in the soil testing laboratories of the state, values of Bray-1 P for class No.1 ranges from 0 - 1.34 ppm and as per the above regression equation the corresponding values for triacid P will be -2.06 to -0.47 ppm. In order to avoid this problem of negative linear constant, a linear regression equation of the model $y = bx$ was fitted taking x as Bray-1 P and y as the triacid P. This was found to be $y = 1.15x$. The co-efficient of determination of this simple linear function was worked out to be 0.9134** indicating that this model can be effectively employed to predict the fertility class intervals without the interference of a linear constant, at the same time not sacrificing the predictability to any considerable extent. Thus, making use of this model the class intervals of the ten fertility classes for available P were calculated in terms of triacid P values. These values are presented in Table 4. They could substitute the fertility class intervals now assigned to various classes in terms of Bray-1 P values.

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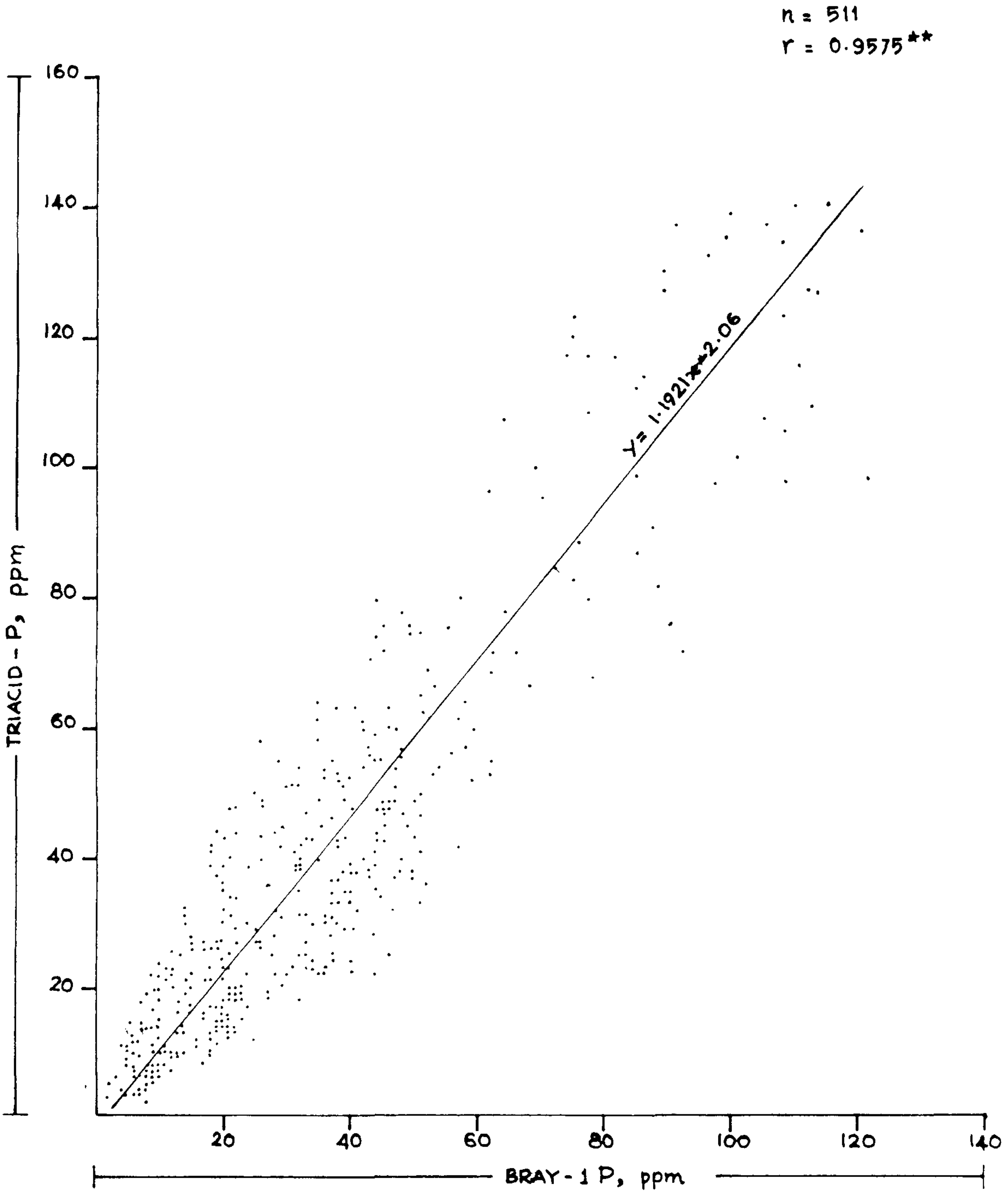
Fig.2 RELATIONSHIP BETWEEN BRAY-1 P AND TRIACID P



n = 511
r = 0.9575**

Table 4. Soil fertility classes in relation to available P and K

Fertility Class No.	Class intervals, ppm*				Fertiliser recommendation (Percentage of general recommendation)
	Bray-1 P	Triacid P	NH_4OAc K	Triacid K	
0	0.00 - 1.34	0.00 - 1.54	0.00 - 15.63	0.00 - 6.89	128
1	1.35 - 2.90	1.55 - 3.34	15.64 - 33.48	6.90 - 14.78	117
2	2.91 - 4.46	3.35 - 5.13	33.49 - 51.34	14.79 - 22.66	106
3	4.47 - 6.03	5.14 - 6.94	51.35 - 69.20	22.67 - 30.55	94
4	6.04 - 7.59	6.95 - 8.74	69.30 - 87.05	30.56 - 38.43	83
5	7.60 - 9.15	8.75 - 10.53	87.06 - 104.91	38.44 - 46.31	71
6	9.16 - 10.71	10.54 - 12.33	104.92- 122.77	46.32 - 54.19	60
7	10.72 - 12.88	12.34 - 14.14	122.78- 140.63	54.20 - 62.08	48
8	12.29 - 13.84	14.15 - 15.93	140.64 -158.48	62.09 - 69.96	37
9	13.85 - 15.40	15.94 - 17.73	158.49 -176.34	69.97 - 77.84	25

*Gives kg/ha when multiplied by 2.24

The triacid P of the soil ranged from 1.73 to 462.50 ppm with a mean value of 42.38 ppm. The ten fertility classes for available P cover only a range of 0 - 15.40 ppm of Bray-1 P and the corresponding values for triacid P calculated from the linear regression model cover only a range of 0 - 17.73 ppm of triacid P. As already pointed out, most of the soils studied contained relatively large amounts of available P as per the rating of the soil testing laboratories. It was observed that 352 soils out of 511, examined in this study could not be fitted in the fertility classes now in vogue indicating the need for revising the values of available P governing the fertility classes.

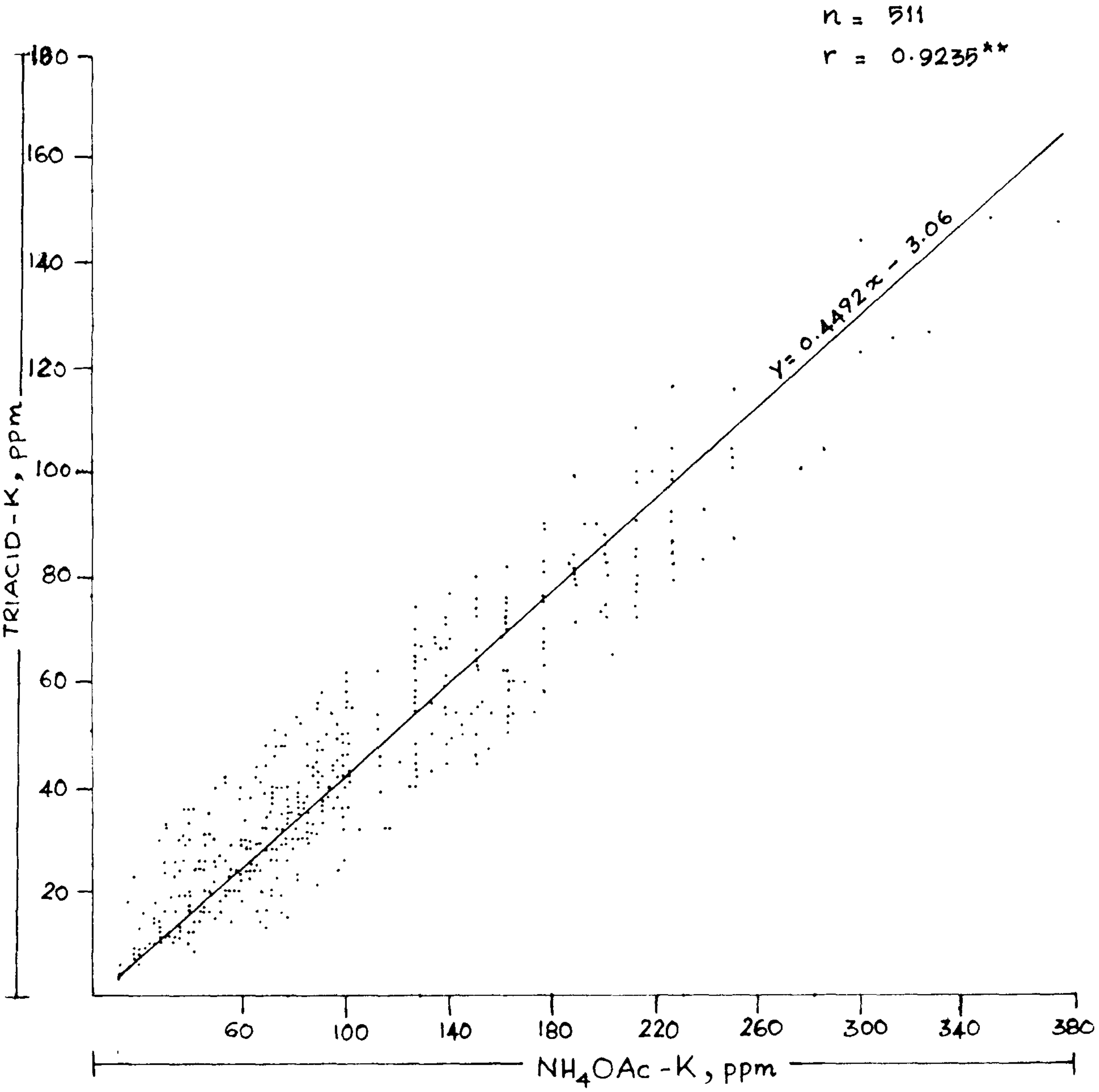
Available potassium

The available K extracted by neutral NH_4OAc ranged from 10.0 - 425.0 ppm the mean value being 105.23 ppm. In general the soils varied significantly in the content of available K. The number of soils in the ranges of less than 25 ppm, 26-50 ppm, 51-100 ppm, 101 to 200 ppm and more than 200 ppm NH_4OAc K was 23, 83, 214, 140 and 51 respectively. As per the rating followed in the soil testing laboratories of the state 100 per cent of the general recommendation for K will apply to a soil containing 51.34 ppm (115 kg/ha) of NH_4OAc extractable K. Assessing from this criterion, there were 108 soils falling below this critical value and 402 soils above this value. Devi (1986) observed a mean value of 233.9 ppm of available K in the 87 soils investigated. As in the case of P, there were more number of soils with the content of available P exceeding the value required for the 100 per cent of the general recommendation. This observation tends to suggest that the critical value for available K to receive 100 per cent of the general recommendation suggested by Nambiar et al. (1977) and now followed in the soil testing laboratories of Kerala needs revision.

Suitability of Mathew's triacid extractant for the extraction of available potassium

In an attempt to find out a common extractant which can simultaneously extract available P and available K, Devi (1986) screened a large number of extractants involving various combinations of different chemical agents. She observed that the fraction of soil K solubilised by Mathew's triacid significantly correlated with the K extracted by neutral NH_4OAc. When the efficiencies of the various extractants to extract both P and K simultaneously were compared, the triacid was found to be the best among the various chemical combinations tried. Also the plant uptake of K was well correlated with the values of K extracted by the triacid. However, the ability of the triacid to extract K from soil was relatively lower compared to that of neutral NH_4OAc. The values of available K extracted by the triacid ranged only from 4.0 to 154.0 ppm while the range for K extracted by NH_4OAc was 10.0 to 425.0 ppm. Consequently the mean values of available K extracted by triacid and NH_4OAc were 42.38 ppm and 105.23 ppm respectively. It is well established that NH_4^+ ions in the neutral NH_4OAc can more effectively replace K^+ ions held in the exchange complex than that could be done by H^+ ions in the triacid. However, the high correlation between the values of K extracted by the two methods shows that K extracted by triacid could also serve as a good index of K availability of the soils under investigation. The co-efficient of linear correlation between K extracted by neutral NH_4OAc and the triacid was found to be 0.9235** ($r^2 = 0.8529$). The relationship between NH_4OAc K and triacid K is graphically represented in Fig.3. The simple linear regression of NH_4OAc K on triacid K was observed to be $y = 0.4492x - 3.062$ where x and y represented NH_4OAc K and triacid K respectively. The slope of this equation indicates that the triacid values are nearly half of the NH_4OAc K values. In order to avoid the influence of

Fig. 3 RELATIONSHIP BETWEEN NH_4OAc-K AND TRIACID-K



the negative linear constant in predicting the class intervals of the fertility classes for available K extracted by triacid, a regression model of $y = bx$ was fitted. This model gave a co-efficient of determination of 0.8521** and the linear model was $y = 0.44x$ where x and y represented NH_4OAc K and triacid K respectively. With the help of this model, triacid K values for the ten fertility classes were worked out. The values are presented in Table 4.

In order to examine, whether more precise relationships between Bray-1 P and triacid P as well as between NH_4OAc K and triacid K can be obtained in individual textural classes of soil, co-efficients of correlation between P and K extracted by the two methods were worked out (Table 3). The results revealed that the coefficients of linear correlation between Bray-1 P and triacid P in sand, loam and clay groups were 0.9580**, 0.9015** and 0.9023** respectively, whereas the corresponding value for all the soils taken together was 0.9575**. This shows that increased precision cannot be obtained by establishing relationships between Bray-1 P and triacid P in separate textural groups. In the case of available K, the correlation coefficients between NH_4OAc K and triacid K in sand, loam and clay groups were 0.9587**, 0.9185** and 0.9345** respectively. As compared to the 'r'

Table 3. Relationship between soil properties in different textural classes

Soil properties		Coefficient of correlation (r)	Regression equation
(x)	(y)		
		<u>Sand (n = 101)</u>	
Bray-1 P	Triacid	0.9580**	$y = 1.198x - 2.505$
NH_4OAc K	Triacid K	0.9587**	$y = 0.428x - 7.158$
		<u>Loam (n = 339)</u>	
Bray-1 P	Triacid P	0.9015**	$y = 1.335x - 4.758$
NH_4OAc K	Triacid K	0.9185**	$y = 0.405x - 6.124$
		<u>Clay (n = 71)</u>	
Bray-1 P	Triacid P	0.9023**	$y = 1.401x - 6.362$
NH_4OAc K	Triacid K	0.9345**	$y = 0.418x - 0.003$

value of 0.9235** for all soils taken together, there was some improvement in the degree of relationship established for the sand and clay groups. However, since the improvement was only marginal and the 'r' value for the loam group was lower than that for all the soils, prediction of fertility class intervals based on regression equations for the different textural classes was not recommended.

Thus the suitability of the triacid extractant for the simultaneous extraction of available P and K in the soils of the state was confirmed. The values of available P and available K extracted by the triacid for the various fertility classes worked out from the regression models could serve as a ready reckoner for giving fertilizer recommendations in the soil testing laboratories of the state. The adoption of the common extractant for simultaneous determination of available P and available K will result in considerable savings of time, materials and labour engaged in advisory soil testing work.

Summary

SUMMARY

An investigation was carried out in order to verify the suitability of Mathew's triacid extractant (0.06 N H_2SO_4 + 0.06 N HCl + 0.05 N oxalic acid) for the combined extraction of available P and K in the soils of Kerala and to establish precise relationships between the amounts of P and K extracted by the triacid and that extracted by the individual extractants now employed in the soil testing laboratories of the state (namely Bray 1 for available P and neutral 1 N NH_4OAc for available K).

A large number of surface soils (0-15 cm) was collected from all over the state which comprised samples from all the districts and various soil groups of the state. The physico-chemical properties of the soil were determined. Available P was extracted by Bray 1 extractant as well as the triacid. Available K in the soil was extracted by neutral N NH_4OAc and the triacid. Relationship between P extracted by Bray 1 and the triacid was established by working out the co-efficient of linear correlation between them. Regression equation in order to predict Bray-1 P values from triacid P values or the vice versa was worked out.

The values of class intervals corresponding to the ten soil fertility classes in terms of triacid P were defined making use of this regression equation. Coefficient of correlation between available K extracted by NH_4OAc and the triacid was examined. In order to predict triacid K values from NH_4OAc K, linear regression equation was established. Values of triacid K corresponding to the soil fertility classes were then worked out making use of the regression established between NH_4OAc K and triacid K.

Most of the soils were acidic in nature with a mean pH of 5.5. The pH of the soil was negatively correlated with electrical conductivity. It was also negatively correlated with the content of organic carbon and positively correlated with available P.

In general, the soils were non-saline, EC varying from 0.004 to 1.000 S/m. with a mean of 0.032 S/m. The EC of the soil was positively correlated with the organic carbon content.

The organic carbon content of the soil ranged from 0.04 per cent to 4.41 per cent. Increasing organic C content resulted in increasing acidity of the soil. Significant positive correlation was obtained between organic C and available K extracted by the triacid.

The content of available P extracted by Bray 1 was in the range of 0.46 to 370.30 ppm whereas that extracted by the triacid ranged from 1.73 - 462.50 ppm. Triacid appeared to be a stronger extractant for available P in soil. A very close positive correlation (0.9575**) was observed between P extracted by Bray 1 and the triacid, the accuracy of prediction being 91.68 per cent. The regression equation y = 1.15 x where x represented Bray-1 P and y the triacid P could be employed in predicting the triacid P values corresponding to the 10 fertility classes for the purpose of giving fertiliser recommendations. Class intervals in terms of triacid P values were worked out making use of the above relationship.

The available K extracted by neutral NH_4OAc ranged from 10.0 to 425.0 ppm the mean value being 105.23 ppm, whereas for triacid K the range was 4.02 - 154.00 ppm with a mean value of 42.38 ppm. Triacid appeared to be a weaker extractant for the extraction of K from soil. However, very high correlation existed between K extracted by NH_4OAc and triacid (r = 0.9235**). A regression equation of y = 0.44x, where x and y represented NH_4OAc K and triacid K respectively, was established. This relationship could be made use of for predicting the values of triacid K from

171004

NH_4OAc K or vice versa. Making use of this model the class intervals were of the ten fertility classes were defined in terms of available K extracted by the triacid.

The relationships between P extracted by Bray 1 and the triacid as well as K extracted by NH_4OAc and the triacid were worked out for the different textural classes of the soil. There was only a marginal improvement by grouping the soil into textural classes and working out the relationships for the separate textural classes.

The present investigation thus confirmed the reliability of using triacid P as the combined extractant for the estimation of available P and K in the soil testing laboratories of the state. Class intervals in terms of triacid P and triacid K corresponding to the 10 fertility classes followed in the soil testing laboratories of the state were furnished which could be made use of for giving fertilizer recommendations.

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CHARACTERIZATION OF KERALA SOILS INTO FERTILITY CLASSES WITH RESPECT TO AVAILABLE P AND K EXTRACTED BY A COMMON EXTRACTANT

By

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ABSTRACT OF A THESIS

Submitted in partial fulfilment of the
requirements for the degree of

Master of Science in Agriculture

Faculty of Agriculture
Kerala Agricultural University

Department of Soil Science and Agricultural Chemistry
COLLEGE OF HORTICULTURE
Vellanikkara, Trichur

1988

ABSTRACT

A laboratory study was undertaken to evaluate the suitability of Mathew's triacid extractant (0.06 N H_2SO_4 + 0.06 N HCl + 0.05 N oxalic acid) for the combined extraction of available P and available K in soil. The suitability of this triacid extractant was confirmed on a large number of soil samples. Precise relationships between the values of triacid P and Bray-1 P as well as between triacid K and NH_4OAc K were established. The ten fertility classes for available P and K currently followed in the soil testing laboratories are based on Bray-1 P and NH_4OAc K. By making use of suitable regression equations the class intervals in terms of triacid P and triacid K values have to be formulated for the purpose of fertilizer recommendation. The use of this extractant can simplify the work in soil testing procedures thus enabling considerable savings of time and labour.

A large number of soil samples was collected representing the entire state of Kerala. The available phosphorus of soil was extracted by Bray No.1 solution (1:10 soil solution ratio with an equilibration period of 5 min) and by Mathew's triacid extractant (1:10 soil

solution ratio with an equilibration period of 30 min). Phosphorus in the extract was then determined colorimetrically by the chlorostannous reduced molybdophosphoric blue colour method in HCl system. The available potassium of the soil was determined by neutral N NH_4OAc with a soil solution ratio of 1:5 and an equilibration period of 5 min as well as by the triacid acid method. Potassium in the extract was determined flame photometrically. Soils were also analysed for organic carbon, pH and EC. Suitable correlation was worked out between Bray-1 P and triacid P. A linear regression equation was fitted to predict triacid P values from Bray-1 P values. Suitable relationship was also established between NH_4OAc K and triacid K. The linear regression model worked out between NH_4OAc K and triacid K was used to predict triacid K values from NH_4OAc K.

Most of the soils were acidic and non-saline. The pH showed a negative correlation with EC and organic carbon content of soil. Soils varied in the content of organic carbon from 0.04 per cent to 4.41 per cent but in general was rich with a mean organic carbon content of 1.14 per cent. Electrical conductivity was positively correlated with organic carbon content of soil. A positive correlation was observed between organic carbon and available K. Mineralisation of organic matter contributed significantly to the increasing acidity of soil. The available P estimated by Bray-1 was found to range from 0.46 to 370.30 ppm whereas triacid P ranged from 1.73 to 462.50 ppm. The triacid extracted larger amounts of available P than the Bray-1. A significant correlation was observed between triacid P and Bray-1 P (r = 0.9575**). By fitting the regression equation y = 1.15x, where y represented triacid P and x represented Bray-1 P, the triacid P values of the ten fertility classes have been worked out.

The available K as estimated by neutral N NH_4OAc ranged from 10.0 to 425.0 ppm whereas triacid K ranged from 4.0 to 154.0 ppm. Triacid extracted lower amounts of available K (42.38 ppm) than the neutral N NH_4OAc K (105.23 ppm). Although triacid showed less efficiency for releasing K from soil it was found to have high correlation with neutral N NH_4OAc (r = 0.9235**). The linear regression equation of the form y = 0.44x was worked out where y represented triacid K and x represented NH_4OAc K. This was employed to redefine the ten fertility classes in terms of triacid K values.

The increase in precision obtained by the relationship between P estimated by Bray 1 and triacid as well as K estimated by neutral N NH_4OAc and triacid by grouping the soils into separate textural classes was only marginal.

The present study therefore confirmed the suitability of the triacid for estimation of both available P and K in the soil of Kerala. The revised class intervals for the ten fertility classes followed in the soil testing laboratories of Kerala have been formulated in terms of triacid P and triacid K values which will serve as a guide for giving fertilizer recommendations for various crops.