BEHAVIOUR OF POTASSIUM IN SELECTED SOIL SERIES OF THIRUVANANTHAPURAM DISTRICT

By
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THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENT FOR THE DEGREE
MASTER OF SCIENCE IN AGRICULTURE
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

DEPARTMENT OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY
COLLEGE OF AGRICULTURE
VELLAYANI
THIRUVANANTHAPURAM

1993

DECLARATION

I hereby declare that this thesis, entitled 'BEHAVIOUR OF POTASSIUM IN SELECTED SOIL SERIES OF THIRUVANANTHAPURAM DISTRICT', 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.

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CERTIFICATE

Certified that this thesis, entitled 'BEHAVIOUR OF POTASSIUM IN SELECTED SOIL SERIES OF THIRUVANANTHAPURAM DISTRICT' is a record of research work done independently by Sri.GEORGE JOSEPH, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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ACKNOWLEDGEMENT

I wish to express my heartfelt gratitude and indebtedness to:

Dr. N. Saifudeen, Associate Professor, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani and Chairman of the Advisory committee, for his inspiring guidance in the planning and conduct of this work, sustained enthusiastic interest, expert advice and for the constant encouragement given throughout the period of study and preparation of the thesis;

Dr. P. Padmaja, Professor and Head, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani and member of the Advisory Committee for her valuable and constructive suggestions and keen interest shown for critically reviewing the manuscript;

Dr. M. Subramonia Iyer, Associate Professor, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani and member of the Advisory Committee for the valuable help rendered during the course of the study and preparation of thesis;

Dr. P. Saraswathy, Professor and Head, Department of Agricultural Statistics, College of Agriculture, Vellayani and member of the Advisory Committee for her valuable suggestions during statistical analysis of the data and its interpretation;

Dr. R.S. Iyer, Retd. Professor and Head, Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani for the keen interest shown in this work;

Shri. C.E. Ajith Kumar, Junior Programmer, Department of Agricultural Statistics for the help and patience shown for the statistical analysis of the data;

Shri. N. Abdul Azeez, Additional Director Soil Conservation, P.T. Mathew, Deputy Director Soil Survey, M. Jayasree, Junior Soil Survey Officer and other staff members, Department of Soil Survey for their sincere help and co-operation in the collection of soil samples;

The members of the teaching and non-teaching staff of the Department of Soil Science and Agricultural Chemistry for the various courtesies extended;

Asharaf.. M, Asok, Happy Mathew, Anil Abraham, Noushad, Vijaya Kumar, Rani. B, Sheela.R, Geetha Kumari, Chithra and all junior P.G. Students of the Department of Soil Science and Agricultural Chemistry for their assistance given during the work;

Kerala Agricultural University for awarding a fellowship for the Post Graduation Programme;

M/s. Repromen neatly typing the thesis;

My parents and brothers for their constant inspiration and encouragement during the course of study and preparation of thesis;

God Almighty, whose blessings helped me a lot throughout the course of my work.

(GEORGE JOSEPH)

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INTRODUCTION

A good understanding of the behaviour of a plant nutrient element such as potassium in the surface soil can be achieved only by linking the fertility problems in terms of plant available potassium with the other geochemical forms of potassium present in soil. The ensuing presentation is an attempt in this direction.

Potassium is abundant in nature and occurs in considerable total amounts in most soils. Forms of potassium available for plant uptake, however are often deficient in soils. Potassium occurs in different forms such as soil solution K, exchangeable K, non-exchangeable K and lattice or structural K. The various forms of K are interrelated and are in dynamic equilibrium. Its availability to plants is related in many ways to the physical chemistry and structure of soil components.

The information on the dynamics of the different forms of soil potassium in Kerala is scanty and inconclusive. The availability is not a question of exchangeable K content, but is the result of interaction of various soil factors which can affect the availability of soil potassium.

Sufficient evidence has accumulated to emphasise the need for an improvement in the approach and methodology of soil fertility evaluation for potassium.

It is desirable to gather information on the quantitative distribution of different forms of soil potassium, along with an estimate of interacting soil parameters. Such an approach will definitely help to develop a scientific basis to predict the availability of soil potassium under different soil conditions. This will facilitate sound management of fertilizer potassium for field crops.

The study in Trivandrum, Kazhakuttom and Kottoor soil series was undertaken on the premise that a complete knowledge of the different forms of soil potassium as well as their interaction between them and other soil properties would contribute to the rational use of the soil and fertilizer potassium for sustained and economic production and the results generated can be suitably extended to similarly classified soils occuring elsewhere. With these overriding considerations the following objective have been set for the study:

Defining the quantitative relationships between soil properties and potassium fertility in selected soil series of Thiruvananthapuram district so as to predict the trends in K availability under varying soil conditions.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

An array of publications are available on the different forms of soil potassium in various soil types of Kerala and elsewhere. The ensuing compilation includes information gleened from recent research output on the soil fractions of potassium and their interactions with other soil components.

2.1. Forms of soil potassium

Different authors have grouped soil potassium into several fractions depending on the ease of availability to crops, kind of reaction products in soil, potassium bearing mineral forms, lattice K forms etc. The present study generated data on six types of soil potassium status. Published work in similar lines was reviewed and the information gathered is presented under different subtitles.

2.1.1. Water Soluble K

A wide range in water soluble K content was noticed by scientists in different regions of India. The contents ranged between 0.10 to 1.22 me L^{-1} (mean = 0.41 me L^{-1}) in rice soils of Tamil Nadu (Ramanathan and Krishna Moorthy, 1981), 1.92, 0.95 and 0.79 me L^{-1}, in red sandy loam soils at Pachalloor, Kasaragod and Beypore in Kerala respectively (Hameed Khan et al. 1982), 0.10 to 0.99 me L^{-1} in Eastern Haryana soils (Singh et al.,1983), 0.20 to 1.27 me L^{-1} (mean = 0.46 me L^{-1}), in the surface soils and mean content 0.42 meL^{-1} for sub surface alluvial soils of Agra region (Prakash and Singh, 1985), 0.05 to 0.97 me L^{-1} in Western Haryana soils (Singh et al.,1985) a mean content of 0.32 me L^{-1} in alluvial soil zones of West Bengal (Tarafdar and Mukhopadhyay, 1986), 0.19 to 1.15 me L^{-1} (mean = 0.43 me L^{-1}) in Mizoram soils (Singh and Datta, 1986), traces to 0.95 me L^{-1} in soils of Garhwal hills (Singh and Singh, 1986), a minimum of 3 ppm in subsoils to a maximum of 10 ppm in surface soils (mean = 5 ppm) in some soils of Assam growing rice (Chamuah 1987) 12.5 to 64.5 ppm in some salt affected soils of Haryana (Tewatia et al., 1987), 0.10 to 0.70 me L^{-1} (mean 0.40 me L^{-1}) in both new alluvium and old alluvium (Sahu and Gupta, 1987), 6-70 ppm in Central Haryana soils (Ravikumar et al.,1987), 0.20 to 1.8 me L^{-1} in some soils under forest cover (Sahu and Gupta, 1988), 0.06 to 4.5 me L^{-1} in dry farming calcareous areas of Saurashtra region in Gujarat (Koria et al.,1989), 0.02 to 0.28 me L^{-1} in some Alfisols of West Bengal (Pal and Mukhopadhyay, 1990), 5.5 to 27.5 ppm in Dandachali, Pankhil and Tegna soil series (Mishra and Srivastava, 1991).

Prabhakumari (1981) observed that the water soluble K in red and lateritic soils of Trivandrum district ranged between 1.53 and 7.16 me L^{-1}.

In interrow samples of coconut plantations in Neyattinkara sandy clay soil the water soluble K content was in the range of 0.205 to 1.535 me L^{-1} (mean = 5.572 me L^{-1}) and the values for Vellayani sandy clay soil was from 0.205 to 0.921 me L^{-1} (mean = 0.427 me L^{-1}). The values for cassava grown fields for Neyattinkara sandy clay was found to be in the range of 0.102 to 0.460 me L^{-1} (mean = 0.256 me L^{-1}) and for Vellayani sandy clay soil it was between 0.358 to 2.353 me L^{-1} (mean = 1.100 me L^{-1}) (Valsaji, 1989).

2.1.2. Exchangeable K

A considerable variation was observed in exchangeable K content from different regions of the country. The exchangeable K content varied between 1.2 to 22.5 $cgkg^{-1}$ in Haryana soils (Singh etal., 1983), 8.99 $cgkg^{-1}$ in laterite soils (Bandyopadhyay and Goswami, 1985), 4.2 to 17.5 $cgkg^{-1}$ in Agra region alluvial soils (Prakash and Singh, 1985), a mean content of 0.213 me/100g in alluvial soils of West Bengal (Tarafdar and Mukhopadhyay, 1986), mean values of 0.07, 0.40, 0.42 and 0.58 $cgkg^{-1}$ in clay, clay loam, silty clay loam and loamy alluvial soils respectively of Andhra Pradesh (Sailakshmiswari et al., 1986), 5.07 and 47.78 $cgkg^{-1}$ (mean = 17.0 $cgkg^{-1}$) in Mizoram soils (Singh and Datta, 1986), traces to 37.4 $cgkg^{-1}$ in Garhwal hills soil (Singh and Singh, 1986) 8.99, 21.50 and 18.76 cg kg^{-1} in red, alluvial and black soils respectively (Yadav, 1986), a minimum value of 1.4 $cgkg^{-1}$ in sub soils to a maximum of 7.8 $cgkg^{-1}$ in surface soils (mean = 3.5 $cgkg^{-1}$) in some Assam soils growing rice (Chamuah, 1987), 5.08 to 13.29 cg kg^{-1} in red and lateritic soils of Nellore district in Andhra Pradesh (Adinarayana et al., 1987), 10.6 to 33.0 $cgkg^{-1}$ in some salt affected soils of Haryana (Tewatia et al. 1987), 3.51 to 7.82 $cgkg^{-1}$ (mean = 5.08 $cgkg^{-1}$) in new alluvium and 3.51 to 10.16 $cgkg^{-1}$ (mean = 6.25 cg kg^{-1}) in old alluvium (Sahu and Gupta, 1987), 2.8 to 5.2 $cgkg^{-1}$ in Central Haryana soils (Ravikumar et al., 1987), 0.04 to 0.42 me/100g in some soils under forest cover (Sahu and Gupta, 1988), 0.27 to 5.35 me/100g in dry farming calcareous areas of Saurashtra region in Gujarat (Koria et al., 1989), 0.06 to 0.34 me/100g in some Alfisols of West Bengal (Pal and Mukhopadhyay, 1990), 5.45 to 21.62 $cgkg^{-1}$ in Dandachali, Pankhil and Tegna soil series of Garhwal Himalayas (Mishra and Srivastava, 1991) and so on.

The exchangeable K content of Neyattinkara sandy clay soil in the interrow samples of coconut plantations varied between 2.00 to 19.20 $cgkg^{-1}$ (mean = 5.15 $cgkg^{-1}$) and the values for Vellayani sandy clay soil was found to be between 0.60 to 8.40 cg kg^{-1} (mean = 3.36 $cgkg^{-1}$). In cassava growing areas in Neyattinkara sandy clay soil the content of exchangeable K ranged from 1.20 to 8.60 $cgkg^{-1}$ (mean = 3.60 $cgkg^{-1}$) and that for Vellayani sandy clay the range was between 1.40 to 9.20 cg kg^{-1} (mean = 4.30 $cgkg^{-1}$) (Valsaji, 1989).

2.1.3. Available K

Studies conducted at various sites of the country reveal a wide range in the content of Ammonium acetate K. The content varied from 1.6 to 21.4 cg kg^{-1}, in Eastern Haryana soils (Singh _et al_., 1983), 3.59 to 76.79 $cgkg^{-1}$ in soils of Andhra Pradesh (Subba Rao _et al_., 1983), 1.6 to 19.7 cg kg^{-1} in Western Haryana soils (Singh _et al_., 1985), 5.1 to 16.9 cg kg^{-1} (mean = 10.4 $cgkg^{-1}$), in gravelly clay loam soils and 3.1 to 7.1

$cgkg^{-1}$ (mean = 4.9 $cgkg^{-1}$) in gravelly clay soils of Nedumangad series in Kerala (Brar and Subha Rao, 1986), 6.09 to 52.28 $cgkg^{-1}$ (mean = 18.68 $cgkg^{-1}$) in soils of Mizoram (Singh and Datta, 1986), 0.8 t0 5.1 cg kg^{-1} in alluvial soils of Agra region (Prakash and Singh, 1985), 8.99 to 21.89 $cgkg^{-1}$ in alluvial soils of Punjab (Samiei and Chahal, 1986), 10.06 to 33.00 $cgkg^{-1}$ in salt affected soils of Haryana (Tewatia et al., (1987), 4.30 to 11.33 $cgkg^{-1}$ (mean = 6.64 $cgkg^{-1}$) in new alluvium and 4.30 to 10.55 cg kg^{-1} (mean = 7.82 $cgkg^{-1}$) in old alluvium (Sahu and Gupta, 1987), 0.06 to 0.37 me/100g in some Alfisols of West Bengal (Pal and Mukhopadhyay, 1990), 6.25 to 24.37 $cgkg^{-1}$ in Dandachali, Pankhil and Tegna soil series of Garhwal Himalayas (Mishra and Srivastava, 1991), 2.50 to 12.50 $cgkg^{-1}$ (mean = 6.61 $cgkg^{-1}$) in the acidic hill soils of Andamans and so on.

Prabhakumari (1981) reported that Ammonium acetate extractable K in red and lateritic soils of Trivandrum district varied from 9.0 to 32.0 cg kg^{-1}.

Valsaji (1989) observed that the available K content in the interrow samples of coconut plantations in Neyattinkara sandy clay varied from 3.40 to 25.20 $cgkg^{-1}$ (mean = 7.39 cg kg^{-1}) and for Vellayani sandy clay soil from 2.00 to 10.80 cg kg^{-1} (mean = 5.03 cg kg^{-1}). The available K content for cassava grown area in Neyattinkara sandy clay ranged from 2.00 to 9.60 cg kg^{-1} (mean = 4.70 cg kg^{-1}) and for Vellayani sandy clay the value was between 2.80 to 12.80 $cgkg^{-1}$ (mean = 6.20 cg kg^{-1}).

2.1.4. Nitric Acid Soluble K

Considerable difference in the amount of HNO_3.K have been reported from different parts of the country. The content of HNO_3.K showed values ranging from 10.0 to 195.0 $cgkg^{-1}$ (mean = 66.7 cg kg^{-1}) in rice soils of Tamil Nadu (Ramanathan and Krishnamoorthy, 1982), 13.1 to 67.5 cg kg^{-1} in Western Haryana soils (Singh et al.,1985), 79.2 to 206.8 $cgkg^{-1}$ in alluvial soil of Agra region (Prakash and Singh, 1985), 25.02 to 124.33 cg kg^{-1} in alluvial soils of Punjab (Samiei and Chahal, 1986), 2.20 to 117.90 $cgkg^{-1}$ in Central Haryana soils (Ravikumar et al.,1987), 0.27 to 5.35 me/100g in some soils of the dry farming calcareous areas of Saurashtra region in Gujarat (Koria et al.,1989) 0.06 and 0.36 percent in the acidic hill soils of Andamans (mean = 0.173 percent) (Mongia and Bandyopadhyay, 1991) and so on.

Prabhakumari (1981) in red and lateritic soils of Trivandrum district found that the HNO_3 soluble K content ranged from 10.0 to 58.0 $cgkg^{-1}$.

HNO_3.K content of interrow samples of coconut plantations in Neyattinkara sandy clay soil was found to be in the range of 4.00 to 28.00 $cgkg^{-1}$ (mean = 12.00 $cgkg^{-1}$) and the value for Vellayani sandy clay soil was from 3.20 to 13.20 $cgkg^{-1}$ (mean=7.51 $cgkg^{-1}$).

The HNO_3.K content for the cassava grown area of Neyattinkara sandy clay soil was between 2.20 to 9.80 $cgkg^{-1}$ (mean = 6.20 $cgkg^{-1}$) and for Vellayani sandy clay soil it was ranging from 6.40 to 32.00 $cgkg^{-1}$, (mean = 11.90 $cgkg^{-1}$) (Valsaji, 1989).

2.1.5. Non-exchangeable K

Non-exchangeable K also showed a great degree of fluctuation in its content in different regions of the country. The content of non-exchangeable K varied from 7.2 to 149.0 $cgkg^{-1}$ (mean = 49.4 $cgkg^{-1}$) in rice soils of Tamil Nadu (Ramanathan and Krishnamoorthy, 1982), 17.5 to 162.5 $cgkg^{-1}$ in Haryana soils (Singh et al., 1983), 60.0 to 240.0 $cgkg^{-1}$ in Agra region alluvial soils (Prakash and Singh, 1985), a mean value of 2.85 me/100g in alluvial soils of West Bengal (Tarafdar and

Mukhopadhyay, 1986), 110.0 to 500.0 cgkg^{-1} in soils of Garhwal hills (Singh and Singh, 1986), 25.0 cgkg^{-1} in surface soils to 106.0 cg kg^{-1} in subsoils (mean = 54.5 cgkg^{-1}) in rice growing soils of Assam (Chamuah, 1987) 29.0 to 76.5 cgkg^{-1} in salt affected soils of Haryana (Tewatia et al., 1987), 39.8 to 281.0 cgkg^{-1} (mean = 152.8 cgkg^{-1}) in new alluvial soils and 47.31 to 98.53 cgkg^{-1}, (mean = 75.46 cgkg^{-1}) in old alluvium (Sahu and Gupta, 1987), 22.0 to 117.9 cgkg^{-1} in Central Haryana soils (Ravikumar et al., 1987), 2.19 to 23.45 me/100g in some soils under forest cover (Sahu and Gupta, 1988), 0.27 to 5.35 me/100g in dry farming calcareous areas of Saurashtra region in Gujarat (Koria et al., 1989), 0.39 to 2.41 me/100g in some Alfisols of West Bengal (Pal and Mukhopadhyay, 1990), 53.70 to 115.60 cgkg^{-1} in Dandachali, Pankhil, and Tegna soil series of Garhwal Himalayas (Mishra and Srivastava, 1991), 60.0 to 360.0 cgkg^{-1} (mean = 173 cgkg^{-1}) in acidic hill soils of Andamans (Mongia and Bandyopadhyay, 1991) and so on.

Valsaji (1989) found that the non-exchangable K content in the interrow samples of coconut plantations in Neyattinkara sandy clay soil was between 0.20 to 18.00 cg kg^{-1} (mean = 4.61 cgkg^{-1}) and that for Vellayani sandy clay was from 0.40 to 7.60 cg kg^{-1}, (mean = 2.49 cg kg^{-1}). The values for cassava growing areas in Neyattinkara sandy clay soil ranged between 0.20 to 4.00 $cgkg^{-1}$ (mean = 1.60 $cgkg^{-1}$) and for Vellayani sandy clay soil the content of non-exchangeable K was from 1.20 to 25.00 $cgkg^{-1}$ (mean = 5.70 $cgkg^{-1}$).

2.1.6. Total potassium

Wide variation in the total content of K was reported from different parts of the country. The values varied between 0.6 to 2.8 percent (mean = 1.37 percent) in alluvial soils of Western U.P. (Prakash and Singh, 1985), 1.96 to 3.84 percent (mean = 2.70 per cent) in Mizoram soils (Singh and Datta, 1986) a mean of 27.08 me/100g soil in alluvial soil zones of West Bengal (Tarafdar and Mukhopadhyay, 1986), 2.00 to 5.57 percent in the soils of Garhwal hills (Singh and Singh, 1986), 2.40 to 4.20 percent (Mean = 2.85 percent) in new alluvial soils and 1.21 to 2.52 percent (Mean = 1.93 percent) in old alluvial soils (Sahu and Gupta, 1987), a minimum of 2.42 percent in subsoils (mean = 1.86 percent) in some soils of Assam growing rice (Chamuah, 1987), 1.12 to 2.40 percent in soils of Central Haryana (Ravikumar *et al*., 1987), 0.81 to 2.87 percent in some soils under forest cover (Sahu and

Gupta, 1988), 6.2 to 23.7 me / 100g soil in the calcareous dry farming areas of Saurashtra region in Gujarat (Koria et al.,1989), 6.97 to 17.46me/100g soil in some Alfisols of West Bengal (Pal and Mukhopadhyay, 1990), 1.05 to 1.60 percent in Dandachali, Pankhil and Tegna soil series of Garhwal Himalayas (Mishra and Srivastava, 1991) and so on.

Tandon and Sekon (1988) reported that the K content of Indian soils varied from 0.5 to over 3.0 percent.

Prabhakumari (1981) noticed that the total K content in red and lateritic soils of Trivandrum district ranged from 1200 to 1290 ppm (mean = 1250 ppm). Byju (1989) reported the depthwise distribution of total potassium in soil profiles of Kottoor and Kazhakkuttom series. In the case of Kottoor series the values varied between 0.426 percent in the reserve forest to 0.349 percent in barren lands and 0.344 percent in Eucalyptus plantations. The mean values for Kazhakkuttom series were 0.027, 0.029, 0.028 and 0.029 percent for barren land, Eucalyptus plantations, Acasia plantations and cultivated land respectively.

The total potassium content of Neyattinkara sandy clay soil in the interrow samples of coconut plantations was found to range between 0.086 to 0.117 percent (mean = 0.104 percent) and for Vellayani sandy clay it was between 0.088 to 0.1556 percent (mean = 0.142 percent). The values for the cassava grown area for Neyattinkara sandy clay was from 0.148 to 0.176 percent (mean = 0.159 percent) and for Vellayani sandy clay it was between 0.083 to 0.167 percent (mean = 0.126 percent) (Valsaji, 1989).

2.2. Relation between forms of soil potassium

Different fractions of soil potassium are in dynamic equilibrium and the equilibrium is influenced by the relative concentration of these fractions as well as the chemical nature of soil. For a given soil series the relation between soil K fractions can be unique and may differ from other soil series. Attempts to establish quantitative relationships between soil K fractions by scientists world wide have resulted in several mathematical models. The correlations between chemically active soil potassium fractions in different soil types is summarised in the write up that follows.

Generalisation of interacton of soil K fractions is often impractical since the relationship show spatial as well as series wise variations. For example, Prabhakumari (1981) reported significant correlation between ammonium acetate K and exchangeable K in the red and laterite soils of Trivandrum. Similar relationship was established by her between ammonium acetate K and water soluble K also. Between NH_4OAc.K and total K a negative significant correlation was obtained. Significant correlation was obtained for all the four fractions in the case of HNO_3.K.

In coastal soils of Orissa and West Bengal, Bandyopadhyay et al. (1985) reported that the non-exchangeable K was positively correlated with exchangeable K.

In alluvial soils of Agra, Prakash and Singh (1985) obtained significant positive correlation of water soluble K with exchangeable K. In these soils water soluble K also showed significant positive correlation with fixed and total K. Fixed K was significantly and positively related with water soluble and exchangeable K. Total K had significant relationship with water soluble K, exchangeable K and fixed K.

In five bench mark soil series namely Pemberty, Noyyal, Vijayapura, Tyamagondulu and

Nedumangad from southern India, Brar *et al*. (1986) observed significant relationship between $NH_4OAc.K$ and $HNO_3.K$.

Tarafdar and Mukhopadhyay (1986) noticed that in alluvial soils of West Bengal all the different forms of K namely water soluble, exchangeable, labile, non-exchangeable and total K were positively correlated with each other except the interlayer K which did not significantly correlate with total K.

Singh and Singh (1986) observed that in soils of Garhwal hills, water soluble K had significant positive relationship with exchangeable and non-exchangeable K but insignificant relationship with total K. Fixed K had significant relationship with exchangeable and water soluble K and total K had significant relationship with exchangeable K and non-exchangeable K.

In five benchmark soils namely Pemberty, Noyyal, Vijayapura, Tyamagondulu and Nedumangad series, Brar and Subba Rao (1986) reported that significant relationship existed between water soluble K and exchangeable K.

Tewatia et al. (1987) reported that in some salt affected soils of Haryana, all the forms of K ie., water soluble, NH_4OAc extractable, non-exchangeable, HCl soluble and total K were found to be positively correlated with each other indicating the existence of active equilibrium among various forms of K.

In Central Haryana soils, Ravikumar et al. (1987) found that all the forms of K namely water soluble, exchangeable, HNO_3 soluble, HCl soluble and total K were interrelated, except total K with water soluble and HNO_3 extractable fractions.

Sahu and Gupta (1988) noticed that in some soils under forest cover there was positive significant relation of total K with lattice, HCl soluble and water soluble K, of HCl soluble K with fixed and exchangeable K, of fixed K with exchangeable K and of exchangeable K with water soluble K.

Singh et al. (1989) in Jaria, Burja, Sidrol, Amba, Hututua, Burmu, Garra, Rege and Maka soil series of Chotanagpur region in Bihar observed that the total and water soluble K were significantly correlated; while HCl extractable fraction was positively associated with all other forms except water soluble and total K.

In soils of dry farming calcareous areas of Saurashtra region in Gujarat, Koria et al. (1989) noted that exchangeable, water soluble and HNO_3 soluble K fractions were interrelated.

Interrelations in Neyattinkara-Vellayani soil association showed that water soluble K, exchangeable K and available K were in dynamic equilibrium. Non-exchangeable K did not show any relationship with available K indicating that it is a poor source of available K (Valsaji, 1989).

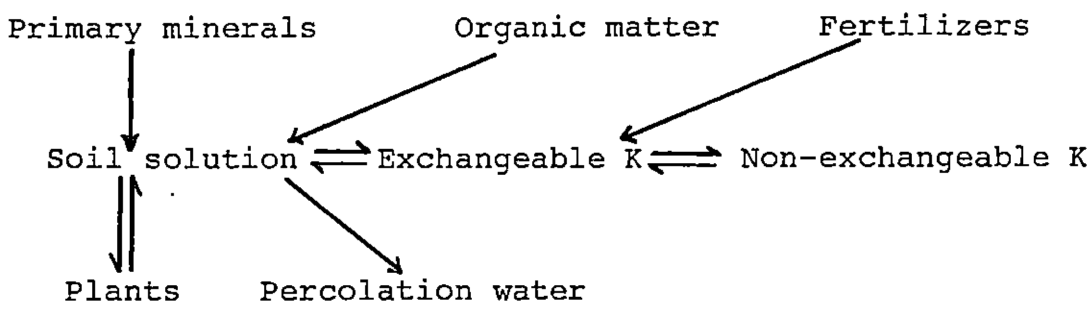
Pal and Mukhopadhyay (1990) observed that in some Alfisols of West Bengal, all the forms of K were interrelated except water soluble and available K, which had insignificant relationship with total K.

Devi et al. (1990) studied forms of potassium in two soils series of South Kerala (Vellayani and Neyattinkara) and found that water soluble K was significantly and positively correlated to exchangeable and available forms of K.

In Dandachali, Pankhil and Tegna soil series of Garhwal Himalayas, Mishra and Srivasstava (1991) reported that among the different K forms water soluble and exchangeable K were positively correlated but the relationship between exchangeable and non-exchangeable

K was not significant.

Subba Rao and Sekhon (1991) observed that water soluble K and exchangeable K were significantly correlated in all the five soil series in Vertisols and Vertic Ustochrepts. A generalised representation of the dynamics of K in soil-plant system (Malavolta, 1985) is presented below.



2.3. Relation of various forms of soil potassium with other soil properties

2.3.1. Water Soluble K

It had positive correlation with sand fraction in nine soil series of Chotanagpur region (Singh *et al.*, 1989) while the relation was negative in Typic Hapludalfs, Typic Eutrochrepts and Typic Ustrochrepts of Himachal Pradesh. (Verma *et al.*, 1982) and in soils of Central Haryana (Ravikumar *et al.*,1987).

Significant positive relation was observed between water soluble K and finer fractions in Typic Hapludalfs, Typic Eutrochrepts and Typic Ustrochrepts of Himachal Pradesh (Verma *et al.*, 1982) in Central Haryana soils (Ravikumar *et al.*, 1987) and in Mizoram soils (Singh *et al.*, 1989). Negative relationship was obtained with finer fractions in Jaria, Burju, Sidrol, Amba, Hututua, Burmu, Gorra, Rege and Maka soil series of Chotanagpur region (Singh *et al.*, 1989). Insignificant positive relation was obtained between water soluble K and clay in alluvial soils of Agra region (Prakash and Singh, 1985) and in soils of Garhwal hills (Singh and Singh, 1986).

Positive correlation of water soluble K with soil pH was reported in alluvial soils of Agra region (Prakash and Singh, 1985). Water soluble K was positively and well correlated with organic carbon content in Mizoram soils (Singh and Datta, 1986), in Central Haryana soils (Ravikumar *et al.*, 1987), in Dandachali, Pankhil and Tegna soil series of Garhwal Himalayas (Mishra and Srivastava, 1991) and in Kharbona (Typic Haplaquept) and Nedumangad (Oxic Dystropept) soils (Subba Rao and Sekhon, 1991). The relationship was positive but insignificant in Agra region soils (Prakash and Singh, 1985).

The relation of water soluble K with CEC was positive and significant in soils of Central Haryana (Ravikumar *et al*. 1987) and in Dandachali, Pankhil and Tegna soil series of Garhwal Himalayas (Mishra and Srivastava, 1991) while the relationship was insignificant in alluvial soils of Agra region (Prakash and Singh, 1985). In Jaria, Burju, Sidrol, Amba, Hututua, Burmu, Garra, Rege and Maka soil series of Chotanagpur region in Bihar Singh *et al*. (1989) reported negative correlation between water soluble K and CEC. Water soluble K had positive and significant correlation with electrical conductivity in soils of dry farming calcareous areas of Saurashtra region in Gujarat (Koria *et al*.,1989) and in Dandachali, Pankhil and Tegna soil series of Garhwal Himalayas (Mishra and Srivastava, 1991).

2.3.2. Exchangeable K

Negative relationship was obtained between exchangeable K and sand content in Typic Hapludalfs, Typic Eutrochrepts and Typic Ustrochrepts of Himachal Pradesh (Verma *et al*.,1982) and in Central Haryana soils (Ravikumar *et al*., 1987). Positive and significant correlation was reported between finer fractions especially clay percentage and exchangeable K in soils of Karnataka (Ranganathan and Sathanarayana, 1980), in Typic Hapludalfs, Typic Eutrochrepts and Typic Ustrochrepts of Himachal Pradesh (Verma et al., 1982), in soils of Central Haryana (Ravikumar et al., 1987), in Vertisols of Indore district (Sharma and Dubey, 1988), in nine soil series of Chotanagpur region (Singh et al., 1989), in Mizoram soils (Singh et al., 1989) and in Alfisols of West Bengal (Pal and Mukhopadhyay, 1990).

Exchangeable K was significantly related to organic carbon content in Haryana soils (Singh et al., 1983), in five soil series of Northern India (Brar and Sekhon, 1985), in Mizoram soils (Singh and Datta, 1986), in soils of Garhwal hills (Singh and Singh, 1986), in Central Haryana soils (Ravikumar et al., 1987), in Dandachali, Pankhil and Tegna soil series of Garhwal Himalayas (Mishra and Srivastava, 1991) and in Kharbona and Nedumangad soils (Subba Rao and Sekhon, 1991).

Negative insignificant relation was obtained between exchangeable K and pH.

Significant correlation existed between exchangeable K and CEC in soils of Haryana (Singh et al., 1983), in alluvial soils of Western Uttar Pradesh (Prakash and Singh, 1985), in Central Haryana soils (Ravikumar et al., 1987), in Jaria, Burju, Sidrol, Amba, Hututua, Burmu, Garra, Rege and Maka soil series of Chotanagpur region of Bihar (Singh et al., 1989), in Mizoram soils (Singh et al., 1989) and in Dandachali, Pankhil and Tegna soil series of Garhwal Himalayas (Mishra and Srivastava, 1991).

The relationship of exchangeable K with CEC was reported to be insignificant in Mizoram soils (Singh and Datta, 1986).

Koria et al. (1989) obtained significant positive correlation of exchangeable K with electrical conductivity in some soils of dry farming calcareous areas of Saurashtra region in Gujarat.

2.3.3. Available K

Available K was reported to be negatively correlated with sand in Western Haryana soils (Singh et al., 1985) which indicated the presence of larger amounts in finer fraction. Ammonium acetate extractable K showed positive correlation with the finer fractions especially clay in Lukhi, Nabha, Khatki, Noyyal, Vijayapura and Tyamagondulu series (Sekhon *et al*., 1985), in Western Haryana soils (Singh *et al*., 1985), in soils of Mizoram (Singh *et al*., 1989), in some Alfisols of West Bengal (Pal and Mukhopadhyay, 1990) and in acidic hill soils of Andamans (Mongia and Bandyopadhyay, 1991).

Organic carbon was significantly correlated with available K in Akbarpur, Pemberty and Nedumangad series (Sekhon *et al*., 1985), in Dandachali, Pankhil and Tegna soil series of Garhwal Himalayas (Mishra and Srivastava, 1991) and in acidic hill soils of Andamans (Mongia and Bandyopadhyay, 1991).

Positive correlation existed between available K and CEC in soils of Mizoram (Singh *et al*., 1989) and in Dandachali, Pankhil and Tegna soil series of Garhwal Himalayas (Mishra and Srivastava, 1991).

Subba Rao and Sekhon (1991) in their study in acid tropical soils showed that in soils with appreciable amounts of organic carbon and pH greater that 5.5, the influence of pH on available K status was negligible.

Positive correlation was observed between available K and electrical conductivity in Dandachali, Pankhil and Tegna soil series of Garhwal Himalayas (Mishra and Srivastava, 1991).

2.3.4. Nitric Acid K

In the acidic hill soils of Andamans Nitric acid K was positively and significantly correlated with sand fraction (Mongia and Bandyopadhyay, 1991) whereas the relation was negative in Western Haryana soils (Singh et al.,1985). Significant relationship was observed between Nitric acid K and finer soil fractions especially clay in bench mark soils (except Akbarpur series) from Northern India (Brar and Sekhon, 1985), in Lukhl, Nabha, Khatki, Vijayapura and Tyamagondulu series (Sekhon et al.,1985), in Central Haryana soils (Ravikumar et al., 1987), and in Nabha soil series (Brar and Sekhon, 1987). The relationship was not significant in Akbarpur series and Pemberty series whereas significant relationship was obtained between HNO_3.K and clay in Nedumangad series (Sekhon et al., 1985) and in the acidic hill soils of Andamans (Mongia and Bandyopadhyay, 1991).

Significant correlation was noticed between Nitric acid K and organic carbon in five bench mark soils from Northern India (Brar and Sekhon, 1985) and in Central Haryana soils (Ravikumar et al.,1987).

The relationship was not significant in Akbarpur soil series (Brar and Sekhon, 1985) and in the acidic hill soils of Andamans (Mongia and Bandyopadhyay, 1991).

Koria et al. (1989) observed significant positive correlation of Nitric acid K with electrical conductivity in the soils of dry farming calcareous areas of Saurashtra region in Gujarat. In these soils HNO_3.K was correlated with lime content also.

In the acidic hill soils of Andamans, Mongia and Bandyopadhyay (1991) reported high positive correlation between HNO_3.K and pH.

The correlation with CEC was positive and significant in soils of Central Haryana (Ravikumar et al., 1987).

2.3.5. Non-exchangeable K

In acidic hill soils of Andamans significant positive correlation was noticed between fixed K and sand (Mongia and Bandyopadhyay, 1991), while negative relation was obtained in Haryana soils (Singh et al., 1983) and in some coastal soils (Bandyopadhyay et al., 1985).

Positive relationship existed between non-exchangeable K and finer fractions in Himachal Pradesh soils (Singh et al., 1983), in some coastal soils (Bandyopadhyay et. al., 1985) and in some Alfisols of West Bengal (Pal and Mukhopadhyay, 1990). In alluvial soils of Western Uttar Pradesh, Prakash and Singh (1985) did not obtain any significant relation of fixed K with clay. However the relationship with silt was positive and significant. Sharma and Mishra (1986) observed that in alluvial soils of Western Uttar Pradesh, the content of non-exchangeable K was higher in fine textured soils. Negative but insignificant relation was reported between fixed K and clay percentage in the soils of Garhwal hills (Singh and Singh, 1986).

Fixed K was highly positively correlated with pH in the acidic hill soils of Andamans (Mongia and Bandyopadhyay, 1991). No significant relation was observed between fixed K and pH in the alluvial soils of Western Uttar Pradesh (Prakash and Singh. 1985) while the relation was negative but insignificant in the soils of Garhwal hills (Singh and Singh, 1986).

Positive insignificant relation was noticed between non-exchangeable K and organic carbon in alluvial soils of Western Uttar Pradesh (Prakash and

Singh, 1985), in soils of Garhwal hills (Singh and Singh, 1986) and in the acidic hill soils of Andamans (Mongia and Bandyopadhyay, 1991).

Non-exchangeable K showed positive correlation with CEC in soils of Haryana (Singh et al., 1983), whereas in alluvial soils of Western Uttar Pradesh Prakash and Singh (1985) did not obtain any significant relation of fixed K with CEC.

2.3.6. **Total K**

Total K had negative correlation with sand content in some soils of Central Haryana (Ravikumar et al., 1987) and in soils under forest cover (Sahu and Gupta, 1988), while positive relation was observed between total K and sand in Jaria, Burju, Sidrol, Amba, Hututua, Burmu, Garra, Rege and Maka soil series of Chotanagpur region in Bihar (Singh et al., 1989). It had significant positive correlation with silt and clay in soils of Central Haryana (Ravikumar et al., 1987), in soils under forest cover (Sahu and Gupta, 1988) and positive correlation was observed between total K and silt content in soils of Mizoram (Singh et al., 1989). Negative correlation of total K with silt and clay contents was reported in nine soil series of content had negative correlation in soils of dry farming calcareous areas of Saurashtra region (Koria *et al.*,1989) and in Dandachali, Pankhil and Tegna soil series of Garhwal Himalayas (Mishra and Srivastava, 1991), while total K was positively related with clay percentage in some Alfisols of West Bengal (Pal and Mukhopadhyay, 1990).

No significant relationship of total K was obtained with pH, organic carbon and silt in alluvial soils of Agra region (Prakash and Singh, 1985). But it had positive significant relation with CEC in the same soil type.

Significant correlation was obtained between total K and organic carbon in the soils of Garhwal hills (Singh and Singh, 1986) and in some soils of Central Haryana (Ravikumar *et al.*, 1987), while the relation was insignificant in Mizoram soils (Singh and Datta, 1986). Positive significant relation existed between total K and CEC in some Central Haryana soils (Ravikumar *et al.*,1987) and in some soils under rice based cropping sequences (Zia *et al.*,1990) while the relation was negative in Jaria, Burju, Sidrol, Amba, Hututua, Burmu, Gorra, Rege and Maka soil series of Chotanagpur region (Singh et al., 1989).

2.4. Ionic interactions in soils

Reports on ionic interactions in soil especially that of potassium with other ions were collected to help the present discussion.

Mengel et al. (1976) reported research with rice where cation antagonism was brought about by lack of adequate K rather than a surplus of K. Low K^+, levels favoured the uptake of magnesium and calcium and resulted in lower plant yields than higher potassium levels.

Gerloff (1976) noted that sodium has the capacity to substitute partially the metabolic functions of potassium.

High exchangeable magnesium in black soils has been reported to suppress the potassium uptake of crops (Patil and Zande, 1975).

The addition of potassium increased the uptake of potassium but decreased that of sodium.

Potassium application did not significantly influence the uptake of calcium, iron, manganese and zinc (Krishnakumari and Rajvir Singh, 1991).

MATERIALS AND METHODS

MATERIALS AND METHODS

Surface soil samples from the different soil series in Thiruvananthapuram district, covering forests, mid uplands and coastal alluvium were collected for the project. The soil types and series are listed below:

Soil Types	Soil Series
1. Mid uplands	Trivandrum series
2. Coastal alluvium	Kazhakuttom series
3. Forest soil	Kottoor series

Number of samples per soil series : 50.

3.1. Trivandrum Series

The Trivandrum series is a member of clayey skeletal, kaolinitic, isohyperthermic family of Kandiustults. The soils occur on laterite mounds and are developed from gneissic rocks under humid tropical climate. The mean annual air temperature is 27.22^{o}C and mean annual rainfall is 1875 mm.

The soils are well drained with moderate permeability, and are cultivated mainly for coconut and tapioca. The series is distributed extensively in Thiruvananthapuram district. The soil responds to management practices including liming. The pH is low and the sesquioxide content is high. In general, the fertility is low and productivity potential is medium.

3.2. Kazhakuttom Series

Kazhakuttom series is a member of the coarse loamy mixed isohyperthermic family of Typic Tropofluents. They have developed in coastal alluvial sediments and occur in coastal plains of Thiruvanantha-puram district. The climate is humid tropical, with mean annual air temperature of 27.22^{o}C and mean annual rainfall of 1875 mm.

The soils are well drained with rapid permeability. The area is cropped mainly under rainfed condition. Coconut is the major crop, followed by tapioca. The ground water table is high and the productivity potential is poor to medium.

3.3. Kottoor Series

The Kottoor series is a member of the clayey skeletal mixed isohyperthermic family of Typic Hapludolls. The soils are strongly acid to medium acid in reaction. They are derived from gneissic rocks located on steep slopes of the Western ghats of

Thiruvananthapuram district. The climate is humid tropical, with mean annual air temperature of 26.8°C and mean annual rainfall of 1821 mm.

Kottoor series is distributed in the reserve forests of Thiruvananthapuram district. Since these are forest soils, and under good vegetative cover, the soils have a fairly high fertility status, with medium to high productivity potential. These are also moderately welldrained soils.

3.4. Analytical Methods

Different forms of soil potassium together with the physical and chemical properties of soils were studied.

The analytical procedures adopted for estimation of physical and chemical properties of soils as well as the different fractions of potassium were as follows.

3.4.1. Physical and Chemical characteristics of the soil

Sl.No.	Characteristics	Methods followed
1.	Mechanical composition	International pipette method, Piper, (1966)
2.	Soil reaction (soil:water 1:2.5)	pH meter with glass electrode as described by Jackson, (1967)

3.	Electrical conductivity (soil:water 1:2.5)	Conductivity bridge as described by Jackson, (1967)
4.	Organic carbon	Rapid titration method of Walkley and Black as described by Jackson, (1967)
5.	Cation exchange capacity	Using neutral normal ammonium acetate as proposed by Chapman, (1965)
6.	Base saturation	Using neutral normal ammonium acetate (Chapman, 1965)
7.	Interacting cations (exchangeable) like Ca, Mg and Na.	Jackson, (1967)

The following laboratory procedures were used to determine the different forms of potassium.

3.4.2. Water soluble K

It was estimated in 1:5 soil water suspension and expressed as me L^{-1}.

3.4.3. Neutral normal ammonium acetate soluble K

The method proposed by Hanway and Heidal (1952) was followed.

5g of soil was treated with 25 ml of neutral normal NH_4OAc and shaken for 5 minutes and filtered. K was determined by Atomic absorption spectrophotometer.

This fraction includes both water soluble and exchangeable K and is termed as available K.

3.4.4. Exchangeable K

This was determined by finding the difference between neutral normal NH_4OAc extractable K and water soluble K.

3.4.5. 1.0 N Boiling nitric acid K

The procedure as proposed by Wood and De Turk (1941) was followed.

2.5g of finely ground soil was taken in an Erlenmeyer flask and 25 ml of 1.0 N nitric acid was added. The contents were boiled for 10 minutes, cooled, filtered and made upto volume by subsequent washings with 1.0 N nitric acid. K was determined by Atomic absorption spectrophotometer.

3.4.6. Non-exchangeable K

This was estimated by subtracting the K determined by neutral normal NH_4OAc from that determined by 1.0 N boiling nitric acid.

The samples collected from each soil series were grouped into different fertility classes based on the levels of neutral normal ammonium acetate extractable potassium as suggested by Kanwar (1976). Accordingly, values ranging from 0-125 kg K_2O/ha was rated as low, 125-300 kg K_2O/ha as medium and above 300 kg K_2O/ha as high in potassium fertility.

Three soil samples (One each from the low, medium and high categories) from each soil series were selected for further estimation of total potassium.

The following procedure was adopted to determine total K.

3.4.7. Total K

Method suggested by Pratt (1965) was followed. 0.1g finely ground sample in a platinum crucible was digested with 5 ml HF and 0.5 ml $HClO_4$, first on a hot plate and then evaporated to dryness in a sand bath to temperature 200 to 225°C. It was cooled, 5 ml of 6.0 N HCl and 5 ml of water were added and boiled over a burner until the residue was completely dissolved. It was cooled, transferred and made up to volume and K was determined by Atomic absorption spectrophotometer.

3.5. Statistical Analysis

The data generated were satistically analysed to draw inference on different types of interactions that exist between the generated data.

3.5.1. Analysis of variance and F test were carried out to determine the extent of variation in the data from within and between the soil series.

3.5.2. Correlation was worked out between different forms of soil potassium.

3.5.3 Relationship between soil K fractions and other soil properties was determined.

3.5.4. The data on NH_4OAc extractable K was grouped into different fertility classes within each soil series. The above said relationship were worked out for different fertility classes for each series as well as for pooled data from all the three series.

RESULTS

RESULTS

4.1. Properties of test soils

4.1. Trivandrum series

4.1.1. Soil seperates

In Trivandrum soil series mean gravel content was 41.92 percent. There were also soils with only 25 percent gravel and with upto 59 percent gravel. Coarse sand content ranged between 35.55 to 64.05 percent with a mean value of 53.51. Fine sand varied from 9.8 to 22.5 percent with a mean of 14.33. Silt content was low with a range of 2.5 to 17.5 percent and with an average of 7.70 percent. The mean clay content was 23.4 percent. There were soils with clay content of 7.5 percent and also with 37.5 percent.

4.1.2. Chemical composition

The pH of the soil samples studied under Trivandrum series fell in the acidic range of 5.0 to 6.4 with a mean of 5.69. Electrical conductivity values for all soil samples were less than 0.05 dSm^{-1}. The organic carbon content of these soils was low with a range of 0.2 to 1.19 percent and a mean of 0.59

Table 1. Particle Size Distribution in Test Soils

Parameter	Trivandrum (n = 50)			Kazhakuttom (n = 50)			Kottoor (n = 50)			ANOVA	
	Mean (percent)	S.D	C.V (percent)	Mean (percent)	S.D	C.V (percent)	Mean (percent)	S.D	C.V (percent)	C.D	F at df 2,47
Gravel	41.92 (25.0-59.0)	7.12	16.98	5.62 (2.0-7.2)	1.34	23.84	31.73 (21.8-38.2)	3.64	11.47	1.84	799.85**
Coarse Sand	53.91 (35.55-64.05)	5.93	11.08	78.3 (62.45-86.20)	6.95	8.87	52.93 (41.15-70.75)	9.27	17.51	2.96	185.93**
Fine sand	14.33 (9.8-22.5)	2.91	20.34	9.10 (2.6-22.9)	5.68	62.42	16.57 (12.8-19.0)	1.44	8.69	1.49	51.51**
Silt	7.70 (2.5-17.5)	3.38	43.9	5.65 (2.5-10.0)	2.25	39.79	4.95 (2.5-10.0)	2.29	46.26	1.06	14.11**
Clay	23.4 (7.5-37.5)	6.03	25.77	7.70 (2.5-12.5)	2.47	32.08	24.00 (7.5-35.0)	6.66	27.75	2.12	147.47**
Textural class	Sandy clay loam			Sand/Loamy sand			Sandy clay loam				

** Significant at 1% level

Values in parenthesis show the range in content of soil separates.

percent. Because of less organic matter and dominance of 1:1 kaolinite clay minerals, these soils exhibited very low CEC. CEC values ranged from 2.4 to 6.5 with a mean of 4.38 cmols(p+)kg^{-1}. Percentage base saturation showed considerable variation in these soils such that the range was between 36 to 87.5 percent and a mean of 62.29 percent. With respect to soil nutrients, calcium content fell in the range of 14.73 to 40.05 cg kg^{-1} and the mean was 25.26 cg kg^{-1}. Magnesium content varied from 3.98 to 15.70 cg kg^{-1} and a mean of 9.01 cg kg^{-1}. With respect to sodium the range in content was between 8.50 to 15.21 cg kg^{-1} with a mean of 10.11 cg kg^{-1}.

4.1.1.3. **Forms of soil potassium**

The results indicated that water soluble K was relatively low in these soils. The mean content was found as 0.12 meq L^{-1} and the range was 0.04 to 0.22 meq L^{-1}.

With respect to available K as extracted by N.N.NH_4OAC, a vast majority of the soils under the present study were medium in content. Out of the 50 soil samples studied in Trivandrum series, 30 samples fell in the medium category with regard to available K content, ie. 60 percent of the test soils were medium in available K. The range was between 2.93 to 21.77 cg kg^{-1} with a mean of 8.39 cg kg^{-1}. (Fig.1)

The mean exchangeable K content was 7.93 cg Kg^{-1} and the range in content was from 2.82 to 20.10 cg kg^{-1}.

HNO_3 soluble K in Trivandrum soils was low with a range of 5.73 to 22.46 cg kg^{-1} and a mean of 11.81 cg kg^{-1}.

The values for non-exchangeable K content varied from 0.01 to 11.46 cg kg^{-1} with mean = 3.42 cg kg^{-1}.

The total K content in Trivandrum series soils ranged from 334 to 590 $cgkg^{-1}$ with a mean of 428 $cgkg^{-1}$.

4.1.2. **Kazhakuttom series**

4.1.2.1. **Soil seperates**

In Kazhakuttom soils gravel content was very low which ranged from 2.0 to 7.2 percent and a mean of 5.62 percent. Since these soils are seen in the coastal areas of Trivandrum district, they are typically sandy in nature which is evidenced from the

Table 2. Chemical Composition of Test Soils

Parameter	Unit	Trivandrum (n = 50) Mean	S.D	C.V (percent)	Kazhakuttom (n = 50) Mean	S.D	C.V (percent)	Kottoor (n = 50) Mean	S.D	C.V (percent)	ANOVA C.D	F at df 2,47
Soil reaction	-	5.69 (5.0-6.4)	0.35	6.22	5.79 (5.1-6.6)	0.35	6.10	5.39 (4.8-6.1)	0.39	7.30	0.14	16.70**
Electrical conductivity	dSm^{-1}											
Organic carbon	percent	0.59 (0.2-1.19)	0.22	36.86	0.21 (0.14-0.24)	2.58	0.13	1.08 (0.72-1.34)	0.18	16.68	6.44	363.08**
CEC	$cmols(p+)kg^{-1}$	4.38 (2.4-6.5)	0.99	22.67	2.91 (1.5-4.5)	0.66	22.81	5.37 (3.8-8.1)	0.94	17.46	0.35	99.43**
Base saturation	percent	62.29 (36.0-87.5)	13.82	22.19	59.06 (33.8-87.0)	14.70	24.89	63.93 (35.0-89.0)	16.54	25.87		1.35 ns
Exchangeable calcium	$cgkg^{-1}$	25.26 (14.73-40.05)	4.86	19.24	18.14 (10.48-38.0)	7.39	40.74	31.21 (18.55-56.25)	8.00	25.60	2.71	45.24**
Exchangeable magnesium	$cgkg^{-1}$	9.01 (3.98-15.70)	3.26	36.18	3.83 (2.12-9.65)	1.62	42.34	11.69 (7.27-18.99)	3.36	28.74	1.13	97.65**
Exchangeable sodium	$cgkg^{-1}$	10.11 (8.50-15.21)	1.25	12.36	7.69 (5.63-10.46)	1.09	14.17	9.50 (6.84-12.63)	1.69	17.79	0.54	42.42**

ns Not significant

** Significant at 1% level

Values in parenthesis show the range in chemical composition.

coarse sand and fine sand contents. The coarse sand varied between 62.45 and 86.20 percent with a mean of 78.30 percent and the mean fine sand content was 9.10 percent with a range of 2.6 to 22.9 percent. The silt and clay contents in these soils were almost similar. The mean content of silt and clay was 5.65 and 7.70 percent respectively and the range 2.5 to 10.0 percent and 2.5 to 12.5 percent respectively.

4.1.2.2. Chemical Composition

pH of the soil was acidic in nature with a mean pH value of 5.79 and the range in pH was from 5.1 to 6.6. Electrical conductivity for all soil samples were less than 0.05 dSm^{-1}. Organic matter content of these soils was very poor and as such the mean organic carbon content was only 0.21 percent (range of 0.14 to 0.24 percent).

Since these soils were sandy in texture and the dominant clay mineral being Kaolinite, they exhibited a very low CEC which fell in the range of 1.5 to 4.5 $cmols(p+)kg^{-1}$ with an average of 2.91 $cmols(p+)kg^{-1}$. Percentage base saturation showed

Table 3. Potassium Fractions in Test Soils (cg kg^{-1})

Parameter	Trivandrum (n = 50)			Kazhakuttom (n = 50)			Kottoor (n = 50)			ANOVA	
	Mean	S.D	C.V (percent)	Mean	S.D	C.V (percent)	Mean	S.D	C.V (percent)	C.D	F at df 2,47
Water soluble K	0.47 (0.17-0.86)	0.17	35.62	0.34 (0.19-0.76)	0.12	35.61	0.58 (0.40-0.97)	0.12	20.82	5.40	37.82**
Available K	8.39 (2.93-21.77)	4.41	52.56	4.69 (1.59-13.23)	2.60	55.44	15.90 (11.27-26.14)	3.81	23.96	1.45	120.33**
Exchangeable K	7.93 (2.82-20.10)	4.30	54.22	4.35 (1.38-12.99)	2.56	58.62	15.34 (8.08-25.39)	3.78	24.66	1.43	119.80**
Nitric acid K	11.81 (5.73-22.46)	4.26	36.07	10.18 (5.69-18.43)	2.49	24.46	31.13 (16.22-48.46)	8.30	26.67	2.20	218.48**
Non-exchange-able K	3.42 (0.01-11.46)	2.32	67.84	5.49 (0.45-10.22)	2.42	44.08	15.19 (1.69-33.44)	7.24	47.66	1.81	92.98**
Total K	428.0 (334-590)			162.0 (139-346)			344.0 (240-447)				

** Significant at 1% level

Values in parenthesis show the range in content of potassium fractions.

considerable variation within the Kazhakuttom soil series. It ranged from 33.8 to 87.0 percent with mean 59.06 percent.

Calcium, magnesium and sodium contents were low when compared to other test soils, with calcium content ranging between 10.48 and 38.0 cg kg^{-1} (mean 18.14 cg kg^{-1}), magnesium between 2.12 and 9.65 cg kg^{-1}, (mean 3.83 cg kg^{-1}) and sodium between 5.63 and 10.46 cg kg^{-1} (mean 7.69 cg kg^{-1}).

4.1.2.3. **Forms of soil potassium**

Because of the dominance of kaolinite type clay mineral and sandy texture, these soils cannot hold the nutrients especially potassium. Hence the present study indicated very low values for all forms of potassium.

Water soluble K content showed a range from 0.05 to 0.19 meq L^{-1} and the mean content being 0.09 meq L^{-1}.

Available K showed a range of 1.59 to 13.23 cg kg^{-1} with mean = 4.69 cg kg^{-1}. (Fig.2)

The mean exchangeable K content fell in the range of 1.38 to 12.99 cg kg^{-1}.

HNO_3.K content varied from 5.69 to 18.43 cg kg^{-1} with a mean value of 10.18 cg kg^{-1}.

Study revealed that the mean non-exchangeable K content was 5.49 cg kg^{-1} and the range was from 0.45 to 10.22 cg kg^{-1}.

In Kazhakuttom series soils, the total K content was in the range of 139 to 346 cgkg^{-1} with a mean of 162 cgkg^{-1}.

4.1.3. Kottoor series

4.1.3.1. Soil seperates

The gravel content of Kottoor forest soil ranged from 21.8 to 38.2 percent with an average of 31.73 percent. The mean value for coarse sand was 52.93 percent (range 41.15 to 70.75 percent) and that for fine sand was 16.57 percent (range 12.8 to 19.0 percent). Silt contributed a lesser extent to soil seperates with a mean content of 4.95 percent (range 2.5 to 10.0 percent) and clay percent was somewhat high, mean content being 24 percent (range 7.5 to 35.0 percent).

4.1.3.2. Chemical composition

pH of Kottoor soil was distinctly acidic in reaction with a mean pH value of 5.39 and the range being 4.8 to 6.1. Electrical conductivity for all soil samples were less than 0.05 dSm^{-1}.

Since Kottoor soil is a forest soil, these soils are rich in organic matter and the results indicated that the mean organic carbon content as 1.08 percent with a range of 0.72 to 1.34 percent.

Because of the presence of high organic matter these soils had slightly higher CEC when compared to other two test soils. CEC values ranged between 3.8 and 8.1 $cmols(p+)kg^{-1}$ with a mean value of 5.37 $cmols(p+)kg^{-1}$. There was considerable variation in percentage base saturation with values ranging from 35.0 to 89.0 percent and mean 63.93 percent. Regarding the soil nutrient contents both calcium and magnesium were higher in these soils. The mean content of calcium being 31.21 cg kg^{-1} (range 18.55 to 56.25 cg kg^{-1}) and that of magnesium was 11.69 cg kg^{-1} (range 7.27 to 18.99 cg kg^{-1}). The mean sodium content was 9.50 cg kg^{-1} (range 6.84 to 12.63 cg kg^{-1}).

4.1.3.3. Forms of soil potassium

A higher content of all forms of K studied was noticed in the case of Kottoor soil series.

Water soluble K ranged from 0.10 to 0.25 meq L^{-1} and the mean was 0.15 meq L^{-1}.

Mean Available K content was 15.09 cg kg^{-1}, with the range of 11.27 to 26.14 cg kg^{-1}. (Fig.3)

Exchangeable K content varied between 8.08 and 25.39 cg kg^{-1} and the mean value was 15.34 cg kg^{-1}. Results from the present study indicated that the mean content of HNO_3 soluble K in Kottoor soils was 31.13 cg kg^{-1} with the range of 16.22 to 48.46 cg kg^{-1}. The mean value for non-exchangeable K content was found as 15.19 cg kg^{-1} and the range was 1.69 to 33.44 cg kg^{-1}.

4.2. Soil Fertility Ratings

The test samples from the three different soil series were classified seperately into different fertility classes based on the levels of ammonium acetate extractable potassium. The procedure suggested by Kanwar (1976) was adopted. Accordingly values ranging from 0-125 Kg K_2O/ha was rated as low, 125-300

Table 4. Fertility Ratings for Test Soils Based on Ammonium acetate Extractable Potassium

	Trivandrum series		Kazhakuttom series		Kottoor series		Total No. of samples	Percentage of total
	No.of samples	Percentage of total	No.of samples	Percentage of total	No.of samples	Percentage of total		
Low	9	18	29	58	-	-	38	25.33
Medium	30	60	20	40	3	6	53	35.33
High	11	22	1	2	47	94	59	39.33
Total	50	100	50	100	50	100	150	100

Kg K_2O/ha as medium and above 300 Kg K_2O/ha as high fertility. The number of samples and the percentage of the total number of samples falling under the different fertility classes are presented in Table 4.

4.2.1. Trivandrum Series

Most of the samples (60 percent of the total) tested for the study from Trivandrum series were falling under medium fertility with respect to ammonium acetate K. The rest of the samples were distributed both under low fertility (9 out of 50 samples ie., 18 percent) and high fertility (11 out of 50 samples ie., 22 percent).

4.2.2. Kazhakuttom Series

Samples from Kazhakuttom series were generally low and medium in potassium fertility (58 percent and 40 percent respectively). Out of the 50 samples analysed only one sample showed high potassium fertility whereas 29 samples were low and 20 samples were medium in potassium fertility.

4.2.3. Kottoor Series

Kottoor soil samples were high in potassium fertility (47 out of 50 samples; ie., 94 percent) except for 3 out of 50 samples (6 percent) falling under medium fertility. None of the samples from Kottoor series could be classified as low in potassium fertility.

4.2.4. Total test samples (pooled)

When the results of the whole test samples (150 Nos) were pooled together, it was observed that 38 samples were low, 53 samples were medium and 59 samples were high in ammonium acetate extractable K.

4.3. Behaviour of soil potassium in different soil series

In order to study the behaviour of different fractions of soil potassium in terms of inter-fraction interaction as well as their interaction with other soil components, simple correlation coefficients were worked out and are presented in the ensuing tables. The relationships worked out within each series are presented in Tables 5,6 and 7.

Table. 5 Behaviour of Soil Potassium in Trivandrum Series.

	Water soulble K	Ammonium acetate K	Exchangeable K	Nitric acid soluble K	Non-exchangeable K
Gravel	0.0092	0.3474*	0.3560*	0.1836	−0.3239*
Coarse sand	−0.1547	−0.0419	−0.0370	−0.0578	−0.0274
Fine sand	−0.1159	−0.1112	−0.1095	−0.0692	0.0843
Silt	0.1255	0.1327	0.1312	0.0566	−0.1489
Clay	−0.0462	−0.2347	0.2389	−0.1670	0.1407
Soil reaction	−0.3273*	−0.2445	−0.2382	−0.1645	0.1630
Organic carbon	0.2887*	0.2535	0.2488	0.1842	−0.1437
CEC	0.1044	0.3221*	0.3261*	0.2511	−0.1508
Base saturation	0.0937	0.2163	0.2184	0.2032	−0.0394
Ex.calcium	0.0906	0.4129**	0.4198**	0.2699	−0.2905*
Ex.magnesium	0.1207	0.4647**	0.4718**	0.4853**	0.0077
Ex.sodium	0.1230	0.4760**	0.4836**	0.3198*	−0.3184*
Water soluble K		0.6802**	0.6593**	0.6022**	−0.1890
Ammonium acetate K			0.9996**	0.8572**	−0.3285*
Exchangeable K				0.8562**	−0.3295*
Nitric acid K					0.2048
Non-exchangeable K					

* Significant at 5% level

** Significant at 1% level

4.3.1. Behaviour of soil potassium in Trivandrum series

4.3.1.1. Inter-fraction interaction

In Trivandrum soil series, water soluble K had highly significant positive relationship with available K, exchangeable K and HNO_3.K but negative and insignificant relationship with non-exchangeagle K.

Available K was positively and highly significantly correlated with exchangeable K and HNO_3.K but the relationship with non-exchangeable K was negative and significant.

Positive and highly significant correlation existed between exchangeable K and HNO_3.K and negative and significant correlation with non-exchangeable K.

The relationship between HNO_3.K and non-exchangeable K was positive but not significant.

4.3.1.2. Potassium fractions Vs soil properties

4.3.1.2.1. Water soluble K

In Trivandrum soil series, water soluble K had positive significant relation with organic carbon and positive but insignificant relation with gravel content, silt, CEC, percentage base saturation, calcium, magnesium and sodium.

It had negative significant relation with pH and negative insignificant relation with coarse sand, fine sand and clay.

4.3.1.2.2. Available K

Positive significant relation was obtained with gravel, CEC and with calcium, magnesium and sodium. Available K was positively and insignificantly related to silt, organic carbon and percentage base saturation. The relationship with coarse sand, fine sand, clay and pH was negative insignificant.

4.3.1.2.3. Exchangeable K

Exchangeable K was significantly and positively related with gravel, CEC and with calcium, magnesium and sodium.

The relationship with silt, organic carbon and percentage base saturation was positive but not significant.

Negative insignificant relation was noticed with coarse sand, fine sand, clay and pH.

4.3.1.2.4. HNO_3.K

The relation was positive and significant with magnesium and sodium. It was found that HNO_3.K was positively and insignificantly related with gravel, silt, organic carbon, CEC, percentage base saturation and calcium. Negative insignificant relation was observed with coarse sand, fine sand, clay and pH.

4.3.1.2.5. Non-exchangeable K

Positive insignificant relation was noticed with fine sand, clay, pH and magnesium. Negative significant relation was obtained with gravel, calcium and sodium. The relationship of non-exchangeable K with coarse sand, silt, organic carbon, CEC and percentage base saturation was negative and not significant.

4.3.2. Behaviour of soil potassium in Kazhakuttom series

4.3.2.1. Inter-fraction interaction

In Kazhakuttom soil series, water soluble K

Table. 6 Behaviour of Soil Potassium in Kazhakuttom Series.

	Water soulble K	Ammonium acetate K	Exchangeable K	Nitric acid soluble K	Non-exchangeable K
Gravel	−0.5121**	−0.3109*	−0.2923*	0.2052	0.5440**
Coarse sand	0.1233	0.1872	0.1846	0.3584*	0.1676
Fine sand	−0.2071	−0.1184	−0.1108	−0.3335*	−0.2157
Silt	−0.0920	0.0473	0.0523	−0.1018	−0.1551
Clay	0.0455	−0.0284	−0.0306	0.0800	0.1121
Soil reaction	0.2384	0.1137	0.1045	−0.0747	−0.1988
Organic carbon	−0.0958	−0.0575	−0.0537	0.1405	0.2057
CEC	0.4509**	0.4637**	0.4508**	0.0057	−0.4910**
Base saturation	0.0824	0.2851*	0.2866*	0.4921**	0.1999
Ex.calcium	0.2805	0.4960**	0.4920**	0.4087**	−0.1117
Ex.magnesium	0.5504**	0.4487**	0.4308**	0.2831	−0.1898
Ex.sodium	0.1410	0.5413**	0.5446**	0.4272**	−0.1412
Water soluble K		0.4070**	0.3669*	0.0409	−0.3939**
Ammonium acetate K			0.9991**	0.5464**	−0.5108**
Exchangeable K				0.5546**	−0.5014**
Nitric acid K					0.4409**
Non-exchangeable K					

* Significant at 5% level

** Significant at 1% level

was positively and significantly correlated with available K and exchangeable K. It had positive but insignificant relation with HNO_3.K. Negative and significant relation was noticed between water soluble K and non-exchangeable K.

It was observed that available K had positive and significant relation with exchangeable K and HNO_3.K and negative and significant relation with non-exchangeable K.

Exchangeable K was positively and significantly related with HNO_3.K. The relation with non-exchangeable K was negative and significant.

Positive and significant relation was noticed between HNO_3.K and non-exchangeable K.

4.3.2.2. Potassium fractions Vs soil properties

4.3.2.2.1. Water soluble K

Positive and significant relation was noted with CEC and magnesium. In Kazhakuttom soil series, it was observed that water soluble K was positively and insignificantly related to coarse sand, clay, percentage base saturation, calcium and sodium.

The relation with gravel was negative and highly significant; while the relationship with fine sand, silt and organic carbon was negative and not significant.

4.3.2.2.2. **Available K**

Positive significant relation was observed with CEC, percentage base saturation and calcium, magnesium and sodium. There was positive and insignificant relation of available K with coarse sand, silt and pH. The relation with gravel content was negative and significant; while the relation was negative but not significant with fine sand, clay and organic carbon.

4.3.2.2.3. **Exchangeable K**

There was positive and significant relation of exchangeable K with CEC, percentage base saturation and calcium, magnesium and sodium contents.

Exchangeable K had positive but in significant relation with coarse sand, silt and pH.

Exchangeable K was negatively and insignificantly related to fine sand, clay and organic carbon; while the relation with gravel was negative and significant.

4.3.2.2.4. HNO_3.K

Positive significant relation was obtained with coarse sand, percentage base saturation, calcium and sodium; while positive insignificant relation was found with gravel, clay, organic carbon, CEC and magnesium. Negative significant relation was obtained only with fine sand.The relation of HNO_3.K with silt and pH was negative but insignificant.

4.3.2.2.5. Non-exchangeable K

Positive significant relation was obtained only with gravel; while it had positive insignificant relation with coarse sand, clay, organic carbon and percentage base saturation.

Negative insignificant relation was noticed with fine sand, silt, pH and calcium, magnesium and sodium while; the relation with CEC was negative and significant.

4.3.3. Behaviour of soil potassium in Kottoor Series

Table. 7 Behaviour of Soil Potassium in Kottoor Series.

	Water soulble K	Ammonium acetate K	Exchangeable K	Nitric acid soluble K	Non-exchangeable K
Gravel	−0.0943	−0.0036	−0.0053	−0.0240	−0.0250
Coarse sand	0.0767	−0.2899 *	−0.2894 *	0.1802	0.3572 *
Fine sand	−0.0285	0.2929 *	0.2905 *	−0.0127	−0.1723
Silt	0.0707	0.1611	0.1653	0.0952	0.0306
Clay	−0.2163	0.1889	0.1926	−0.1836	−0.3192 *
Soil reaction	0.1372	−0.2973 *	−0.2990 *	0.0270	0.1813
Organic carbon	−0.2176	0.2189	0.2231	−0.0236	−0.1464
CEC	0.2470	0.5811 **	0.5750 **	−0.0070	−0.3145 *
Base saturation	0.0110	−0.2517	−0.2503	0.0087	0.1392
Ex.calcium	0.1987	−0.0587	−0.0622	−0.2662	−0.2776
Ex.magnesium	0.0737	−0.1254	−0.1290	−0.1567	−0.1258
Ex.sodium	0.0654	0.3060 *	0.3092 *	0.4960 **	0.4126 **
Water soluble K		0.2939 *	0.2653	0.1465	0.0142
Ammonium acetate K			0.9994 **	0.5048 **	0.0571
Exchangeable K				0.5050 **	0.0576
Nitric acid K					0.8900 **
Non-exchangeable K					

* Significant at 5% level

** Significant at 1% level

4.3.3.1. Inter-fraction interaction

In Kottoor soil series, it was found that water soluble K had positive and significant relation only with available K. The relation with exchangeable K, HNO_3.K and non-exchangeable K was positive but not significant.

Available K was positively and significantly related with exchangeable K and HNO_3.K and the relation with non-exchangeable was positive but not significant.

Exchangeable K showed positive and significant relation with HNO_3.K and positive but insignificant relation with non-exchangeable K.

Positive and highly significant relation existed between HNO_3.K. and non-exchangeable K.

4.3.3.2. Potassium fractions Vs soil properties

4.3.3.2.1. Water soluble K

In Kottoor soil series, water soluble K was positively and insignificantly related with coarse sand, silt, pH, CEC, percentage base saturation and calcium, magnesium and sodium.

It had negative insignificant relation with gravel, fine sand, clay and organic carbon.

4.3.3.2.2. **Available K**

It was found that available K was positively and significantly related with fine sand, CEC and sodium; while positively and insignificantly related with silt, clay and organic carbon. Negative significant relation was observed with coarse sand and pH. Negative insignificant relation was obtained with gravel, percentage base saturation, calcium and magnesium.

4.3.3.2.3. **Exchangeable K**

The relation of exchangeable K with fine sand, CEC and sodium was positive and significant. Exchangeable K had positive but insignificant relation with silt, clay and organic carbon.

Negative and significant relation was obtained with coarse sand and pH. It had negative insignificant relation with gravel, percentage base saturation, calcium and magnesium.

4.3.3.2.4. HNO_3.K

It was found that HNO_3.K was positively and significantly related with sodium but insignificantly related with coarse sand, silt, pH and percentage base saturation.

HNO_3.K had negative but insignificant relation with gravel, fine sand, clay, organic carbon, CEC, calcium and magnesium.

4.3.3.2.5. Non-exchangeable K

In Kottoor series, it was observed that non-exchangeable K was positively and significantly related with coarse sand but insignificantly related with silt, pH and percentage base saturation.

The relation was negative and significant with clay and CEC but negative and not significant with gravel, fine sand, organic carbon, calcium and magnesium.

4.4. Behaviour of soil potassium under varying soil fertility

Correlation coefficients were worked out

Table. 8 Behaviour of Soil Potassium;(a) when available K was low in Trivandrum Series.

	Water soulble K	Ammonium acetate K	Exchangeable K	Nitric acid soluble K	Non-exchangeable K
Gravel	−0.6190	0.1345	0.3218	0.2228	0.1919
Coarse sand	−0.4677	0.1824	0.3242	0.1991	0.1451
Fine sand	−0.5463	0.3649	0.5326	0.3240	0.2094
Silt	0.6621	0.1670	−0.0279	−0.0773	−0.1555
Clay	0.7065*	−0.0455	−0.2562	−0.1355	−0.1302
Soil reaction	0.1314	−0.2819	−0.3250	0.1574	0.2904
Organic carbon	−0.2714	0.6072	0.6974*	0.5202	0.3279
CEC	−0.6760*	0.3599	0.5672	−0.0348	−0.1881
Base saturation	0.2897	−0.3328	−0.4269	−0.1234	0.0007
Ex.calcium	−0.6673*	0.2705	0.4721	−0.1554	−0.2858
Ex.magnesium	−0.7028*	0.4122	0.6265	0.0376	−0.2128
Ex.sodium	−0.0698	0.5455	0.5721	−0.2412	−0.4947
Water soluble K		0.1994	−0.0960	0.1945	0.1335
Ammonium acetate K			0.9562**	0.4454	0.0804
Exchangeable K				0.3970	0.0448
Nitric acid K					0.9282**
Non-exchangeable K					

* Significant at 5% level

** Significant at 1% level

between different forms of potassium as well as those between potassium fractions and soil properties in different fertility classes within each series and irrespective of taxonomic difference. The results are presented in the following sections.

4.4.1. Trivandrum Series (Low fertility)

4.4.1.1. Inter-fraction interaction

It was observed that water soluble K had positive but insignificant relation with available K, HNO_3.K and non-exchangeable K but the relation with exchangeable K was negative and not significant.

Available K was positively and significantly related to exchangeable K while positive but insignificant relation was noticed with HNO_3.K and non-exchangeable K.

Exchangeable K had positive insignificant relation with HNO_3.K and non-exhangeable K.

HNO_3.K was positively and significantly related with non-exchangeable K.

4.4.1.2. Potassium fractions Vs soil properties

4.4.1.2.1. Water soluble K

It had positive significant relation with clay; while the relation with silt, pH and percentage base saturation was positive but not significant.

Significant negative relation was observed with CEC, calcium, magnesium and sodium. The relation with gravel, coarse sand, fine sand and organic carbon was negative but not significant.

4.4.1.2.2. Available K

Positive insignificant relationship existed between available K and most of the soil properties studied except with clay, pH and percentage base saturation which was negative but not significant.

4.4.1.2.3. Exchangeable K

It had significant positive relation only with organic carbon. Positive insignificant relation was noticed with gravel, coarse sand, fine sand, CEC, calcium, magnesium and sodium. The relation with silt, clay, pH and percentage base saturation was negative but not significant.

4.4.1.2.4. HNO_3.K

Nitric acid soluble K was positively but insignificantly related with gravel, coarse sand, fine sand, pH, organic carbon and magnesium. The relationship with silt, clay, CEC, percentage base saturation, calcium and sodium was negative and insignificant.

4.4.1.2.5. Non-exchangeable K

Positive insignificant relation existed with gravel, coarse sand, fine sand, pH, organic carbon and percentage base saturation; while negative but insignificant relation was observed with silt, clay, CEC, calcium, magnesium and sodium.

4.4.2. Trivandrum Series (Medium fertility)

4.4.2.1. Inter-fraction interaction

It was seen that water soluble K was positively and significantly related with available K, exchangeable K and HNO_3.K. The relationship with non-exchangeable K was negative but not significant.

Table. 9 Behaviour of Soil Potassium; (b) when available K was medium in Trivandrum Series.

	Water soulble K	Ammonium acetate K	Exchangeable K	Nitric acid soluble K	Non-exchangeable K
Gravel	−0.0422	0.3612*	0.3777*	−0.1252	−0.4425*
Coarse sand	0.0028	0.1358	0.1406	−0.0522	−0.1721
Fine sand	−0.0644	−0.3698*	−0.3875*	−0.1787	0.0814
Silt	0.0345	−0.1107	−0.1172	−0.1299	−0.0678
Clay	−0.1438	0.0047	0.0140	0.0559	0.0644
Soil reaction	−0.1706	0.1218	0.1367	0.1486	0.0832
Organic carbon	0.2520	0.1771	0.1676	−0.1087	0.2744
CEC	0.1498	0.0911	0.0846	0.0264	−0.0408
Base saturation	−0.0213	0.2973	0.3100	0.1595	−0.0467
Ex.calcium	0.2860	0.4557*	0.4545*	0.0794	−0.2716
Ex.magnesium	−0.1248	0.3142	0.3335	0.3029	0.1151
Ex.sodium	−0.1346	0.2306	0.2477	−0.0595	−0.2583
Water soluble K		0.6225**	0.5833**	0.3740*	−0.0506
Ammonium acetate K			0.9988**	0.5708**	−0.1151
Exchangeable K				0.5692**	−0.1160
Nitric acid K					0.7499**
Non-exchangeable K					

* Significant at 5% level

** Significant at 1% level

with both exchangeable K and HNO_3.K and negative insignificant relation with non-exchangeable K.

The relation between exchangeable K and HNO_3.K was positive and significant while negative but insignificant relation was obtained with non-exchangeable K.

HNO_3.K had positive and highly significant relation with non-exchangeable K.

4.4.2.2. Potassium fractions Vs Soil properties

4.4.2.2.1. Water soluble K

Positive insignificant relation of water soluble K was observed with coarse sand, silt, organic carbon, CEC and calcium, while the relation with gravel, fine sand, clay, pH, percentage base saturation, magnesium and sodium was negative but not significant.

4.4.2.2.2. Available K

It was seen that available K was positively and significantly related with gravel and calcium. Positive insignificant relation was noticed with coarse sand, clay, pH, organic carbon, CEC, percentage base saturation, magnesium and sodium.

Negative significant relation was obtained with fine sand fraction; while the relation with silt was negative but not significant.

4.4.2.2.3. Exchangeable K

Exchangeable K was positively and significantly related with gravel and calcium. The relation was positive but not significant with coarse sand, clay, pH, organic carbon, CEC, percentage base saturation, magnesium and sodium.

Negative significant relation was observed with fine sand only and negative but insignificant relation with silt.

4.4.2.2.4. HNO_3.K

It was noticed that positive but insignificant relation existed between HNO_3.K and other properties like clay, pH, CEC, percentage base saturation, calcium and magnesium.

Negative but insignificant relation was found with gravel, coarse sand, fine sand, silt, organic carbon and sodium.

4.4.2.2.5. Non-exchangeable K

It had positive insignificant relationship with fine sand, clay, pH, organic carbon and magnesium.

The relation was negative and significant with gravel content. Negative but insignificant relation was noticed with coarse sand, silt, CEC, percentage base saturation, calcium and sodium contents.

4.4.3. Trivandrum Series (High fertility)

4.4.3.1. Inter-fraction interaction

The relation between water soluble K and available K was positive and significant. Water soluble K had positive but insignificant relation with exchangeable K and HNO_3 K. The relationship with non-exchangeable K was negative but not significant.

Available K had positive and highly significant relationship with both exchangeable and

Table. 10 Behaviour of Soil Potassium; (c) when available K was high in Trivandrum Series.

	Water soulble K	Ammonium acetate K	Exchangeable K	Nitric acid soluble K	Non-exchangeable K
Gravel	—0.0427	—0.0840	—0.0842	—0.0494	0.0718
Coarse sand	—0.0286	0.2525	0.2621	0.2980	0.0613
Fine sand	—0.0969	—0.1898	—0.1903	—0.0936	0.1989
Silt	0.0560	0.3113	0.3176	0.1667	—0.3058
Clay	0.0678	—0.4642	—0.4819	—0.4036	0.1585
Soil reaction	—0.4731	0.1408	0.1689	0.2122	0.1226
Organic carbon	0.3902	0.0089	—0.0103	0.0961	0.1673
CEC	0.3192	0.3970	0.3931	0.3986	—0.0281
Base saturation	—0.0453	0.1638	0.1713	0.1674	—0.0108
Ex.calcium	0.0151	0.5402	0.5563	0.4502*	—0.2203
Ex.magnesium	0.3194	0.5058	0.5056	0.6090	0.1505
Ex.sodium	—0.0289	0.4004*	0.4145	0.2920	—0.2414
Water soluble K		0.6298	0.5994**	0.5652**	—0.1781
Ammonium acetate K			0.9993	0.8696**	—0.3372
Exchangeable K				0.8683	—0.3383
Nitric acid K					0.1716
Non-exchangeable K					

* Significant at 5% level

** Significant at 1% level

HNO_3.K; while the relation with non-exchangeable K was negative insignificant.

Positive significant relation was observed between exchangeable K and nitric acid K. The relation between exchangeable K and non-exchangeable K was negative but not significant.

HNO_3.K had positive insignificant relation with non-exchangeable K.

4.4.3.2. Potassium fractions Vs Soil properties

4.4.3.2.1. Water soluble K

It had positive insignificant relation with silt, clay, organic carbon, CEC, calcium and magnesium. The relation was negative but not significant with gravel, coarse sand, fine sand, pH, percentage base saturation and sodium.

4.4.3.2.2. Available K

Positive insignificant relation existed with coarse sand, silt, pH, organic carbon, CEC, percentage base saturation, calcium, magnesium and sodium. The relation was negative but not significant with gravel, fine sand and clay.

4.4.3.2.3. **Exchangeable K**

It had positive insignificant relation with coarse sand, silt, pH, CEC, percentage base saturation, calcium, magnesium and sodium contents.

The relation with gravel, fine sand, clay and organic carbon was negative but not significant.

4.4.3.2.4. **HNO_3.K**

It was observed that HNO_3.K was positively and significantly related with magnesium but insignificantly related with coarse sand, silt, pH, organic carbon, CEC, percentage base saturation calcium and sodium.

It had negative but insignificant relation with gravel, fine sand and clay.

4.4.3.2.5. **Non-exchangeable K**

Positive insignificant relationship was noticed with gravel, coarse sand, fine sand, clay, pH, organic carbon and magnesium.

Table. 11 Behaviour of Soil Potassium; (a) when available K was low in Kazhakuttom Series.

	Water soulble K	Ammonium acetate K	Exchangeable K	Nitric acid soluble K	Non-exchangeable K
Gravel	−0.1160	0.1163	0.1283	0.2999	0.3157
Coarse sand	0.1273	0.4136*	0.4091*	0.5560**	0.5052**
Fine sand	−0.0745	−0.4511*	−0.4523*	−0.6397**	−0.5910**
Silt	−0.2546	−0.2048	−0.1871	−0.1668	−0.1188
Clay	0.1580	0.1770	0.1675	0.2195	0.1298
Soil reaction	0.2969	0.0432	0.0187	−0.3159	−0.4005*
Organic carbon	−0.0779	−0.1643	−0.1598	−0.0058	0.0591
CEC	0.1480	−0.2002	−0.2169	−0.5892**	−0.6320**
Base saturation	0.1709	0.3211	0.3129	0.4684*	0.4366*
Ex.calcium	0.3696*	−0.0074	−0.0390	−0.2487	−0.2982
Ex.magnesium	0.3776*	0.2012	0.1721	−0.0508	−0.1429
Ex.sodium	0.1033	0.5275**	0.5271**	0.4999**	0.3913*
Water soluble K		0.2425	0.1607	0.0682	−0.0152
Ammonium acetate K			0.9965**	0.6406**	0.3690*
Exchangeable K				0.6458**	0.3766*
Nitric acid K					0.9501**
Non-exchangeable K					

* Significant at 5% level

** Significant at 1% level

The relation was negative but not significant with silt, CEC, percentage base saturation, calcium and sodium contents.

4.4.4. Kazhakuttom series (Low fertility)

4.4.4.1. Inter-fraction interaction

It was noticed that water soluble K was positively but insignificantly related with available K, exchangeable K and HNO_3.K but with non-exchangeable K it had negative insignificant relationship.

Positive significant relation was obtained between available K and the other forms, ie., exchangeable K, HNO_3.K and non-exchangeable K.

Exchangeable K had positive significant relation with both HNO_3.K and non-exchangeable K.

Highly significant positive relation was observed between HNO_3.K and non-exchangeable K.

4.4.4.2. Potassium fractions Vs Soil properties

4.4.4.2.1. Water soluble K

It had positive significant relation with calcium and magnesium. Positive but insignificant relation was observed with coarse sand, clay, pH, CEC, percentage base saturation and sodium.

The relation was negative but not significant with gravel, fine sand, silt and organic carbon.

4.4.4.2.2. Available K

Positive and significant relation was noticed with coarse sand and sodium; while the relation was positive but not significant with gravel, clay, pH, percentage base saturation and magnesium.

The relationship was negative and significant with fine sand and negative but not significant with silt, organic carbon, CEC and calcium.

4.4.4.2.3. Exchangeable K

Exchangeable K had significant positive correlation with coarse sand and sodium; while insignificant positive relation was observed with gravel, clay, pH, percentage base saturation and magnesium.

The relation with fine sand was negative and significant, while insignificant negative relation was noticed with silt, organic carbon, CEC and calcium.

4.4.4.2.4. HNO_3.K

Positive significant relation was obtained with coarse sand, percentage base saturation and sodium; while negative significant relation was noticed with fine sand and CEC.

Positive insignificant relation was found with gravel and clay. The relation with silt, pH organic carbon, calcium and magnesium was negative but not significant.

4.4.4.2.5. Non-exchangeable K

It had significant positive relation with coarse sand, percentage base saturation and sodium; while insignificant positive relation was observed with gravel, clay and organic carbon. The relation with fine sand, pH and CEC was negative and significant, but negative insignificant relation was noticed with silt, calcium and magnesium.

4.4.5. Kazhakuttom Series (Medium fertility)

Table. 12 Behaviour of Soil Potassium; (b) when available K was medium in Kazhakuttom Series.

	Water soulble K	Ammonium acetate K	Exchangeable K	Nitric acid soluble K	Non-exchangeable K
Gravel	−0.3420	0.1785	0.2119	0.5549*	0.4991*
Coarse sand	−0.2108	−0.0641	−0.0445	−0.0941	−0.0616
Fine sand	−0.2589	0.0976	0.1222	0.2412	0.2029
Silt	0.1540	0.0220	0.0062	−0.2011	−0.2372
Clay	−0.0696	−0.0420	−0.0343	0.0217	0.0517
Soil reaction	0.1587	0.1949	0.1802	0.1220	0.0062
Organic carbon	−0.0827	0.2048	0.2135	0.4610*	0.3776
CEC	0.3003	0.0558	0.0272	0.1319	0.1099
Base saturation	−0.0281	0.2551	0.2585	0.4553*	0.3376
Ex.calcium	0.0491	0.3807	0.3775	0.6654**	0.4862*
Ex.magnesium	0.4427*	0.1960	0.1541	0.2993	0.2037
Ex.sodium	−0.2045	0.2384	0.2595	0.1202	−0.0239
Water soluble K		0.0723	−0.0235	−0.2293	−0.3029
Ammonium acetate K			0.9954**	0.4577*	−0.1532
Exchangeable K				0.4814*	−0.1239
Nitric acid K					0.8085**
Non-exchangeable K					

* Significant at 5% level

** Significant at 1% level

4.4.5.1. Inter-fraction interaction

Positive but insignificant relation was obtained between water soluble K and available K.

The relation between water soluble K and other forms of K, ie. exchangeable K, HNO_3.K and non-exchangeable K was negative but not significant.

Available K had significant positive correlation with both exchangeable K and HNO_3.K; while the relation with non-exchangeable K was negative insignificant.

Exchangeable K was positively and significantly related with HNO_3.K and negatively but insignificantly related with non-exchangeable K.

HNO_3.K had significant positive relation with non-exchangeable K.

4.4.5.2. Potassium fractions Vs Soil properties

4.4.5.2.1. Water soluble K

There was significant positive relation between water soluble K and magnesium. The relation was positive insignificant with silt, pH, CEC and with gravel, coarse sand, fine sand, clay, organic carbon, percentage base saturation and sodium.

4.4.5.2.2. Available K

It was noticed that available K had positive insignificant relation with gravel fine sand, silt, pH, organic carbon, CEC, percentage base saturation, calcium, magnesium and sodium. Negative but insignificant relation was found only with coarse sand and clay.

4.4.5.2.3. Exchangeable K

There was positive but insignificiant relationship with gravel, fine sand, silt, pH, organic carbon, CEC, percentage base saturation, calcium, magnesium and sodium.

The relation with coarse sand and clay was negative but not significant.

4.4.5.2.4. HNO_3.K

HNO_3.K was positively and significantly related to gravel, organic carbon, percentage base saturation and calcium, and insignificant positive relationship with fine sand, clay, pH, CEC, magnesium and sodium.

The relationship was negative but not significant with coarse sand and silt.

4.4.5.2.5. Non-exchangeable K

There was positive significant relation of non-exchangeable K with gravel and calcium. Insignificant positive relation was obtained with fine sand, clay, pH, organic carbon, CEC, percentage base saturation and magnesium.

The relation with coarse sand, silt and sodium was negative but not significant.

In Kazhakutton series sufficient soil samples were not there in the high available K category so as to get a correlation.

4.4.6. Kottoor series (High fertility)

In Kottoor series only very limited soil samples were there in both low and medium K status categories and hence correlation could not be worked out.

Table. 13 Behaviour of Soil Potassium; (b) when available K was high in Kottoor Series.

	Water soulble K	Ammonium acetate K	Exchangeable K	Nitric acid soluble K	Non-exchangeable K
Gravel	−0.0746	0.1136 *	0.1118 *	0.0610	0.0107 *
Coarse sand	0.0398	−0.3267	−0.3246	0.1355	0.3143
Fine sand	0.0384	0.2656	0.2626	−0.0393	−0.1820
Silt	0.0729	0.1809	0.1856	0.1060	0.0330 *
Clay	−0.2033	0.2233 **	0.2268 **	−0.1596	−0.3008
Soil reaction	0.0907	−0.3981 *	−0.3984 *	−0.0802	0.1058
Organic carbon	−0.1753	0.2957 **	0.2988 **	0.0913	−0.0529 *
CEC	0.2484	0.5636 *	0.5562 *	−0.0400	−0.3306
Base saturation	−0.0226	−0.3445	−0.3422	−0.0672 *	0.0964 *
Ex.calcium	0.1799	−0.1745	−0.1784	−0.3712	−0.3280
Ex.magnesium	0.0494	−0.2305	−0.2343	−0.2423 **	−0.1657 *
Ex.sodium	0.0023	0.2678	0.2730	0.4325	0.3514
Water soluble K		0.2710	0.2397 **	0.0710 **	−0.0572
Ammonium acetate K			0.9993	0.4574 **	0.0084
Exchangeable K				0.4594	0.0110 **
Nitric acid K					0.8923
Non-exchangeable K					

* Significant at 5% level

** Significant at 1% level

4.4.6.1. Inter-fraction interaction

It was seen that water soluble K was positively but insignificantly related with available K, exchangeable K and HNO_3.K. The relationship with non-exchangeable K was negative but not significant.

Available K had significant positive relation with both exchangeable K and HNO_3.K; while the relation was positive but not significant with non-exchangeable K.

Exchangeable K was positively and significantly related with HNO_3.K but the relation with non-exchangeable K was positive but not significant.

Highly significant positive relation was obtained between HNO_3.K and non-exchangeable K.

4.4.6.2. Potassium fractions Vs Soil properties

4.4.6.2.1. Water soluble K

Water soluble K had positive insignificant relation with coarse sand, fine sand, silt, pH, CEC, calcium, magnesium and sodium; while negative but insignificant relationship was observed with gravel, clay, organic carbon and percentage base saturation.

4.4.6.2.2. Available K

Positive significant relation was noticed with organic carbon as well as CEC. The relation was positive but not significant with gravel, fine sand, silt, clay and sodium.

Negative significant relation was observed with coarse sand, pH and percentage base saturation; while the relation was negative insignificant with calcium and magnesium.

4.4.6.2.3. Exchangeable K

Significant positive relation was found with organic carbon and CEC. Exchangeable K had positive but insignificant relation with gravel, fine sand, silt, clay and sodium.

Coarse sand, pH and percentage base saturation was negatively and significantly related with exchangeable K. The relation was negative but not significant with calcium and magnesium.

4.4.6.2.4. HNO_3.K

It had positive significant relation only with sodium. The relation with gravel, coarse sand, silt and organic carbon was positive but not significant.

Significant negative relationship was noticed with calcium content. The relation was negative but not significant with fine sand, clay, pH, CEC, percentage base saturation and magnesium.

4.4.6.2.5. Non-exchangeable K

It had significant positive relation with coarse sand and sodium, while positive but insignificant relation was observed with gravel, silt, pH and percentage base saturation.

Significant negative relationship was obtained with clay, CEC and calcium; while the relation was negative but not significant with fine sand, organic carbon and magnesium.

4.4.7. Low fertility status irrespective of taxonomic difference

4.4.7.1. Inter-fraction interaction

It was seen that water soluble K had positive

Table 14 (a) Test of Significance for Pooled Correlation

	Water soulble K	Ammonium acetate K	Exchangeable K	Nitric acid soluble K	Non-exchangeable K
Gravel	1.795	0.002	0.204	0.033	0.086
Coarse sand	1.966	0.318	0.047	0.881	0.820
Fine sand	1.413	3.678	5.700*	5.832*	3.877*
Silt	5.445*	0.690	0.127	0.040	0.007
Clay	2.533	0.246	0.906	0.623	0.519
Soil reaction	0.148	0.540	0.618	1.151	2.550
Organic carbon	0.196	3.692	5.106*	1.654	0.386
CEC	4.595*	1.638	3.637	2.007	1.498
Base saturation	0.077	2.247	2.965	1.948	1.065
Ex.calcium	6.948*	0.395	1.484	0.046	0.001
Ex.magnesium	7.864*	0.268	1.539	0.001	0.025
Ex.sodium	0.147	0.003	0.020	3.083	4.452*
Water soluble K		0.010	0.326	0.081	0.109
Ammonium acetate K			7.908*	0.383	0.459
Exchangeable K				0.590	0.602
Nitric acid K					0.172
Non-exchangeable K					

* Significant at 5% level

Table 14(b) Behaviour of Soil Potassium when Available K was Low Irrespective of Taxonomic Difference

	Water soulble K	Ammonium acetate K	Exchangeable K	Nitric acid soluble K	Non-exchangeable K
Gravel	−0.2263	0.1197	0.1658	0.2857	0.2932
Coarse sand	0.0089	0.3731*	0.3937*	0.4985**	0.4457**
Fine sand	−0.1738	−0.3124	NE	NE	NE
Silt	NE	−0.1363	−0.1577	−0.1502	−0.1257
Clay	0.2863	0.1360	0.0880	0.1549	0.1333
Soil reaction	0.2669	−0.0192	−0.0480	−0.2317	−0.2809
Organic carbon	−0.1151	−0.0026	NE	0.1030	0.1114
CEC	NE	−0.0940	−0.0584	−0.5051**	−0.5651**
Base saturation	0.1937	0.2027	0.1757	0.3709*	0.3631*
Ex.calcium	NE	0.0460	0.0644	−0.2315	−0.2954
Ex.magnesium	NE	0.2430	0.2721	−0.0483	−0.1561
Ex.sodium	0.0710	0.5309**	0.5358**	0.3800*	NE
Water soluble K		0.2345	0.1132	0.0922	0.0128
Ammonium acetate K			NE	0.6086**	0.3183
Exchangeable K				0.6062**	0.3187
Nitric acid K					0.9466**
Non-exchangeable K					

* Significant at 5% level

** Significant at 1% level

NE Non Estimable

but insignificant relation with all the other potassium fractions, viz; available K, exchangeable K, HNO_3.K and non-exchangeable K.

The relation between available K and exchangeable K was found non estimable; while available K had positive and significant relation with HNO_3.K and positive but insignificant relation with non-exchangeable K.

Exchangeable K was positively and significantly correlated with HNO_3.K, whereas the relation was positive but not significant with non-exchangeable K.

It was also observed that HNO_3.K and non-exchangeable K had positive significant relation between them.

4.4.7.2. Potassium fractions Vs soil properties

4.4.7.2.1. Water soluble K

It was noticed that water soluble K had positive but insignificant correlation with coarse sand, clay, pH, percentage base saturation and sodium; while the relation was negative and insignificant with gravel, fine sand and organic carbon. The relation between water soluble K and properties like silt content, CEC, calcium and magnesium contents were found nonestimable.

4.4.7.2.2. **Available K**

It had positive and significant relation with coarse sand and sodium content whereas the relation was positive but not significant with gravel, clay, percentage base saturation, Calcium and magnesium contents. Negative but insignificant relation was noticed between available K and properties like fine sand, silt, pH, organic carbon and CEC.

4.4.7.2.3. **Exchangeable K**

Positive and significant relation was observed with coarse sand and sodium content. The relationship of exchangeable K with properties like gravel, clay, percentage base saturation, calcium and magnesium contents was positive but not significant. Negative but insignificant correlation was found with silt, pH and CEC while the relation of exchangeable K with organic carbon was non estimable.

4.4.7.2.4. HNO_3.K

It was seen that HNO_3.K was positively and significantly correlated with coarse sand, percentage base saturation and sodium and positively but insignificantly correlated with gravel, clay and organic carbon content. Negative significant relation was obtained with CEC and negative insignificant relation with silt, pH, calcium and magnesium contents. However, the relation with fine sand fraction was found non estimable.

4.4.7.2.5. Non-exchangeable K

Positive significant relation was observed with coarse sand and percentage base saturation. The relation with gravel, clay and organic carbon was positive but not significant. Negative significant relation was observed only with CEC. It had negative insignificant correlation with silt, pH, calcium and magnesium contents. The relationship of non-exchangeable K with fine sand, and sodium contents was non estimable.

4.4.8. Medium fertility status irrespective of taxonomic difference

4.4.8.1. Inter-fraction interaction

The relationship of water soluble K with

Table 15 (a) Test of Significance for Pooled Correlation

	Water soulble K	Ammonium acetate K	Exchangeable K	Nitric acid soluble K	Non-exchangeable K
Gravel	1.029	0.408	0.346	5.888*	10.927*
Coarse sand	0.490	0.421	0.361	0.019	0.131
Fine sand	1.132	2.465	2.949	1.899	0.161
Silt	0.152	0.185	0.160	0.056	0.315
Clay	0.059	0.023	0.024	0.012	0.002
Soil reaction	1.152	0.059	0.021	0.008	0.062
Organic carbon	1.209	0.009	0.024	3.853*	4.808*
CEC	0.263	0.013	0.035	0.118	0.238
Base saturation	-	0.022	0.033	1.139	1.653
Ex.calcium	0.627	0.086	0.091	5.397*	6.839*
Ex.magnesium	3.768	0.167	0.382	-	0.086
Ex.sodium	0.054	0.001	0.002	0.339	0.603
Water soluble K		4.498*	4.980*	4.095*	0.716
Ammonium acetate K			4.721*	0.248	0.016
Exchangeable K				0.154	0.001
Nitric acid K					0.235
Non-exchangeable K					

* Significant at 5% level

Table 15(b) Behaviour of Soil Potassium when Available K was Medium irrespective of Taxonomic Difference

	Water soulble K	Ammonium acetate K	Exchangeable K	Nitric acid soluble K	Non-exchangeable K
Gravel	−0.1621	0.2930*	0.3158*	NE	NE
Coarse sand	−0.0808	0.0590	0.0695	−0.0684	−0.1298
Fine sand	−0.0627	−0.1977	−0.2007	−0.0158	0.1288
Silt	0.0810	−0.0596	−0.0697	−0.1576	−0.1343
Clay	−0.1153	−0.0134	−0.0047	0.0427	0.0595
Soil reaction	−0.0439	0.1501	0.1536	0.1383	0.0535
Organic carbon	0.1254	0.1878	0.1854	NE	NE
CEC	0.2092	0.0775	0.0625	0.0674	0.0176
Base saturation	−0.0239	0.2811*	0.2903*	0.2808*	0.1067
Ex.calcium	0.1969	0.4274**	0.4255**	NE	NE
Ex.magnesium	0.1064	0.2695	0.2662	0.3015*	0.1496
Ex.sodium	−0.1618	0.2336	0.2523	0.0101	−0.1698
Water soluble K		NE	NE	NE	−0.1507
Ammonium acetate K			NE	0.5292**	−0.1299
Exchangeable K				0.5366**	−0.1191
Nitric acid K					0.7742**
Non-exchangeable K					

* Significant at 5% level

** Significant at 1% level

NE Non Estimable

available K, exchangeable K and HNO_3.K was found non estimable but negative insignificant relation was obtained with non-exchangeable K.

Correlation was found non estimable between available K and exchangeable K, but available K had positive and significant relation with HNO_3.K. The relationship of available K with non-exchangeable K was negative but not significant.

Exchangeable K had significant positive relation with HNO_3.K and negative but insignificant relation with non-exchangeable K.

HNO_3.K was observed to be positively and significantly correlated with non-exchangeable K.

4.4.8.2. **Potassium fractions Vs soil properties**

4.4.8.2.1. **Water soluble K**

Positive insignificant correlation was found with silt, organic carbon, CEC, calcium and magnesium contents; while the relation was negative but not significant with gravel, coarse sand, fine sand, clay, pH, percentage base saturation and sodium content.

4.4.8.2.2. Available K

Available K had positive significant relation with gravel, percentage base saturation and calcium whereas the relation was positive and not significant with coarse sand, pH, organic carbon, CEC, magnesium and sodium contents. Negative but insignificant relation was observed with fine sand, silt and clay fractions of the soil seperates.

4.4.8.2.3. Exchangeable K

Positive significant relationship was noticed with gravel, percentage base saturation and calcium. With coarse sand, pH, organic carbon, CEC, magnesium and sodium contents the relation was positive but insignificant. Exchangeable K was negatively and insignificantly correlated with fine sand, silt and clay fractions.

4.4.8.2.4. HNO_3.K

It had significant positive correlation with percentage base saturation and magnesium content. Positive but insignificant relation was noticed with

Table 16 (a) Test of Significance for Pooled Correlation

	Water soulble K	Ammonium acetate K	Exchangeable K	Nitric acid soluble K	Non-exchangeable K
Gravel	0.007	0.266	0.262	0.083	0.025
Coarse sand	0.032	2.414	2.479	0.198	0.472
Fine sand	0.023	1.459	1.442	0.020	1.007
Silt	0.002	0.131	0.135	0.026	0.824
Clay	0.508	3.605	3.872*	0.482	1.497
Soil reaction	2.478	2.147	2.375	0.592	0.002
Organic carbon	2.350	0.593	0.687	-	0.333
CEC	0.040	0.322	0.304	1.445	0.673
Base saturation	0.003	1.862	1.899	0.378	0.078
Ex.calcium	0.188	4.126*	4.417*	5.180*	0.092
Ex.magnesium	0.537	4.244*	4.284*	6.168*	0.688
Ex.sodium	0.007	0.152	0.175	0.178	2.546
Water soluble K		1.452	1.357	2.194	0.102
Ammonium acetate K			-	4.747	0.874
Exchangeable K				4.659	0.893
Nitric acid K					10.743*
Non-exchangeable K					

* Significant at 5% level

Table 16(b) Behaviour of Soil Potassium when Available K was High Irrespective of Taxonomic Difference

	Water soulble K	Ammonium acetate K	Exchangeable K	Nitric acid soluble K	Non-exchangeable K
vel	−0.0697	0.0834	0.0818	0.0440	0.0201
rse sand	0.0293	−0.2423	−0.2390	0.1612	0.2773*
e sand	−0.0474	0.1980	0.1953	−0.0477	−0.1241
t	0.0703	0.2015	0.2065	0.1154	−0.0207
y	−0.1626	0.1144	NE	−0.1993	−0.2337
. reaction	−0.0021	−0.3228*	−0.3191*	−0.0348	0.1084
nic carbon	−0.0863	0.2536*	0.2535*	0.0920	−0.0188
	0.2595*	0.5403**	0.5333**	0.0310	−0.2867*
saturation	−0.0261	−0.2715*	−0.2684*	−0.0309	0.0800
alcium	0.1550	NE	NE	NE	−0.3119*
agnesium	0.0925	NE	NE	NE	−0.1176
odium	−0.0025	0.2890*	0.2958*	0.4120**	0.2661*
r soluble K		0.3357**	0.3035*	0.1574	−0.0760
nium acetate K			0.9993**	NE	−0.0468
angeable K				NE	−0.0448
ic acid K					NE
exchangeable K					

ignificant at 5% level

Significant at 1% level

Non Estimable

clay, pH, CEC and sodium content. The relation was negative and not significant with coarse sand, fine sand, and silt fractions. Correlation could not be worked out with gravel, organic carbon and calcium content.

4.4.8.2.5. Non-exchangeable K

The relation of non-exchangeable K with soil properties like gravel content, organic carbon and calcium was non estimable. Positive insignificant correlation existed with fine sand, clay, pH, CEC, percentage base saturation and magnesium content. The relation of non-exchangeable K with coarse sand, silt and sodium content was negative and not significant.

4.4.9. High fertility status irrespective of taxonomic difference

4.4.9.1. Inter-fraction interaction

Water soluble K was positively and significantly correlated with available K and exchangeable K and positively but insignificantly related with HNO_3.K. The relation with non-exchangeable K was negative insignificant.

Available K had significant positive relationship with exchangeable K and negative but insignificant relation with non-exchangeable K. The relation with HNO_3.K was non estimable.

Negative but insignificant relation was observed between exchangeable K and non-exchangeable K; while the relation of exchangeable K with HNO_3.K could not be estimated.

Correlation between HNO_3.K and non-exchangeable K was also found nonestimable.

4.4.9.2. Potassium fractions Vs soil properties

4.4.9.2.1. Water soluble K

It had significant positive relation only with CEC. With coarse sand, silt, calcium and magnesium contents the relation was positive but insignificant. Negative insignificant correlation was observed with gravel, fine sand, clay, pH, organic carbon, percentage base saturation and sodium content.

4.4.9.2.2. Available K

Significant positive relationship was

established with organic carbon, CEC and sodium content; whereas the correlation was positive insignificant with gravel, fine sand, silt and clay fractions. pH and percentage base saturation had significant negative relation with available K and negative but insignificant relation was observed with coarse sand. The relation with calcium and magnesium contents were found non estimable.

4.4.9.2.3. **Exchangeable K**

Positive significant correlation was obtained with organic carbon, CEC and sodium; whereas the relation was positive but insignificant with gravel, fine sand and silt fractions. With percentage base saturation and pH, exchangeable K had significant negative correlation and with coarse sand the relation was negative insignificant. Relationship of exchangeable K with clay, calcium and magnesium contents was non estimable.

4.4.9.2.4. HNO_3.K

Significant positive correlation was observed only between HNO_3.K and sodium content. The relationship was positive but insignificant with gravel, coarse sand, silt, organic carbon and CEC. With fine sand, clay, pH and percentage base saturation the relation observed was negative but insignificant. Correlation of HNO_3.K with calcium and magnesium contents was non estimable.

4.4.9.2.5. Non-exchangeable K

It had significant positive correlation with both coarse sand and sodium content. Positive insignificant relationship was established with gravel, pH and percentage base saturation. CEC and calcium content had significant negative correlation with non-exchangeable K, whereas negative but insignificant relation was obtained with fine sand, silt, clay, organic carbon and magnesium.

DISCUSSION

DISCUSSION

Minerals and soils in nature are found to contain considerable total amounts of potassium. Inspite of this, crops grown in most soils respond to fertilizer sources of potassium favourably. In most cases potassium is the major growth limiting nutrient, next to nitrogen. Field crops demand large quantities of soluble potassium in the soil for successful growth and yield. Eventhough this monovalent cationic element is soluble and easily exchanged from phyllosilicate surfaces, in general, the overall availability in the soil is often determined by the nature of soil physical and chemical behaviour. Information on the interaction of different forms of soil potassium with other soil components would provide support to decision making in the rational use of this costly input. It was under this presumption that the study was undertaken with test soils from three different series.

The test soils constituted 50 samples each from Trivandrum, Kazhakuttom and Kottoor series. The samples selected randomly from different locations were subjected to experimentation in the laboratory and the results are presented in the preceeding chapter. The data generated are discussed in the light of previous findings and theoretical evidences with suitable titles in the ensuing pages.

1. Properties of test soils

Soils from Trivandrum series contain large quantities of gravel (41.92 percent) when compared to Kazhakuttom series (5.62 percent) and Kottoor series (31.73 percent). In contrast Kazhakuttom series comprise more than 80 percent sand of which 78.3 percent was coarse sand. The silt percent was highest in Trivandrum series (7.7 percent) followed by Kazhakuttom (5.65 percent) and Kottoor series (4.75 percent). In the case of clay content Trivandrum and Kottoor series were on par (23.4 percent and 24 percent respectively). Kazhakuttom series contained only 7.7 percent clay.

According to textural classes suggested by Soil Survey Staff (1992), the Trivandrum Series can be classified as sandy clay loam, the Kazhakuttom series as sand/loamy sand and the Kottoor series as sandy clay loam. This is however based on the mean values and sufficient precaution is advised in the light of large coefficient of variations observed in many cases (Table

1). The data also suggest that samples from within a well defined soil series cannot always be grouped into the same textural class.

All the test samples tried were acidic in soil reaction, the pH values ranging from a mean of 5.39 in Kottoor series to 5.69 in Trivandrum series and 5.79 in Kazhakuttom series. The tendency of potassium availability under near neutral soil reactions was described by Kadrekar and Kibe (1972) in soils derived from granite and gneiss of Maharashtra, Bolan (1976) in soils of Nilgris District, Ram and Singh (1975) in paddy soils of eastern Uttar Pradesh and Palaniswamy et al. (1978) in rubber growing soils.

Subba Rao and Sekhon (1991) in their study in acid tropical soils showed that in soils with appreciable amounts of organic carbon and pH greater than 5.5, the influence of pH on available K status was negligible.

Organic matter content between test samples were significantly different. The mean values for Kottoor, Trivandrum and Kazhakuttom series in the case of organic carbon were 1.08, 0.59 and 0.21 percent respectively. There are considerable evidences to show that the nature and quantity of organic matter in the soil will affect the trends in potassium availability. The findings of Kalbande and Swamynatha (1976) in black soils of Tungabhadra catchment, Tiwari and Pati Ram (1976) in some Vindhyan soils of Uttar Pradesh, Mishra and Srivastava (1991) in Dandachali, Pankhil and Tegna soil series of Garhwal Himalayas and Mongia and Bandyopadhyay (1991) in the acidic hill soils of Andamans confirms the above statement.

The effect of organic matter on water soluble and exchangeable K contents was studied in 3 acid soils from tropical parts of India by Subba Rao and Sekhon (1991). It was concluded that management of organic matter in tropical soils rich in Kaolinite is important to maintain the available K status for sustainable farming.

In the case of exchange properties the test soils though varied significantly, did not show appreciable values for cation exchange capacity. The values ranged from 2.91 cmols $(p+)kg^{-1}$ in Kazhakuttom series to 4.38 and 5.37 cmols $(p+)kg^{-1}$ in Trivandrum and Kottoor series respectively. The low values obtained for CEC is mainly due to the predominance of nonexpanding 1:1 type clay minerals in these soils.

The low potassium fixing capacity of these clay minerals are wellknown suggesting considerable leaching of potassium consequent to low potassium retention in these soils.

On the contrary, the extent of base saturation in the test soils were found appreciable. The values were 62.29, 59.06 and 63.93 percent in Trivandrum, Kazhakuttom and Kottoor series respectively. The results suggest appreciable competition among cationic elements including potassium for exchange sites in the clay minerals.

The relative concentration of cationic elements like calcium, magnesium and sodium in the soil were found to influence potassium availability. (Patil and Zande (1975), Mengel et al. (1976) and Gerloff (1976).

In the present study the content of these elements were found to vary significantly between test soils (Table 2). Therefore the equlibrium established between potassium and these elements and thus the extent of potassium availability in these soils must also differ considerably.

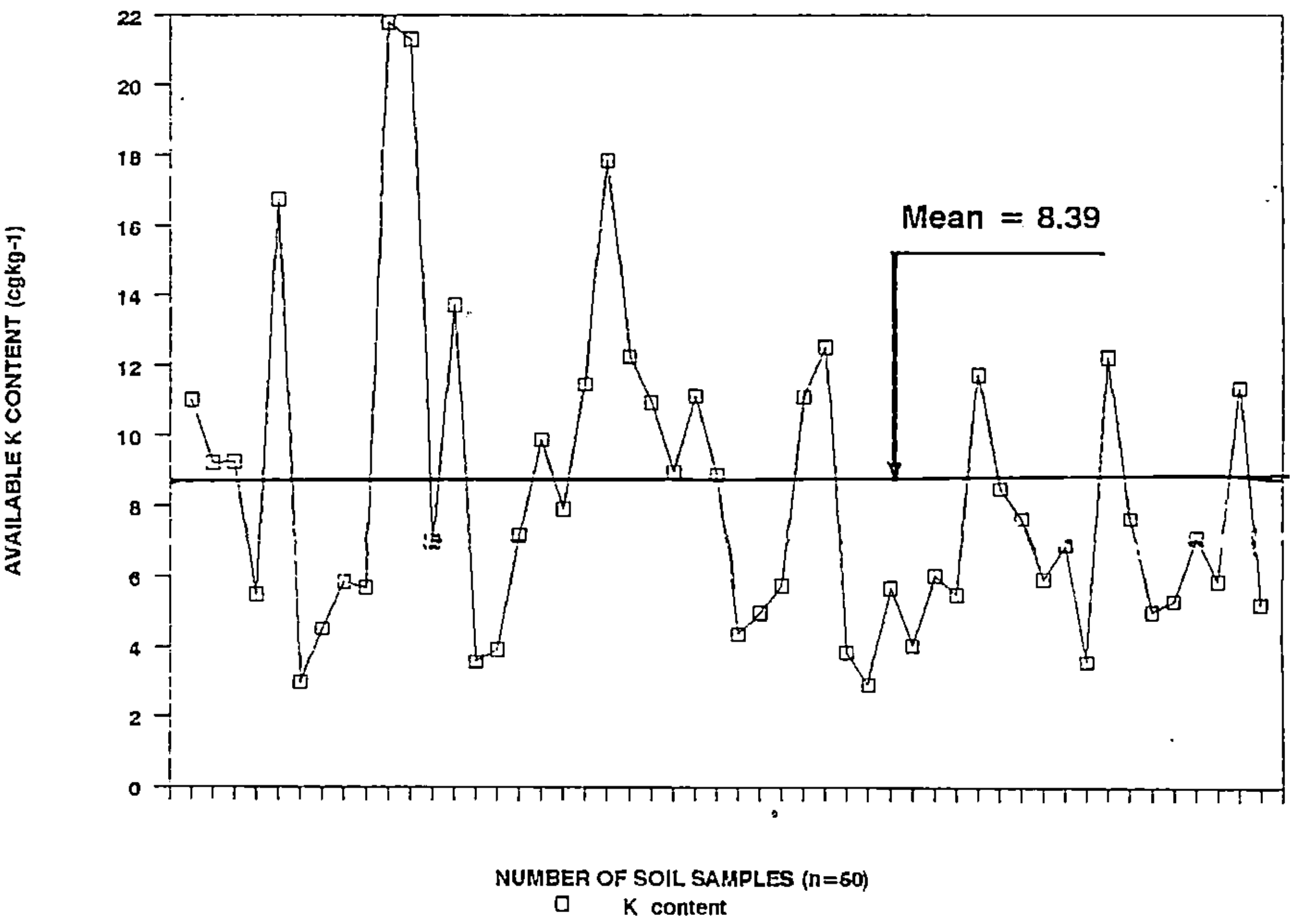


Fig. 1 : Variability of available Soil Potassium in Trivandrum series

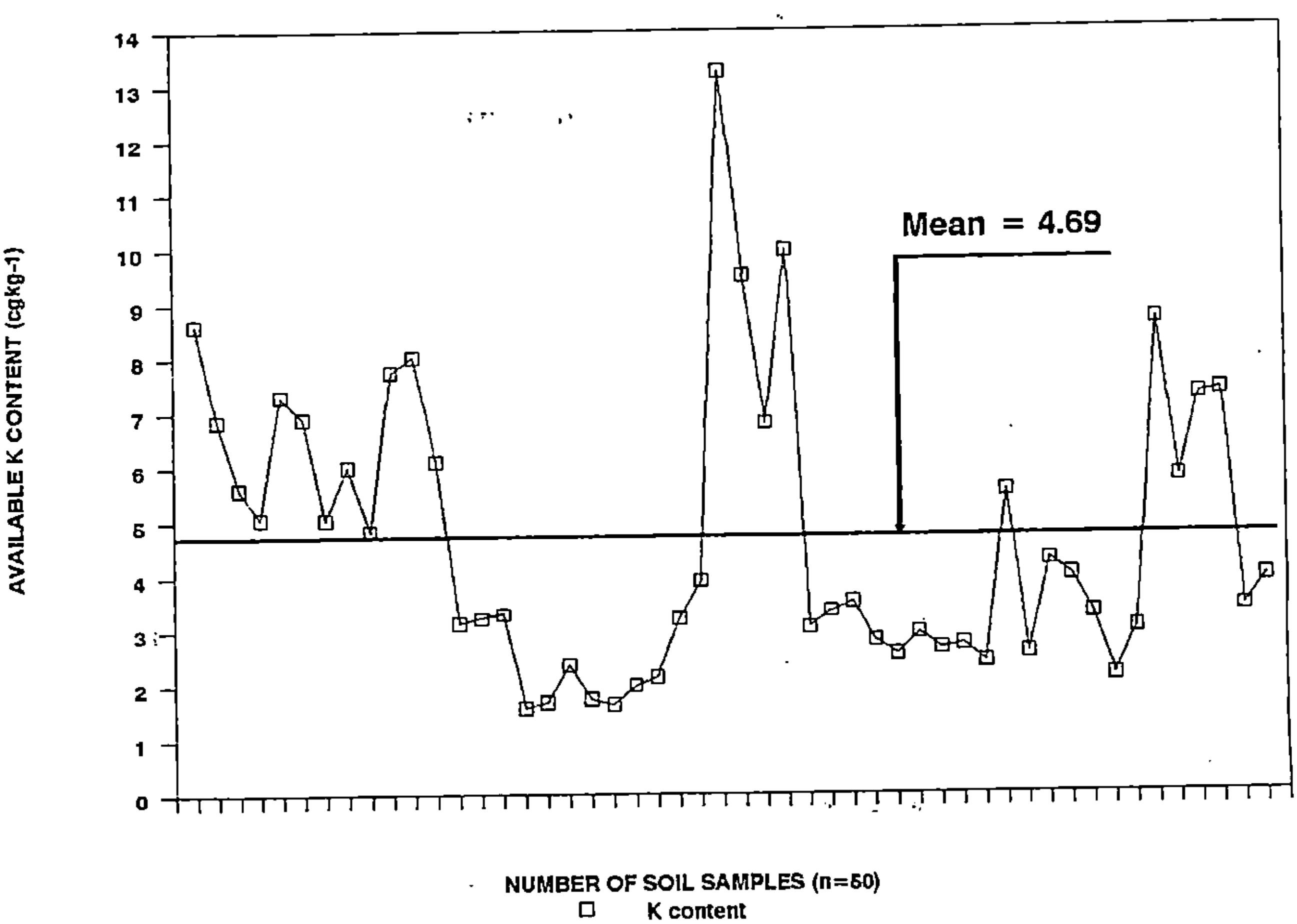


Fig. 2 : Variability of available Soil Potassium in Kazhakuttom series

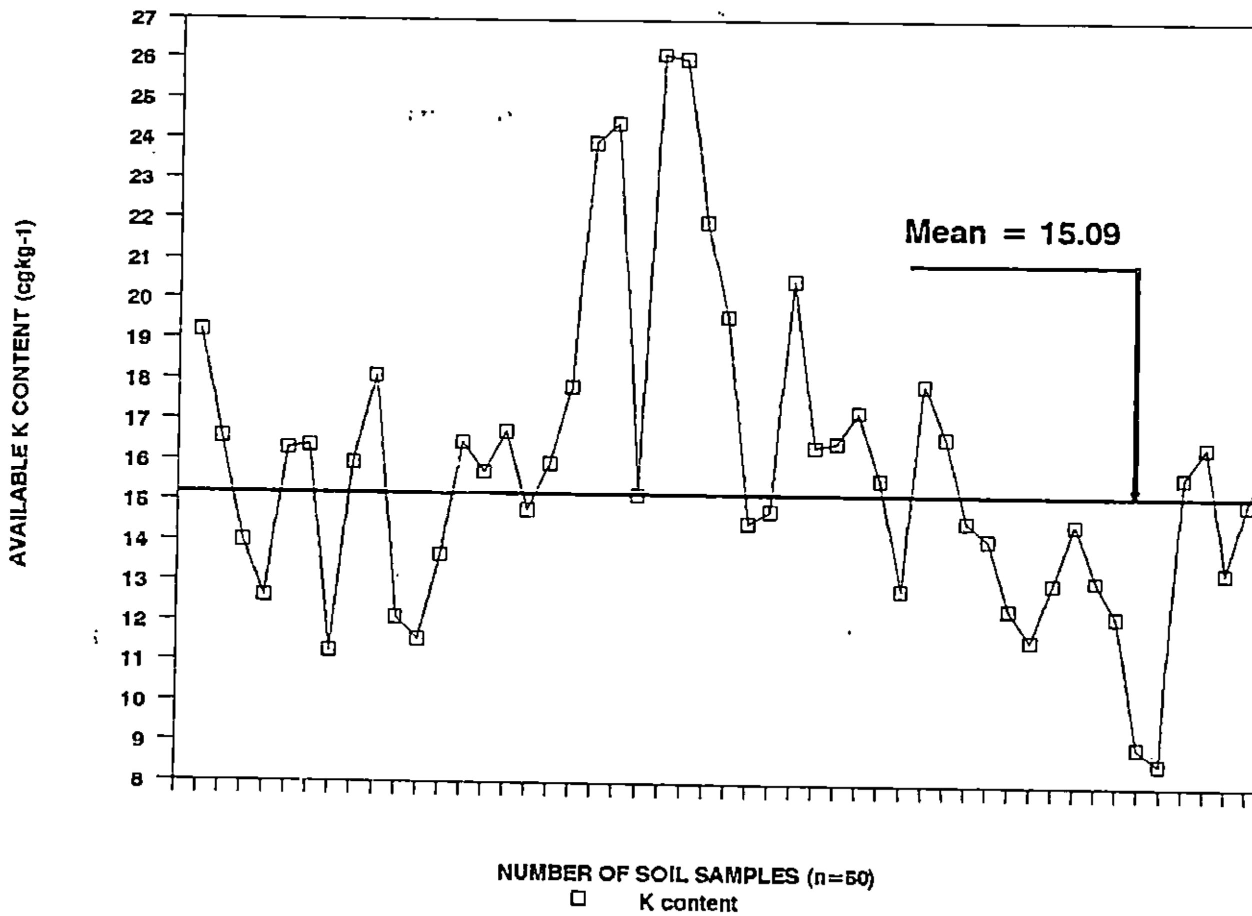


Fig. 3 : Variability of available Soil Potassium in Kottoor series

2. Potassium Status of test soils

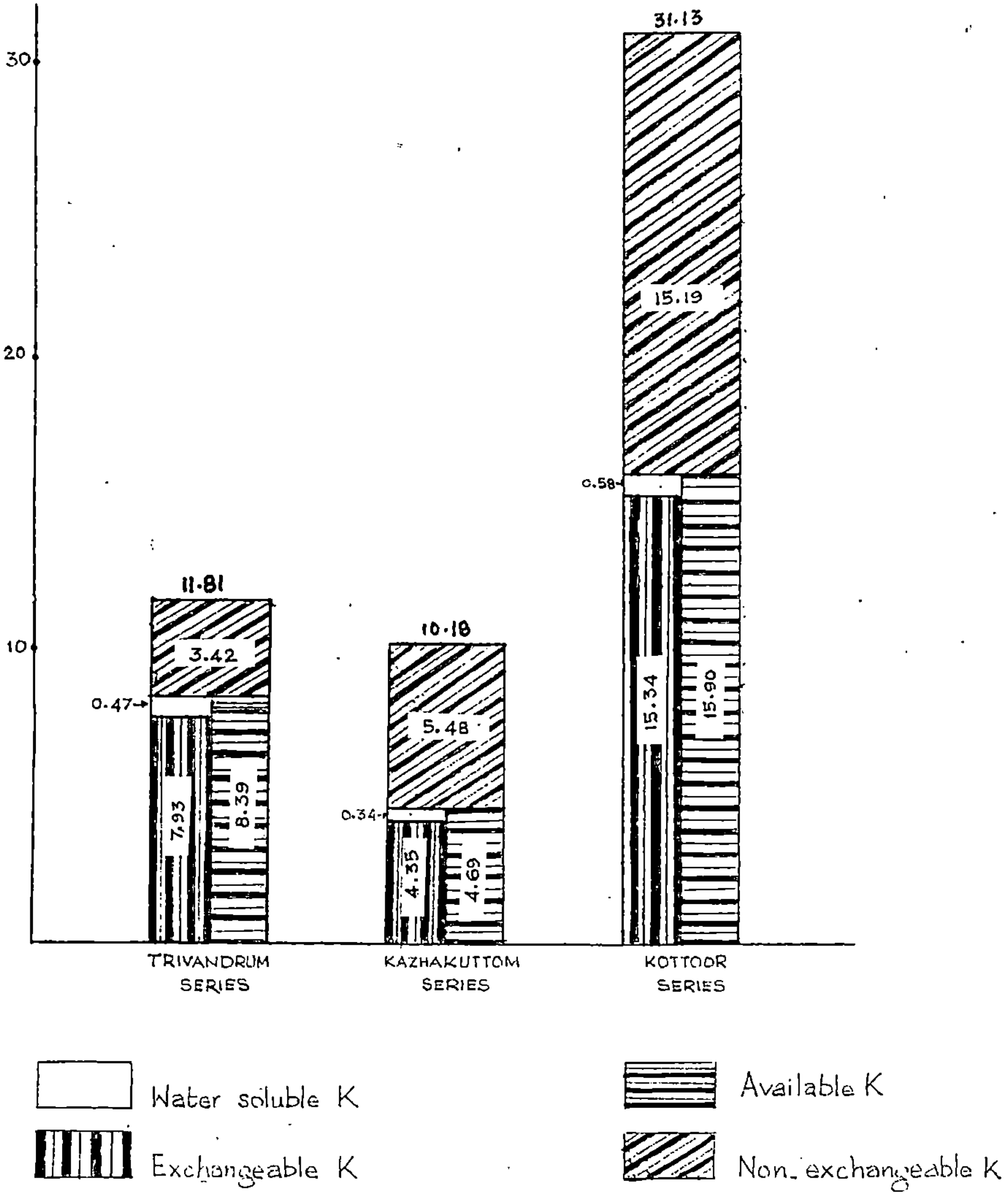
Soil fertility with respect to different fractions of soil potassium was assessed through various extractants and the data is presented in Table 3.

The quantity of all the forms of potassium varied significantly between the three series of soils under investigation. Moreover there was also considerable variation among the contents of these fractions within each soil series as evidenced by the coefficient of variation. It can be inferred that spatial variation in soil physical and chemical properties even within a well defined series can affect the nature of potassium fractions and their relative concentrations. The findings of Ravikumar <u>et</u> <u>al</u>. (1987) and Valsaji, (1989) corroborates the present results. The results of an attempt to partition the quantity of potassium extracted by boiling nitric acid (1.0 N) is available in Fig. 4 and Table 17. While 71 percent of the nitric acid K were available to crops in Trivandrum series the corresponding values were only 46 and 51 percent in Kazhakuttom and Kottoor series respectively. The contribution of potassium from the exchange complex was 67.15 percent of HNO_3.K in Trivandrum series, 42.73 percent in Kazhakuttom series

Table 17. Partitioning of Hot 1.0 N HNO_3.K in Test Soils ($Cg.Kg^{-1}$)

	Trivandrum Series		Kazhakuttom Series		Kottoor Series	
	Mean (n=50)	Percent of HNO_3.K	Mean (n=50)	Percent of HNO_3.K	Mean (n=50)	Percent of HNO_3.K
HNO_3 .K	11.81	100	10.18	100	31.13	100
Non-ex.K	3.42	28.96	5.48	53.93	15.19	48.80
Available K	8.39	71.04	4.69	46.07	15.90	51.08
Ex. K	7.93	67.15	4.35	42.73	15.34	49.28
Water Sol.K	0.47	3.98	0.34	3.34	0.58	1.86

Fig: 4. Partitioning of hot 1.0N HNO_3.K in test soils ($cgkg^{-1}$)



and 49.28 percent in Kottoor series (Table 17). Obviously, the relative contributions are dependant on other soil properties.

Another finding was that exchangeable potassium contributed more than 90 percent of the available potassium in the test soils. The exchangeable K was 94.51 percent of available K in Trivandrum series, whereas the same was 92.75 and 96.48 percent in Kazhakuttom and Kottoor series respectively. Similar findings were reported by Singh et al. (1989) in Jaria, Burju, Sidrol, Amba, Hututua, Burmu, Garra, Rege and Maka soil series of Chotanagpur regions, where exchangeable K fractions contributed 92 percent towards K availability and Singh et al. (1989) in soils of Mizoram, where exchangeable K contributed 93.48 percent to available K.

The present investigation and the results quoted from elsewhere confirms the fact that contribution towards available potassium in the soil from exchangeable and water soluble sources cannot be quantified as a generalised value; but has to be computed with respect to specific soil physical and chemical environment. There are reports suggesting contribution of non-exchangeable potassium also towards K availability to crops. Bhangu and Sindhu (1990) in 5 bench mark soils of Central Punjab found that Tulewal series had the lowest amount of reserve K, although a high rate of release from exchangeable to water soluble K and from non-exchangeable to water soluble K was observed in this series.

The ensuing discussions will reveal the relationships established between these fractions in the test soils.

3. Behaviour of potassium in test soils

Correlation coefficients worked out between different forms of potassium in the three series of test soils was found to be similar in nature. The relationship of water soluble K with ammonium acetate K, exchangable K and nitric acid K was positive and significant in all the test soils. However, the relationship with non-exchangeable K was found negative in these soils. In the case of available K and exchangeable K also the trend was same.

Nitric acid K showed a positive significant correlation with non-exchangeable K. Similar results was obtained by Gupta et al. (1983) in Nagaland soils. The results reveal definite dependance of plant available forms of K with the fraction extracted by hot nitric acid. When the content of HNO_3.K in the soil increased there is a concomitant increase in all other forms of potassium. It may also be observed that when exchangeable K increases there must be a corresponding decrease in non-exchangeable K for the same level of nitric acid K. Since nitric acid K has a positive significant correlation with non-exchangeable K as well as available K, there must be other soil factors which determine the ultimate availability of this nutrient to the crops.

Cation exchange capacity is one of the main factors which determine the availability of potassium in soil. Similar findings was reported by Ravikumar et al. (1987) in 12 representative soil profiles of Central Haryana, Singh et al. (1989) in Mizoram soils and Mishra and Srivastava (1991) in Dandachali, Pankhil and Tegna soil series of Garhwal Himalayas.

In the present study also a positive significant correlation was established with available forms of potassium and a negative relation with non-exchangable K. A high retention of K in the exchange complex and its release in response to potassium depletion in soil solution provides a conducive environment for better potassium availability.

However, the results of the study reveal a positive relationship between available K and other cations studied, namely calcium, magnesium and sodium. Inter-ionic competition for exchange sites have been studied with respect to potassium by Patil and Zande (1975), Mengel et al. (1976) and Gerloff (1976).

It was also observed that organic matter as well as soil seperates influence the availability of potassium. The findings of Singh and Singh (1986), Singh et al. (1989) and Subba Rao and Sekhon (1991), corroborates the present results. The content of gravel had a significant correlation with the potassium fractions. Sand fractions also influenced the forms of potassium significantly. One of the conclusions which can be drawn from the trends available is that the exchange capacity and consequent availability of potassium in the soil is also a function of soil seperates other than clay. Basic studies quantifying the influence of soil factors towards availability of potassium to plants has been under taken elsewhere. Reddy et al. (1985) identified parent material, soil reaction, particle size, cation exchange capacity, associated anions, soil moisture and depth of soil as soil factors affecting availability of potassium. Similar reports are available from Singh et al. (1989), Subba Rao and Sekhon (1991) and so on.

Similar works considering crop response also are suggested as a future line of research.

4. **Behaviour of soil potassium under varying soil fertility**

It may be noted that 94 percent of test soils from Kottoor series were grouped into high fertility class whereas most of the soils were divided into medium (40 percent) and low (58 per cent) fertility in Kazhakuttom series (Table 4). In the case of Trivandrum series 60 percent of the samples were of medium fertility and the rest were distributed evenly among high (22 percent) and low (18 percent) fertility classes.

Random samples were selected, one each from every fertility class and analysed for the total amount of potassium employing the method suggested by Pratt (1965).

Total K in test soils showed a very wide range even within established series. In the case of

Trivandrm series a low fertile soil contained 334 cg kg^{-1} of total K_2O as against 359 and 590 cg kg^{-1} for medium and high fertile soils in the same series. Low fertile soils in Kazhakuttom series had 139 cg kg^{-1} of total K_2O and medium fertile soils contained 147cgkg^{-1}, K_2O. The single soil sample which showed high potassium availability contained 346 cgkg^{-1} of total K_2O. In the case of Kottoor series also the total K_2O content was far high (447 cgkg^{-1}) for high fertility soils than for medium fertility soils (240 cgkg^{-1}).

Forgoing results reveal that total potassium content of the soil has a bearing on the potassium fertility. This aspect has to be studied further following previous reports from Ekambaram _et al._ (1975), Palaniswamy _et al._ (1978) in rubber growing soils, Prakash and Singh (1985) in alluvial soils of Agra region, Singh and Singh (1986) in soils of Garhwal hills and Sahu and Gupta (1988) in some soils under forest cover.

Eventhough this investigation succeeded in establishing correlations between different forms of potassium and soil components in different series the trends need not be the same under varying potassium fertility. This is because potassium fertility of a soil is a function of several different soil chemical and environmental factors (Reddy *et al*. 1985). Therefore soils falling under low, medium or high fertility classes with respect to potassium may express different relationships with the accompanying soil features. Thus it is often wise to consider the correlations between different components with respect to the fertility class as well as taxonomic class of the soil. With this view analytical data from the soils falling under different fertility classes within each series were subjected statistical analysis separately. Correlation coefficients were established in these cases also (Table 8 to 13). Similar analysis was conducted by pooling the data for each fertility class from different series also (Table 14,15 and 16) Trends in the behaviour of potassium under varying fertility levels are discussed hereunder.

4.1. Soils with low available potassium

Low available potassium (Ammonium acetate extractable K below 125 kg K_2O/ha) was noticed in Trivandrum (18 per cent) and Kazhakuttom (58 per cent) soil series only. Available K was positively and significantly correlated with exchangeable K in both cases (Table 8 and 11). The correlation between available K and non-exchangeable K was also positive in these cases. The results suggest contribution of non-exchangeble K towards potassium availability to crops under low levels of fertility. Similar obervations were made by Ram and Singh (1975), Bandyopadhyay et al. (1985) and Singh and Singh (1986).

It can be suggested that the extracting power of neutral normal ammonium acetate is more under low fertility and can vary with fertility levels.

It is accepted that crop response to added potassium will be positive under low potassium fertility. However, the practise of considering the fraction of soil potassium extracted by ammonium acetate as an index for plant availability has to be established further under varying fertility levels. Contribution of soil potassium fractions other than that extracted by ammonium acetate towards plant available potassium was reported earlier. (Ram and Singh (1975), Ravikumar et al. (1987).

There was significant relationship between sand fractions and different forms of potassium. The influence of bigger fractions of soil components towards potassium dynamics in the soils was studied earlier. (Chandel et al., (1976) in Mollisols of Nainital Tarai and Singh et al., (1989) in acid sedentary soils of Chotanagpur region).

Another important observation in low fertile soils is the negative correlation establised between cation exchange capacity and potassium fractions in Kazhakuttom series (Table 11). The trend was similar in Trivandrum series as well as pooled analysis of same level of fertility from both series (Table 8 and 14). It is obvious that the quantum of non-exchangeable potassium fractions in the soil will vary inverselly with the exchange capacity of the soil. But the results also suggest that when the relative concentration of potassium in exchange complex and soil solution is low, ie., low potassium fertility, the cation exchange capacity has inverse relationship with available forms of potassium also. Considering the low activity clay minerals present in the test soils (mainly 1:1 type) it can be suggested that potassium fertility of the soil may decrease with soil amendments resulting in increase of CEC.

4.2. Soils with medium available potassium

The number of test samples rated under medium available potassium were 30, 20 and 3 in Trivandrum, Kazhakuttom and Kottoor series respectively. Out of the overall total of 150 samples 53 samples (35.33 percent) were rated under this class. Since the number of samples falling under medium fertility in Kottoor series was only 3 this was included only in the pooled analysis for medium fertility (Table 15).

Gravelly nature of the soil favourably affected the available and exchangeable forms of potassium in soils with medium potassium fertililty. The effect was significant in Trivandrum series (Table 9) as well as under pooled analysis (Table 15). The influence of coarser fractions on potassium availability was reported earlier. (Chandel et al., (1976) and Singh et al.,(1989). However, in a sandy soil like Kazhakuttom series with medium potassium fertility water soluble potassium expressed negative correlation with other fractions of potassium, whereas in Trivandrum series (sandy clay loam) the relationship was positive and significant. Correlation was unestimatable in this case when the samples were pooled. The influence of textural class on potassium fractions in the soil was reported elsewhere. (Verma et al., (1982), Ravikumar et al.,(1987), Singh et al., (1989) and Pal and Mukhopadhyay (1990). Sandy soils may result in excessive leaching of soluble fractions especially water soluble potassium. Therefore, the ammonium acetate K extracted from sandy soils will be mainly from the exchange complex. However, this suggestion was found applicable to soils with medium fertility only.

There was positive significant correlation between available K and nitric acid K as well as exchangeable K and nitric acid K in all the cases under medium fertility (Tables 9,12 and 15). Available K and exchangeable K were also positively and significantly correlated under medium fertility. Reports of Prakash and Singh (1985), Singh and Singh (1986), Sahu and Gupta (1988) and Singh et al. (1989) supports the present finding.

The effect of interacting cations and base saturation was found positive under medium fertility conditions. (Tables 9,12, and 15). The relative concentration of exchangeable cations affects the ultimate ionic equilibria in soil and thus potassium availability.

Studies on the extent of influence of other cations in. soil solution on potassium exchange and availability are suggested as a future line of work in these soils.

4.3. Soils with high available potassium

Only one sample in Kazhakuttom series was found high in fertility with respect to available potassium, whereas 94 percent of the test samples (47 out of 50 samples) from Kottoor series were rated under this class. From Trivandrum series 11 samples (22 percent) were rated as highly fertile soils.

The effect of coarser fractions of soil seperates was found to be negative towards available and exchangeable K in Kottoor series (Table 13) and also as a general case (Table 16) when the overall potassium fertility was high. It may be noted that the case was different under medium and low fertility.

Studies on the effect of soil aggregates and textural class on the potassium fractions in the soil are further emphasised for these soils in the light of present finding as well as on the basis of previous reports.

Significant positive correlations were noticed among different fractions of potassium in this case also. Attempts must be made to quantify the percentage contribution of different fractions towards plant availability under varied soil conditions as well as cropping situations.

The effect of soil reaction, organic carbon, cation exchange capacity and percentage base saturation was much pronounced under high fertility as reflected by the significant correlation coefficients (Tables 10,13 and 16). As per the results acidic situations reduces potassium availability in soil. Raychoudhari and Landey (1960) investigated the variation of available K in six different soils and found that available K generally decreases with decreasing pH in the case of alluvial sandy soils of Rajasthan and laterite soils of Kerala. The same trend was observed by Rajakkannu et al. (1969) in red and alluvial soils of Tamil Nadu, Ram and Singh (1975) in paddy soils of eastern Uttar Pradesh and Palaniswamy et al. (1978) in rubber growing soils.

Organic matter, cation exchange capacity and base saturation favourably affects available and exchangable. forms of potassium in soil. Reports of Kalbande and Swamynatha (1976) in soils of Tungabhadra catchment and Mishra and Srivastava (1991) in Dandachali, Pankhil and Tegna soil series of Garhwal hills support the finding.

It can be inferred that high organic matter content and its influence on CEC and the concentration of interacting cations will affect the distribution of potassium fractions in the soil.

SUMMARY

SUMMARY

Successful crop production is very often limited by the extent of soil potassium available for plant uptake. Large quantities of this costly input is a pre-requisite for intensive agriculture. Knowledge on the behaviour of potassium in the soil, with respect to its chemical nature and interactions with other soil components, will help in the rational use of this fertilizer element.

Thus, the objective of this thesis work was set to define the quantitative relationships between soil properties and potassium fertility in selected soil series of Thiruvananthapuram district so as to predict the trends in potassium availability under varying soil conditions.

Three soil series from different pedogenic environments were utilised as test materials. They were the Trivandrum, Kazhakuttom and Kottoor series covering mid uplands, coastal alluvium and forest soils respectively. The Trivandrum series is a member of clayey skeletal, kaolinitic, isohyperthermic family of Kandiustults, Kazhakuttom series is a member of the coarse loamy mixed isohyperthermic family of Typic Tropofluents and the Kottoor series is a member of the

clayey skeletal mixed isohyperthermic family of Typic Hapludolls. Surface soil samples (0-30 cm) were collected randomly from 50 sites in each series.

The samples were subjected to chemical analysis for six different forms of soil potassium, viz., water soluble, available, exchangeable, nitric and soluble, non-exchangeable and total potassium. The physical and chemical properties of all the samples were studied through observations on soil seperates, pH, electrical conductivity, organic carbon, cation exchange capacity, base saturation, other interacting cations and the different forms of potassium.

Trivandrum series fall under the textural class, sandy clay loam. Since Kazhakuttom series is located in the coastal areas of Thiruvananthapuram district, sand fractions on an average contributed more than 87 percent to the soil seperates. Hence these soils were included in the sand/loamy sand textural class. Kottoor soil series also was included in the same textural class as Trivandrum series ie., sandy clay loam. The data on the mechanical composition of test soils also suggest that samples from within a well defined soil series cannot always be grouped into the same textural class.

All the test soils were acidic in nature, the mean pH of Trivandrum series soils being 5.69, that of Kazhakuttom series soils was 5.79 and that of Kottoor series soils was 5.39.

Organic carbon content estimated by the rapid titration method was found to be low in both Trivandrum and Kazhakuttom series soils, the mean content being 0.59 and 0.21 percent respectively. Kottoor series recorded a higher organic carbon content (mean = 1.08 percent).

Because of the dominance of 1:1 nonexpanding kaolinitic clay minerals in these soils, all the soils under study exhibited very low cation exchange capacity. The mean CEC values were 4.38, 2.91 and 5.37 cmols(p+)kg^{-1} for Trivandrum, Kazhakuttom and Kottoor series soils respectively. Since these clays have low potassium fixing capacity, considerable leaching of potassium will occur consequent to low potassium retention in these soils.

The percentage base saturation showed wide variations within each soil series. It varied from 36.0 to 87.5 percent (mean = 62.29 percent) in Trivandrum series, 33.8 to 87.0 percent (mean = 59.06 percent) in Kazhakuttom series and 35.0 to 89.0 percent (mean = 63.93 percent) in Kottoor series. The above values suggest appreciable competition among cationic elements including potassium for exchange sites.

All the test samples contained higher amounts of calcium. On an average, calcium content was 25.26, 18.14 and 31.21 $cgkg^{-1}$; magnesium content was 9.01, 3.83 and 11.69 $cgkg^{-1}$, and sodium content was 10.11, 7.69 and 9.50 $cgkg^{-1}$ in Trivandrum, Kazhakuttom and Kottoor series respectively.

The contents of all the forms of potassium varied significantly between the three soil series as well as within each soil series as evidenced by the coefficient of variation.

The results indicated that the mean content of water soluble K in Trivandrum series was 0.12 meq L^{-1} (range = 0.04 to 0.22 meq L^{-1}). for Kazhakuttom series, the mean was 0.09 $meqL^{-1}$, (range = 0.05 to 0.19 $meqL^{-1}$) and for Kottoor series the mean content was 0.15 $meqL^{-1}$ (range = 0.10 to 0.25 $meqL^{-1}$).

With respect to available potassium as extracted by neutral normal ammonium acetate, about 60 percent of the total soil samples (50 nos) in Trivandrum series were medium in content. Soil samples from Kazhakuttom series were low and medium in potassium fertility. Out of the total 50 samples analysed, 58 percent were low and 40 percent were medium in available K. In the case of Kottoor soil series the potassium fertility was high for 94 percent of the samples.

Exchangeable K content in Trivandrum series varied between 2.82 and 20.10 $cgkg^{-1}$ with a mean content of 7.93 $cgkg^{-1}$. In Kazhakuttom series it was found to range between 1.38 and 12.99 $cgkg^{-1}$ (mean = 4.35 $cg\ kg^{-1}$ and in Kottoor forest soils exchangeable K content was found to be between 8.08 and 25.39 $cgkg^{-1}$. with a mean value of 15.34 $cgkg^{-1}$.

The nitric acid (1.0N boiling) potassium content was relatively low in Trivandrum series with a range of 5.73 to 22.46 $cgkg^{-1}$ (mean = 11.81 $cgkg^{-1}$). In Kazhakuttom series the range was between 5.69 and 18.43 $cgkg^{-1}$ (mean = 10.18 $cgkg^{-1}$) and in Kottoor soil series the range in content of HNO_3.K was from 16.22 to 48.46 $cgkg^{-1}$ with a mean of 31.13 $cgkg^{-1}$. About 71 percent of the nitric acid soluble K were available to crops in Trivandrum series. Only 46 and 51 percent of HNO_3.K were in available form in Kazhakuttom and Kottoor series respectively.

The mean total K contents were 428, 162 and 344 $cgkg^{-1}$, in Trivandrum, Kazhakuttom and Kottoor series respectively.

Assessment of the interactions between chemical forms of soil potassium and other soil components were achieved through correlation studies. The correlation coefficients workedout between different forms of potassium revealed that water soluble K had significant positive relation with available K, exchangeable K and nitric acid K in all the soils under study. But it had negative relation with non-exchangeable K. In the case of available K and exchangeable K also the relation with other potassium fractions was positive and significant. In all the soils studied nitric acid K showed significant positive correlation with non-exchangeable K. The results reveal definite dependance of plant available forms of K with the fraction extracted by hot nitric acid. It may be noticed that when exchangeable K increases there must be a corresponding decrease in non-exchangeable K for the same level of nitric acid K.

It was observed that soil seperates and soil reaction influence potassium availability. But the relationships were not uniform in all the series.

Organic carbon had positive relation with available as well as exchangeable K in Trivandrum and Kottoor series but negative relation in Kazhakuttom series.

Cation exchange capacity and percentage base saturation had positive relation with both available and exchangeable K in all the three soil series studied except in Kottoor series where base saturation had negative relationship with both the potassium fractions.

The above mentioned trends need not be the same under varying potassium fertility. With this view, correlations were worked out between different components with respect to the fertility class as well as taxonomic class of the soil.

Available K was positively and significantly correlated with exchangeable and non-exchangeable K in both Trivandrum and Kazhakuttom series when available K was low. Available K had significant positive relation with nitric acid K; while the relation with exchangeable K was unestimable when the soils with low available K were pooled. Nitric acid K also had significant positive relation with non-exchangeable K. The results suggest contribution of non-exchangeable K towards potassium availablility to crops under low levels of fertility.

There was significant relationship between sand fraction and different forms of potassium. An important observation in low fertile soils was the negative correlation established between CEC and potassium fractions in Kazhakuttom series. Similar trend was also observed in Trivandrum series, as well as pooled analysis of low fertilie soils from all series. The results suggest that when the relative concentration of potassium in exchange complex and soil solution is low (ie. low potassium fertility) CEC has inverse relationship with available forms of potassium.

Soil reaction had negative relation with both available and exchangeable forms of K in low fertile soils of Trivandrum series as well as in the pooled analysis; while positive relation was observed in low fertile Kazhakuttom soils.

Organic carbon was positively related to available and exchangeable potassium forms under low fertility but when low fertile soil samples were pooled, the relation with available K was negative but non estimable with exchangeable K.

In soils with medium available potassium, gravelly nature of soil favourably affects the available and exchangeable forms of potassium in Trivandrum series as well as under pooled analysis. However, in a sandy soil like Kazhakuttom series with medium potassium fertility water soluble K expressed negative correlation with other potassium forms; but the relation was positive and significant in Trivandrum series with sandy clay loam texture. Correlation was unestimable in Trivandrum series when the samples were pooled. Positive significant relation existed between available and exchangeable K, between available and nitric acid K as well as between exchangeable and nitric acid K in all the cases under medium fertility condition.

The effect was positive with CEC, base saturation and interacting cations under medium potassium fertility. The results reveal that the relative concentration of exchangeable cations affects the ultimate ionic equilibria in soil and thus potassium availability.

In soils with high potassium fertility the effect of coarser fractions was found to be negative towards available and exchangeable K in Kottoor series and also in general.

Significant positive relation was observed among the different potassium fractions in soils with high potassium fertility also. Organic carbon, CEC and base saturation were found to favourably affect the available and exchangeable forms of potassium as evident from the significant correlation coefficients.

In general, this experiment indicated the interdependance of potassium fractions in soil as well as their positive and negative relations with other soil components. Attempts must be made to quantify the percentage contribution of different fractions towards plant availability under varied soil conditions as well as cropping situations. Basic studies on the extent of influence of other cations in soil solution on potassium exchange and availability is also suggested as a future line of work in these soils. Thus it is recommended that decision making for potassium fertilisation must be supported by not only soil fertility interms of available potassium, but also the nature of other potassium fractions as well as interacting cations and soil seperates.

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* Original not seen.

BEHAVIOUR OF POTASSIUM IN SELECTED SOIL SERIES OF THIRUVANANTHAPURAM DISTRICT

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ABSTRACT OF A THESIS
SUBMITTED IN PARTIAL FULFILMENT OF THE
REQUIREMENT FOR THE DEGREE
MASTER OF SCIENCE IN AGRICULTURE
FACULTY OF AGRICULTURE
KERALA AGRICULTURAL UNIVERSITY

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VELLAYANI
THIRUVANANTHAPURAM

1993

ABSTRACT

An experiment was conducted at the Department of Soil Science and Agricultural Chemistry, College of Agriculture, Vellayani with 50 surface soil samples each from Trivandrum, Kazhakuttom and Kottoor series to assess the behaviour of soil potassium.

Water soluble, available, exchangeable, nitric acid soluble and non-exchangeable potassium in these soils were determined. Sample observations on total potassium from soils with low, medium and high available potassium were also undertaken. In addition, the physical and chemical properties of all the samples were studied through observations on soil seperates, pH, electrical conductivity, organic carbon, cation exchange capacity, base saturation and exchangeable forms of calcium, magnesium and sodium.

Neutral ammonium acetate (1.0 N) extractable potassium (available form) was found to be positively influenced by water soluble, exchangeable and nitric acid extractable forms of potassium. The organic carbon content positively influenced the available potassium where the soil organic carbon was low viz., Trivandrum and Kazhakuttom series. Cation exchange capacity also had a positive influence on available

potassium. Percentage base saturation influenced available potassium positively, except in forest soils.

In Trivandrum series 71 percent of nitric acid potassium was available to crops; while the corresponding values were 46 and 51 percent in Kazhakuttom and Kotoor series respectively. The total potassium content was also relatively high in Trivandrum series.

The relationship between various forms of soil potassium and also between potassium fractions and other soil components expressed varying trends in soils falling under different fertility classes. This aspect needs further investigation.

Quantification of the contribution of different fractions of soil potassium towards crop uptake is suggested as a future line of work. Basic studies on the ionic equilibria in soil solutions which affect potassium exchange and availability in these soils also warrants attention.