HORIZONTAL AND VERTICAL MOVEMENT OF POTASSIUM IN THE NEYYATTINKARA-VELLAYANI SOIL ASSOCIATION FROM A LONG TERM FERTILIZER EXPERIMENT UNDER COCONUT

BY

PREMAKUMAR S.

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
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1989

DECLARATION

I hereby declare that this thesis entitled "Horizontal and vertical movement of potassium in the Neyyattinkara - Vellayani soil association from a long term fertilizer experiment under coconut" 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.

Vellayani,
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CERTIFICATE

Certified that this thesis entitled "Horizontal and vertical movement of potassium in the Neyyattinkara-Vellayani soil association from a long term fertilizer experiment under coconut" is a record of research work done independantly by Sri. Prema Kumar, S. 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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INTRODUCTION

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As a mobile cation potassium is susceptible to loss by leaching when applied as a fertilizer. A substantial portion of this applied K is translocated both vertically and horizontally with a diffusive flux resulting in both removal and loss beyond the feeding zone of the roots along with percolating water. This especially happens in high rainfall areas and also with coarse textured soils. This K is is usually readsorbed by clays in the lower layers depending upon the texture of the soil. Thus,this K is partly reutilised by deep rooted tree crops.

Only a small fraction of potassium requirement of a plant is met by direct contact through root interception. The largest proportion of K needed by the plant has to be transported in the soil to the roots. The mobility of potassium ions is an important factor deciding K availability. It occurs mainly in the soil solution, the liquid phase of the soil; by mass flow and diffusion along a concentration gradient that is built up around the absorbing root. Continuous potassium supply to the plant is ensured only when the rate of potassium release to the soil solution and its transport to the roots keep

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Only a small fraction of potassium requirement of a plant is met by direct contact through root interception. The largest proportion of K needed by the plant has to be transported in the soil to the roots. The mobility of potassium ions is an important factor deciding K availability. It occurs mainly in the soil solution, the liquid phase of the soil; by mass flow and diffusion along a concentration gradient that is built up around the absorbing root. Continuous potassium supply to the plant is ensured only when the rate of potassium release to the soil solution and its transport to the roots keep pace with the rate of nutrient uptake.

Clay minerals are the most important source of soil K. They hold the bulk of the mobile K and release it when the concentration of soil solution drops due to plant uptake or due to an increase in soil moisture. The composition of soil solution changes rapidly due to variations in soil moisture; nutrient uptake by plants and other factors.

Diffusion is one of the major factors of potassium movement in the soil. It increases with improved K saturation of the clay minerals. When comparing two soils with equal levels of exchangeable K; but different levels of clay content, higher diffusion rates are found in the soil with lower clay content because of its higher K concentration in the soil solution. The diffusion rate also depends on the moisture status of soil.

In laboratory tests it has been shown that K movement is faster in a moist than a dry soil. In a relatively dry soil more K has to be applied inorder to overcome the effect of dry spells of short duration.

Due to the impaired movement of nutrients potassium deficiency and corresponding losses in yield and quality will occur in case of insufficient K saturation.

Besides moisture status a number of soil and environmental conditions also influence the rates of potassium diffusion. Some of these are temparature; clay content; salt content; and potassium concentration.

Application of potassic fertilizer leads to an increase in mobile K; which however gets depleted due to uptake and leaching. Thus movement of potassium in soil both laterally and vertically is brought about by leaching, water movement; and processes of diffusion and mass movement from the site of application. Thus, K will reach all the zones of absorption, after each application of fertilizer. This happens to be very sharp when they are band applied twice in a year for a tree crop such as coconut, once in June-July and another during September-October corresponding to the periods of South West and North East monsoon.

A long term fertilizer experiment in coconut with three levels of N, P and K in 27 combinations done continuously over 25 years, possibly gives the ideal experimental material to investigate the vertical and horizontal movement of potassium vis a vis its uptake.

Such an experiment currently is available at the Coconut Research Station, Balaramapuram to get into answers regarding vertical and horizontal movement of potassium in the red loam soil of Neyyattinkara Vellayani soil association. The applied K fertilizer has had opportunities of being leached downwards in the profile vertically and diffused horizontally as well. With this consideration the following objectives are set forth for the present study.

(i) To asses the horizontal and vertical movement of K in a long term fertilizer experiment under coconut.

(ii) To study the concentration of K in the standardised coconut plant part viz., the 14th leaf and relate the K status to the mobility of the element.

(iii) To rationalise soil sampling tehniques currently in vogue and enable scientific fertilizer recommendation.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Although leaching rate and pattern of movement, of essential plant nutrients, both laterally and depthwise have received attention in recent years, most of the results have come from experiments based either in the laboratory, green house or field lysimeter experiments. These studies are less likely to reveal the true movement pattern and their residual accumulation, since very often the natural system would be disturbed. Thus, studies conducted under field conditions especially from permanent fertilizer experiments after several years of experimentation assume greater significance. Under field conditions the nature of the soil profile may profoundly alter the pattern of K movement horizontally and vertically. In view of this, various aspects on movement and residual accumulation of applied potassium and its utilisation by plantation crops and trees especially coconut has been reviewed.

3.1. Movement of Potassium

Warren (1956) pointed out that K appeared to move down the profile to a depth of 45-65 cm based on studies on soils taken from a classical experiment at Rothamstead where fertilizers had been continuously added for eleven years.

Overdahl and Munson (1966) reported little movement of potassium below 46 cm in a fine textured soil even under irrigation. They also stated that top dressed K moves very little in a clay soil unless extremely high rates of K were applied.

Courpron (1966) studied the mobility of potassium applied to a humic sandy soil of Gaskong islands and found that, from out of 250 ppm of K added either as chloride or sulphate and subjected to downward and transverse movement in 26 days by leaching with a quantity of water equivalent to an annual rainfall of 840 mm and retained 27.8 per cent and 26.9 per cent in exchangeable and 26.2 per cent and 34.3 per cent as non-exchangeable form. Most of the soil K retained in the first 10 cm.

The rate, depth and pattern of movement of K applied, as KNO_3 was studied in two widely different fallowed soils under field conditions by Boswell and Anderson (1964). They found that the applied K was present in the top 15 cm of both soils after 5 weeks, having received a rainfall of 4.6 cm and 3.3 cm. They also observed that after 14 weeks and 43 cm of rainfall on one soil and 17 weeks 26 cm of rainfall on the other, virtually most of the applied K was found in the top 30 cm of both soils except for the higher rate of K upheld on loamy sands. They concluded that both soil texture and amount of rainfall influenced K movement.

Further a high rate of application of K, tended to move down faster and to greater depths as compared with moderate rates. Irrespective of application rates, the highest concentration was found in the 15-30 cm layer even though normal rainfall was obtained. From these, it was concluded that a normal application of K will not leach beyond the root zone in such soils.

Reikerk (1971) investigated the mobility of potassium in forest soil using Rubidium. This mixed with stable elements were applied to a well drained Doylass-forest soil simulating rainwash. Input analysis of the leachates indicated that 8 per cent of the labelled 'K' represented 27 per cent of leached K. Elemental mobility was dependant on physico-chemical properties of the soil, ionic properties and biological function of the nutrient element.

Greenham (1971) reported that K application to a fine sandy loam soil increased the available K content to a depth of 30-36 cm. Downward movement of K was more marked in loamy and sandy soil and was found to be encouraged by $(NH_4)_2 SO_4$ application.

Yoo and Song (1974) found that downward movement of applied K and other nutrients occurred in the order $NH4^{+} > NO^{-}_{3} > K^{+} > Mg^{2+} > Ca^{2+}$. Downward movement of Potassium increased with soil moisture and calcium.

Ghosh (1976) reported that when K was applied to the top of the column at 1 me/100g of soil, it was retained in the upper 5 cm.

Tinker (1978) has reported that the movement of K within the profile is fairly rapid and leads to sufficient distribution. High rainfall, low buffer capacity of the soil and higher anion concentration leads to excessive mobility and leaching losses from the profile.

The downward movement of surface applied K ions in a Papua soil was reported by Best and Drover (1979). KCl solution was applied to the surface of a soil column in the laboratary and leached with water. The soil used was from coconut growing areas of Papua and contained a high level of exchangeable Mg. Much of the K applied was retained within the top 45 cm. Increasing the amount of K or intensive leaching with water resulted in greater downward movement of ions.

Prudniknow (1980) studied the effect of long term application of potassium fertilisers on forms of potassium and the movement of applied potassium in the soil profile. On derno-podzolic loamy soil with an yearly application of 80 kg/ha of K in NK, PK, and NPK combinations over a 15 year period, increased the content of water soluble and exchangeable forms of K in the soil. Potassium application has little effect on the content of non-exchangeable K but increased the content of exchangeable K upto a depth of 45 cm expecially when the treatment included lime and manure application.

K and Cl movement in a forest soil under simulated rainfall was reported by Talsmo et al (1980). An initial appraisal of the mechanisms involved in reactive solute transport through a weathered soil profile was made by following the movement of K and Cl during prologed leaching on a sprinkle irrigated native forest. Nearly all of the K was retained in the soil at 60 cm depth. Although both ions underwent ion-exchange, adsorption of potassium was reasonably uniform through out the profile.

Prasad et al (1981) investigated the movement of applied phosphorus and potassium in arid soils. Laboratory experiment was conducted to determine the extent of P and K movement in some arid soils. Considerable movement of K was observed in the sandy loam. About 75 per cent of applied K moved more than 45 cm depth. Where as in a loamy soil about 80 per cent of K remained in the top 15 cm.

Lakchiri (1983) investigated the vertical and lateral movement of phosphate and potassium. Placement of P and K fertilizers or surface application in a narrow band in the zone where irrigation water is applied improves phosphate status of the soil up to a depth of 30 cm and potassium up to 50 cm. There is enrichment in P and K at the depth of application to at least 40 cm from the site of application due to lateral movement through the irrigation water.

Ganeshmurthy and Biswas (1984) studied movement of K in a Ustochrept soil profile in a long term experiment and reported a downward movement of K in plots in a loamy sand profile which had received various levels of N,P and K fertilizers. The distribution of different forms of K and the percentage of the K saturation of the CEC of the soil at various depths indicated that the applied K moved down to a depth of 75 cm in the high K plots after 6 cycles of crop rotation. Movement of K was not observed in plots that did not receive K fertilizers. The uptake of K far exceeded the amount of applied K. Application of K fertilizer reduced the release of K from non-exchangeable sources.

Lipkina (1987) showed that mobile K compounds in highly fertilized sod-podzolic soils leached up to 60 cm depth. Trends in the concentration and reserves of mobile K in the profile of a derno-podzolic soils were studied in relation to land use and duration of intensive cultivation.

Swarup and Singh (1987) studied the movement of K in a sodic soil profile as influenced by long term use of inorganic fertilizers under rice-wheat pattern and reported that movement of native and applied K was taking place in such conditions. The distribution pattern of water soluble, exchangeable and non-exchangeable K and the percentage K saturation of the cation exchangeable sites in soil at various depths of differentially fertilized plots indicated that a major portion of applied K remained in the top 30 cm of the soil and moved in successively decreasing amounts down the profile up to 75 cm in the plots receiving K fertilizer after 11 cycles of rice-wheat rotation. However, movement of K was not noticed in plots in which no K fertilizer was applied K fertilizer increased the uptake of K by plants and the release of K from non-exchangeable sources.

3.2. Leaching of Potassium

Ayers (1944) reported that the leaching of soils having initially high exchangeable K levels with 500 inches of water, the amount of K leached diminished with decreasing levels of K. Finally the lower sections of the soil column contained more exchangeable K than the upper sections.

Volk (1944) measured the leaching of exchangeable K from Notfold fine sandy loam and other sandy loams and Decatur clay during 8 years of annual K application of 4.5, 18 and 36 kg/acre of K_2O. The coarser soils lost about three to four times as much as the applied potassium from the surface 20 cm. The per centage losses at the highest rate of application for the three soils were 34,31,9 respectively.

Kim (1949) observed that 4 cm of water leached out virtually all the exchangeable K and from a mixed fertilizer. The loss appeared to proceed at two rates, the initial higher rate being attributed to the soluble fertilizer K, the second slover rate to exchangeable and organic K.

Nolan and Pritchett (1960) had shown that both the method and rate of K application influence the leaching of K from sandy soils and that band placement and higher rates of application were more conducive to its downward movement.

Zhukova (1960) reported that the mobility, leaching and availability of K are high in derno podzolic soil and systematic application of NPK increased mobility, leaching etc.

In lysimeter studies Doi and Ayers (1963) indicated that virtually no K was lost from either a humic ferruginous latosol. They also reported heavy losses of K from hydrol-humic latosol and they associated this with the low K release status of the hydrol humic latosol.

Lysimetric studies by Bobritskaya (1967) showed that in rainy years,15 kg of K could be leached away from a sandy soil.

Bohorquez and Lamenca (1969) investigated the leaching of K in soils of the Valle region, and found that K was lost more easily from a Kaolinite soil than from an illite or vermiculite soil. In both soils leaching with 0.1 N HCl removed more potassium.

The leaching loss of K was studied by Misra and Hati (1975) analysing the available K content of soils collected from 0-15, 15-30,30-45 cm depth. This was supplemented by analysing soils from 0-100 cm depth sampled at 15 cm intervals with respect to the treatments receiving K in full dose at planting. The potash content of the soil at all depth was not changed significantly due to different treatments and leaching loss was not appreciable.

Bower (1975) worked on the leaching of adsorbed potassium from humid tropical soils and reported that, the equilibrium between solution and adsorbed K in humid tropical soils leached by rainfall was found to be described by the Lougmeir adsorption isotherm.

Leaching of nutrients and organic substances in intensively fertilized grey brown soil was found out by Facek (1977). Over a 11 year period of application of high fertilizer rates on uncropped grey brown soil, K migrated to a depth of 40 cm where as nitrate-N 100 cm. The depth of K migration was related to the total amount of Potassium applied and did not exceed 35 cm depth. To a lesser degree K migration was affected by concentration.

Singh and Sekhon (1978) studied the leaching of K in illitic soil profiles as influenced by long term application of inorganic fertilizers and found out a correlation between sorption and mobility of K in illitic soil. They studied the K leaching in profiles under different fertilizer treatments, in long term fertilizer experiments. Estimates of K saturation of C E C in soil layers to a depth of 225 cm indicated maximum leaching of K in unfertilized soils. Application of N,P and K increased the K uptake by plants, reduced K saturation and leaching.

Burns (1980) examined the distribution of added K in column studies on three soils viz., coarse sand, medium sand and a loam. Mean displacements calculated from the difference between the initial and final distribution of K following the application of 100 $kgha^{-1}$ were 1.6, 8.7, and 1.3 in above soils. Besides the amount of residual K and the ionic composition of the soil solution also influenced rate of leaching.

Omoti and Ataga (1980) reported that the leaching losses of K were generally less than that of Ca and Mg. The lower leaching rate of K compared with Ca and Mg suggest that some selective adsorption of K is taking place in soils.

Playsier and Juo (1981) studied the leaching of fertilizer ions in an ultisol from the high rainfall tropics, leaching through undisturbed soil columns. Downward movement of Ca^{++}, K^{+} and NO^{-}_{3} in coarse textured kaolinite ultisol profile was studied in the laboratory using undisturbed soil columns. The soil columns were leached with an amount of water equivalent to the rainfall of sampling sites (2400 mm), though a rainfall simulator over a period of 72 days. Added K was leached readily through the profiles. The leachability of cations under these experimental conditions follow the order $K>Al>Ca>Mg$.

Espinova and Reis (1984) reported that leaching of K, Ca and Mg was measured at the depths of 30,75 and 105 cm during the growing cycle of irrigated corn in each of the four plots that had received similar fertilizer and liming treatments. Nutrient leaching in the 0-75 cm depth took place mainly in the first 60 days after initial irrigation. Ca, K and Mg losses in the 105 cm depth averaged 122.95, 20.28 and 42.71 kg ha^{-1} respectively. This study was conducted in dark Red Latosol in Cerrado.

3.3 Factors Affecting Movement of K in Soil

Nolan and Pritchett (1960) pointed out that anions may have influenced the rate and depth of movement pattern of applied K.

The role of anions and exchange reactions in K^+ ion movements involved in potassium nutrition of plants was studied by Bos and Blanchet (1975). They conducted lab studies using small column of soil. The movement of K^+ ions by diffusion, and mass flow were accelerated by an increase in Cl^- concentration.

Kanivets and Berguleva (1975) reported that the K buffering capacity depends on the content of non-exchangeable and exchangeable K in the soil.

Gamonova and Pannikova (1980) reported long term application of KCl at the rate of 100 kg ha^{-1} increased the exchangeable K content in a limed soil down to 20 cm and in an unlimed soil down to 40 cm. Liming increased the amount of K removal by crops and non-exchangeable K content in soil especially in arable layer.

Schroder and Zakosek (1981) reported that the losses of K, Ca and Na increased with increasing amount of eluate and with increasing initial amounts of sorbed cations present in the soil.

Pokhlebkina and Ignatov (1984) studied the effect of liming on the mobility of potassium in a dernopodzolic soil and found that samples from different layers of arable horizon showed that the contents of labile potassium and the extent of their mobility were higher in samples having pH 5.5 than in sample with pH 6.

3.4 Solute movement in soil-theory

Barry *et al* (1983) studied theory of solute movement in soils from the method of ion characteristics. A general theory of vertical solute movement in a soil is presented, which takes into account uptake of water and solute by roots, irrigation or rainfall and the surface application of fertilizers are arbitary functions of time. The main limitation of the theory is the neglect of the variability of soil water conductivity with position. The theory is illustrated by comparing predictions and experimental observations of solute leaching losses measured by lysimetere.

3.5. Modelling for solute movement in the soil plant system:-

The ultimate aim of modelling the soil root interface must be to develop a mathematical system that will predict the effect of changes both in the environment and due to crop management.

In the overall movement of K ions through soil the proportions and mobilities of potassium in both solid and liquid are involved. However, in a heterogeneous medium it is impossible to develop theoretical equation to express accurately the overall flux in terms of the mobilities and concentration gradients of the ions in constituent parts (Nye,1969). Nevertheless, considering diffusion in large volumes approximate judgement of microscale variations it may be possible to consider a quasi-homogenous body for which we may define diffusion 'D' by Fick's First Law.

Flux = $-D\,dC/dx$ ---- eqn.1.

C is the concentration of diffusable ions in the system; ie, all those ions which are in or pass through a mobile phase during a period of time which is short compared with time over which the diffusion is measured. C will thus include the exchangeable potassium and the potassium in the soil solution.

To understand the measured values of diffusion coefficient and to predict its value, consider the total rate of transfer of ions through unit cross section of soil as being due to a flux through the pore solution alone together with an excess flux created by the mobility of the ions on the solid.

Hence Flux $= -D_1V_1f_1dC_1/d\,x + FE$ --- eqn.2.

Where D_1:diffusion coefficient of the ion in free solution.

V_1: fraction of the soil volume occupied by the solution and gives the cross section for dilution;

f_1 = impedence factor.

C_1: concentration of ion in the soil solution FE: excess flux created by the exchangeable ions. Combining equations (1) and (2) we obtain.

$$D = D_1 V_1 f_1 dC_1/dC + D\ E$$

Where D E is an excess term which is zero when the ions on the solid have no surface mobility, but represent their extra contribution to the diffusion coefficient if they are mobile.

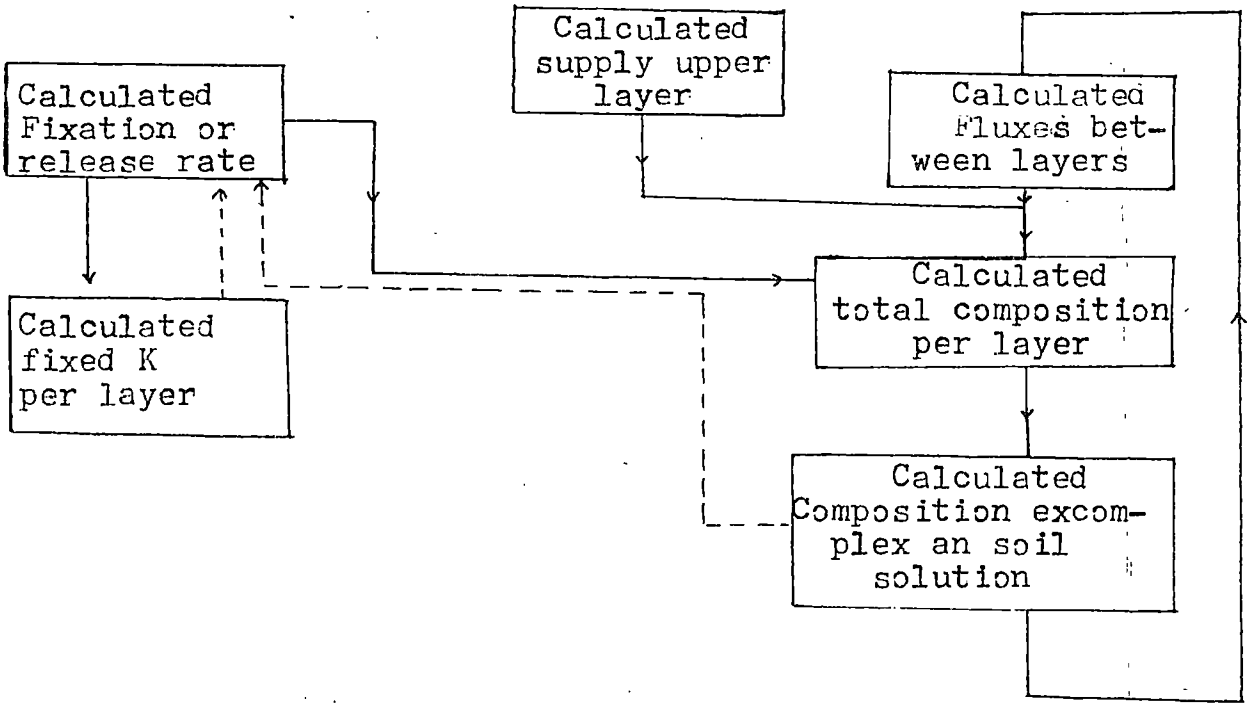
It will be noted that the diffusion coefficient depends on the slope of the sorption isotherm dC_1/dC, if this dC_1/dC increases with C_1. This provides means for assessing importance of the excess term, DE, at levels of potassium characteristic of soils. Vaidyanathan <u>et al</u> (1968) measured the diffusion coefficient of potassium in a soil prepared at different levels of potassium.

It seems likely that in soils the contribution of exchangeable potassium by surface diffusion may be neglected. If confirmed, it is very convenient, because it means that the diffusion coefficient may be calculated from a knowledge of isotherm, the moisture level and impedence factor. The relation between the impedience factor and moisture fraction is roughly linear between the wilting point where it nearly is zero to saturation where it is about 0.5 (Porter, 1960; Rowell et al, 1967). For more accurate assessment it may be determined from the self-diffusion coefficient of a non-adsorbed ion such as chloride. The values of potassium diffusion coefficients range from C. 10^{-7} cm^2/s in a well buffered soil. In dry soils the corresponding values will be one or two orders of magnitude lower.

3.6. Movement of Potassium by mas flow:-

In addition to transport by diffusion, some potassium may be convected to the root surface by water movement. By comparing average soil solution concentrations with plant uptake of potassium and water, Barber et al. (1963) showed that this process would not, in general, satisfy a plant's potassium requirements. Brewster and Tinker (1970) showed that the contribution to the total flow from mass flow did not exceed ten per cent. The word 'apparent' is used because diffusion and mass flow interact, and it is not strictly correct to treat the total flow as the sum of the two processes acting independently.

3.7 Mathematical model on the Vertical transport of Potassium ions in soil



Calculation Scheme for the Vertical transport, exchange and fixation.

A general theory for the description of the vertical transport of ions in soil may be formulated by conservation equation.

$$Qi = \text{div } Ji + \text{Prod } i$$

in which Qi is the variation of the quantity of species i at a point P during the time interval dt.

The term' div Ji' is the divergence of the flux J of species, 'i' so it is the flow rate of species i towards a point P minus the flow rate of species i from point P. The Production term 'Prod i' stands for the processes such as dissolution, fixation, release and so on.

Overview of structure of the model

To set up a model, the soil is divided into a variable number of layers, usually 20. The aim is to calculate the ion fluxes between those layers-including the ion flux towards the top layer and the integration of those fluxes, to obtain the distribution of the various species over the profile.

Four cations are taken into account, namely K, Ca, Na and Mg. In the model the transport itself is only caused by flow of the soil solution in which the ions are dissolved. Both diffusion and dispersion are accounted by choosing an appropriate layer thickness. The ions of the soil solution react in two ways with the solid phase.

-Calculation of the supply of the upper layer.
-Calculation of the fluxes between layers.
-Calculation of fixation and release rates
-Calculation of the distribution of the available ions over the liquid and solid phase.

[Frissel, M.J. (1972)]

Diffusive flux of K

According to Nye and Tinker (1977) the diffusivity may be described by the equation.

$D = D_1 O f_1 dC_1/dC$

Di = diffusion coefficient of K^+ in free solution.
O = the fraction of the soil volume occupied by solution.
fi = concentration of K^+ ion in soil solution
C = Concentration of K^+ in the whole soil system.
C_1 = the K^+ concentration in the soil solution.

MATERIALS AND METHODS

MATERIALS AND METHODS

A long term fertilizer experiment in coconut is being conducted at the Coconut Research Station, Balaramapuram of Kerala Agricultural University since 1964. The soils of the area represents Neyyattinkara-Vellayani soil association identified by the State Soil Survey organisation. This experiment is a 3^3N P K, factorial confounded design with two replication,

Potassium fertilizers had been applied for the last 24 years at three levels Viz., K_o = ogK_2O/tree; K_1 = 450 g K_2O/tree and K_2 = 900 g K_2O/tree/year. The doses for N and P were as follows No = 0g, N_1=340 g N_2 = 680 g, P_o = 0g, P_1 = 280 g and P_2 = 560 g P_2O_5/ tree/year.

This applied K has had opportunities of being leached downwards in the soil profile and, diffused or moved by mass flow, horizontally aswell.

2.1. Collection of Soil Samples

a) Collection of surface and subsurface soil samples:-

Soil samples were collected from the experimental plot in two different depths of 0-30 cm and 30-60 cm and from all the plots of one set of replication.

The samples were collected in April 1988 by that time, the fertilizer applied during 1987 would have equilibriated within the soil system. Thus the samples will represent the residual influence of all the applications since the start of the experiment up to the beginning of the season of 1988.

Surface and subsurface samples as already described were collected at 90 cm intervals horizontally from the bole of the tree ie, the first set of samples at 90 cm from the bole, the second at 180 cm (at the site of manuring), the third at 270 cm and the fourth at 360 cm. The last set was almost at the midpoint between the boles of two adjacent trees.

2.2. Profile Samples

Three profiles were dug one in each plot of the treatment $N_2P_2K_0$, $N_2P_2K_1$ and $N_2P_2K_2$. The combination of K_0, K_1 and K_2 with the highest doses of N&P - Viz, N_2P_2 were selected. The location of the profile was at the fertilizing zone (180 cm from the bole) of one of the trees under the above mentioned treatments. Being a red loam soil, it is already known that clear-cut morpholigical differentiation of the profile cannot be obtained. Therefore soil samples were collected at 15 cm interval upto 105 cm. In actual observation also profile differentiation could not be noticed.

2.3 Collection of leaf samples

The mid leaflets of the 14th frond as recommended in the sampling procedures of IRHO (Van Uoxkull and Cohen, 1978) were collected at the time of soil sample collection.

2.4 Chemical and Physical Analysis of Soil Samples

Samples of soil (Surface and subsurface as well as profile samples) were subjected to the following analytical estimations.

2.4.1 Physical

1. Soil separates (coarse sand, fine sand, silt and clay) by the International Pipetee Method)

2.4.2 Chemical

1. Soil reaction : (Soil sample : Water = 1:2.5) (Jackson,1973)
2. CEC : Neutral normal Ammonium acetate (Jackson,1973)
3. Organic carbon : (Jackson - 1973)

4. Water soluble K : Soil saturation method (Jackson, 1973)

5. Exchangeable K : Neutral normal Ammonium acetate (Jackson, 1973)

6. Non-exchangeable K: 1 N HNO_3 (Jackson, 1973)

7. Exchangeable bases: Neutral normal Ammonium acetate (Jackson, 1973)

2.5. Plant Analysis

Plant samples collected are digested with triple acid and their K content determined.

2.6. Statistical Analysis

For finding out the consequence of the movement of K in the soil over 25 years of the experiment the K_0, K_1 and K_2 levels are taken as the main treatment. The analysis was conducted as follows.

Vertical distance - 2 levels, 0-30 cm, 30-60 cm. Horizontal distance - 4 levels; 90, 180, 270, 360 cm from the bole. Potassium levels - K_0 - control, K_1 and K_2 treatments. So we considered NP treatment as blocks, so that the error within the different levels of potassium was minimised.

ANOVA splits as follows

Source	Df
NP (Blocks)	8
Treatments	23 (3 factor-A-Vertical distance B-Horizontal distance C-Levels of K)
A	1
B	3
C	2
A x B	3
B x C	6
A x C	2
ABC	6
Error	184
Total	215

In this, there are 24 treatments and each treatment have nine replications. K_o - can be taken as control for comparison. The significance of each of the treatment was found out by analysing the data in the above mentioned form. This type of analysis was done for the three different forms of K such as water soluble, exchangeable and non-exchangeable.

Correlation studies:-

Different forms of K at various horizontal and vertical distances were correlated to soil characteristics such as sand, fine sand, silt, clay, pH, CEC, organic carbon, and exchangeable bases. In consequence their effect on the movement of K and its residual accumulation at various distances and depths were found out.

The available K content at various depths were also correlated with potassium content of the 14th leaf analysed to bring out the effect of applied potassium in the plant.

Treatment Combinations

1. $A_1B_1C_1$ - $(0-30,90,K_o)$
2. $A_1B_1C_2$ - $(0-30,90,K_1)$
3. $A_1B_1C_3$ - $(0-30,90,K_2)$
4. $A_1B_2C_1$ - $(0-30,180,K_o)$
5. $A_1B_2C_2$ - $(0-30,180,K_1)$
6. $A_1B_2C_3$ - $(0-30,180,K_2)$
7. $A_1B_3C_1$ - $(0-30,270,K_o)$
8. $A_1B_3C_2$ - $(0-30,270,K_1)$
9. $A_1B_3C_3$ - $(0-30,270,K_2)$
10. $A_1B_4C_1$ - $(0-30,360,K_o)$
11. $A_1B_4C_2$ - $(0-30,360,K_1)$
12. $A_1B_4C_3$ - $(0-30,360,K_2)$
13. $A_2B_1C_1$ - $(30-60,90,K_o)$
14. $A_2B_1C_2$ - $(30-60,90,K_2)$
15. $A_2B_1C_3$ - $(30-60,90,K_2)$
16. $A_2B_2C_1$ - $(30-60,180,K_o)$
17. $A_2B_2C_2$ - $(30-60,180,K_1)$
18. $A_2B_2C_3$ - $(30-60,180,K_2)$
19. $A_2B_3C_1$ - $(30-60,270,K_o$
20. $A_2B_3C_2$ - $(30-60,270,K_1)$
21. $A_2B_3C_3$ - $(30-60,270,K_1)$
22. $A_2B_4C_1$ - $(30-60,360,K_o)$
23. $A_2B_4C_2$ - $(30-60,360,K_1)$
24. $A_2B_4C_3$ - $(30-60,360,K_2)$

0-30 cm - Vertical distance-A_1

30-60 cm- Vertical distance-A_2

90 cm - Horizontal distance - B_1

180 cm- Horizontal distance - B_2

270 cm- Horizontal distance - B_3

360 cm- Horizontal distance - B_4

K_o dose of potassium applied - C_1

K_1 dose of potassium applied - C_2

K_2 dose of potassium applied - C_3

RESULTS AND DISCUSSION

RESULTS AND DISCUSSION

Soil and plant samples from a long term fertilizer trial on coconut at the C.R.S. Balaramapuram of the K.A.U. were used as the material for the present investigation. The experiment was started in 1964 with three levels each of N,P and K in a 3^3 confounded factorial design. The experimental area comes under Neyyattinkara-Vellayani soil association. The present discussion aims at demarkating the effect of long term addition of graded doses of potassium on the transformation of soil potassium and its spatial variability. The cumulative effect of application of KCl for 24 years on the horizontal and vertical movement of K and its transformations in the soil was studied through an assay of water soluble, exchangeable and non-exchangeable fractions of this element at four distances (90,180,210 and 360 cm) from the bole of coconut palm and two vertical layers of soil viz., surface and subsurface. In order to enable a meaningful discussion of data generated thorough studies on the physico-chemical characteristics of the soil under the experiment were carried out and the data are appended.

4.1. Soil properties:-

Data on the different soil properties which may influence the fate of applied fertilizer potassium in the soil are presented in Appendix I (a) to I (i).

The soil in the experimental site is loamy as evidenced by the textural analysis (Appendix I (a) to I (d)). The coarse and fraction varried from 35.3 to 45.1 per cent, fine sand from 18.3 and 25.5 per cent, silt from 17.1 to 25.3 and clay 13.4 to 24.1 per cent.

The gravel content in the soil is practically nil. The soil is a typical redloam of Kerala with high infiltration rate and good drainage.

The soil is acidic in reaction, pH values ranging from 4.6 to 5.3 (Appendix I (e)). With respect to the organic carbon content there was a decreasing trend towards the deeper layers. In general the content was low except in certain areas where the quantity of organic matter showed higher ranges with a concomittant increase in CEC as well as clay content. The data on organic carbon content and CEC are presented in Appendix I (f) and (g) respectively. The CEC of the soil showed wide variation ranging from 3.1 to 8.1 C mol/kg. Evidently a higher CEC was noticed whereever the soil samples showed higher clay and organic matter content. However for various discussions on the potassium transformations and its conversion and dispersion in soil, it is assumed that the clay content has not been changed during a relatively short span of 24 years of experimentation.

Results of chemical analysis of soil for exchangeable Ca and Mg are presented in Appendix I (h) and I (i). There has been very wide variation in the content of these two nutrients in the experimental area. The observed variation may be mainly due to the graded long term application of Superphosphate containing gypsum.

Moreover organic matter additions are not included as treatment so much so the CEC of soil has also been assumed to have not changed significantly in the various plots during the coarse of the experiment.

Observations on the contents of water soluble, exchangeable and non-exchangeable forms of potassium in the various plots are discussed seperately.

4.2. Forms of Soil Potassium

In the field experiment, fertilizer potassium has been applied at three levels Viz., Ko = 0, K_1 = 450, and K_2 = 900 g/tree/year.

The fertilizer application is done in a circular band at 20 cm depth and at 180 cm from the bole of the palm.

Every year, application of potassium is done twice (June-July and September-October). Soil samples for chemical analysis were drawn in April 1988, after both the applications of fertilizer for the year 1987 allowing sufficient time for equilibriation of added potassium in the soil.

4.2.1 Water soluble potassium

Results of laboratary analysis of soil for water soluble potassium content are presented in Table (1)

A perusal of the data revealed that there was considerable variation in the content of water soluble potassium (Kws) among the different doses, distances and depths. The values range from 7.8 to 73.8 ppm. It is evident that the remarkable variation in Kws values is due to both continuous application of potassium at graded levels and due to its mobility in the soil through leaching and other processes under the influence of continuous uptake by the coconut palms. The highest amount of Kws was found in plots supplied with K_2 level of potassium and at 180 cm from bole. Both surface as well as subsurface samples gave highest readings for potassium at this site. That is 71.4 ppm for $N_oP_2K_2$ in the surface layer and 73.8 ppm Kws in the subsurface

Table I

Water Soluble K in the soil samples of various distances away from the bole of the coconut tree and at two different depths under various treatments (ppm)

Sl. No.	Treatment \ H.D. / V.D.	90cm 0-30 cm	90cm 30-60 cm	180 cm 0-30 cm	180 cm 30-60 cm	270 cm 0-30 cm	270 cm 30-60 cm	360 cm 0-30 cm	360 cm 30-60 cm
1	$N_0 P_0 K_0$	13.1	9.2	8.1	11.3	8.3	9.1	9.1	19.1
2	$N_0 P_0 K_1$	11.7	19.1	51.2	48.3	13.6	36.1	12.2	19.2
3	$N_0 P_0 K_2$	11.3	48.1	60.8	59.8	11.4	43.6	14.4	21.4
4	$N_0 P_1 K_0$	9.6	11.8	13.6	9.6	13.9	7.6	13.9	14.8
5	$N_0 P_1 K_1$	13.1	21.2	46.3	55.3	13.2	29.6	13.2	11.3
6	$N_0 P_1 K_2$	11.6	29.7	59.2	41.6	13.3	37.4	12.6	29.6
7	$N_0 P_2 K_0$	8.1	14.6	11.3	9.2	8.6	9.9	10.9	7.9
8	$N_0 P_2 K_1$	11.3	26.2	50.3	54.2	13.6	29.1	12.1	13.2
9	$N_0 P_2 K_2$	8.3	39.1	71.4	61.3	12.6	31.2	9.6	24.2
10	$N_1 P_0 K_0$	6.2	9.3	7.8	9.3	8.7	11.9	11.6	16.1
11	$N_1 P_0 K_1$	9.6	29.7	49.8	53.1	10.8	36.8	9.6	14.8
12	$N_1 P_0 K_2$	12.9	36.4	58.3	44.8	14.6	39.8	11.4	24.8
13	$N_1 P_1 K_0$	11.1	8.4	7.9	12.1	9.6	7.8	9.6	12.3
14	$N_1 P_1 K_1$	14.1	28.6	46.7	42.1	11.9	31.6	9.1	18.4
15	$N_1 P_1 K_2$	11.2	39.9	43.1	54.1	14.2	29.9	12.3	21.3
16	$N_1 P_2 K_0$	9.3	8.4	13.7	14.3	11.6	9.8	11.3	10.9
17	$N_1 P_2 K_1$	13.2	32.4	41.2	49.3	14.4	21.7	14.7	13.8
18	$N_1 P_2 K_2$	13.1	31.3	53.2	61.8	13.2	29.1	9.8	18.6
19	$N_2 P_0 K_0$	10.1	11.8	9.6	11.72	9.8	10.7	11.6	14.6
20	$N_2 P_0 K_1$	13.8	23.8	47.4	43.7	11.6	29.6	14.8	11.6
21	$N_2 P_0 K_2$	9.6	39.8	58.6	59.9	12.8	35.5	13.6	22.8
22	$N_2 P_1 K_0$	8.8	10.1	7.8	9.3	11.4	8.6	14.3	12.8
23	$N_2 P_1 K_1$	11.1	28.6	53.1	44.2	11.8	23.8	9.6	13.8
24	$N_2 P_1 K_2$	13.1	29.1	58.1	64.7	9.1	27.1	8.4	23.6
25	$N_2 P_2 K_0$	12.1	9.6	8.3	11.7	13.6	9.1	12.3	14.1
26	$N_2 P_2 K_1$	13.7	26.8	66.7	54.7	16.8	29.4	13.6	13.6
27	$N_2 P_2 K_2$	13.3	35.1	68.6	73.8	19.8	35.6	11.8	18.7

H.D. Horizontal Distance

V.D. Vertical Distance

layer in $N_2P_2K_2$. This observation is justified by the fact that this site of sampling is where the fertilizer is incorporated into the soil. The high Kws values at this site may be the contribution of the current years application of fertilizer.

The surface soil from the first site of sampling showed relatively lower values of Kws ranging from 8.3 to 14.1 ppm. However the subsurface layer in this site contained higher levels which varried from 8.4 to 48.1 ppm. The extent of Kws at this site varried with the levels of potassium application, the values rising with the K levels. The Kws ranges for K_0, K_1 and K_2 plots were 8.4 to 14.6, 19.1 to 29.7 ppm and 29.1 to 48.1 ppm respectively. The surface samples from the second sampling site show significant difference in the Kws content of K_0, K_1, and K_2 plots. Thus in the K_0 plots the values range from 7.8 to 13.7, in K_1 plots 41.2 to 66.7 and in K_2 plots from 43.1 to 68.6 ppm.

The subsurface samples of the second sampling site also showed a similar trend in the Kws content. In the K_0 plots the Kws ranges from 9.3 to 14.3, in K_1 plots from 42.1 to 55.3 and in K_2 plots from 41.6 to 73.8 ppm.

In the third sampling site in the surface samples the Kws ranges from 8.3 to 19.8 ppm. At this site much variation in the values of Kws is not observed among the samples from K_0, K_1 and K_2 treatments.

The subsurface samples of the third sampling site also showed significant variation in the Kws content. Here the range is between 7.6 to 43.6 ppm. In the K_0 plot the Kws ranges from 7.6 to 11.9, in the K_1 plots between 21.7 to 36.8 and in the K_2 plots between 27.1 to 43.6 ppm.

The Kws content of the surface samples of the fourth site of sampling ranges from 9.1 to 14.7 ppm. Here also variation is not so significant. In the subsurface samples of the fourth site of sampling the Kws values ranges from 7.9 ppm to 29.6 ppm.

The effect of levels of potassium on the pattern of Kws at the various sampling site, indicate the following.

The Kws at various sampling sites in the Ko treatment shows no definite pattern. This is due to the face that no potassium has been applied in the Ko treatment and the Kws observed is only due to the native Kws. In the K_1 and K_2 treatments, however a higher level of Kws at the surface and sub-surface of the second sampling site and

Subsurface layers of the first and third sampling sites have been observed. Thus the surface samples of first and third site of sampling are less affected by application of potassium in the second site, where as the subsurface layers are enriched with water soluble potassium. Therefore a slanding movement of water soluble potassium from the site of application in the soil is predicted.

The subsurface layer of second site also showed higher Kws content in the case of K_1 and K_2 treatments. This may be due to leaching of potassium through rain water and its subsequent accumulation in this layer.

It may be seen that the content of Kws in the K_2 treatments though higher than in K_1, is not commensuratedly as high as expected for the treatment K_2, which is double that of K_1. This is possibly due to transformation of water souble K to exchangeable and non-exchangeable forms. This is evident from the data being presented in the ensuing sections.

4.2.2 Exchangeable K

The exchangeable K content (K ex.) of various soil samples collected from the experimental area are presented in Table (2). A general review of the K ex. values showed

Exchangeable K in the soil samples of various distances away from the bole of the coconut tree and at two different depths under various treatments (ppm)

Sl. No	H.D. / V.D. / Treatment	90 cm		180 cm		270 cm		360 cm	
		0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
1	$N_0 P_0 K_0$	41.3	49.2	42.4	39.8	40.7	49.7	51.6	47.12
2	$N_0 P_0 K_1$	46.4	59.8	81.3	73.3	46.1	71.2	44.1	41.9
3	$N_0 P_0 K_2$	40.1	79.2	102.6	108.3	42.6	81.4	39.8	53.8
4	$N_0 P_1 K_0$	40.6	46.8	42.6	46.2	38.3	42.1	41.6	39.6
5	$N_0 P_1 K_1$	51.3	59.1	81.6	101.2	29.6	62.2	37.5	48.4
6	$N_0 P_1 K_2$	46.2	73.1	93.2	91.7	41.3	71.4	39.4	67.9
7	$N_0 P_2 K_0$	43.8	43.6	39.8	43.2	31.8	43.7	43.8	45.2
8	$N_0 P_2 K_1$	51.2	61.2	91.3	91.3	51.8	72.1	49.0	51.3
9	$N_0 P_2 K_2$	40.6	69.7	104.6	123.6	40.9	59.6	48.6	51.6
10	$N_1 P_0 K_0$	38.3	40.6	39.8	39.2	38.3	43.9	21.7	39.2
11	$N_1 P_0 K_1$	31.2	60.1	79.6	94.6	51.4	69.8	39.4	43.1
12	$N_1 P_0 K_2$	49.2	68.2	89.4	59.73	55.3	72.4	27.1	34.2
13	$N_1 P_1 K_0$	43.2	41.3	37.8	45.7	28.7	49.3	63.2	54.2
14	$N_1 P_1 K_1$	47.1	69.2	89.8	91.8	51.3.	54.6	47.1	69.8
15	$N_1 P_1 K_2$	48.2	73.8	74.6	84.6	49.8	59.6	30.3	38.4
16	$N_1 P_2 K_0$	41.6	42.6	42.3	29.8	61.6	47.1	38.1	46.9
17	$N_1 P_2 K_1$	42.1	41.9	78.1	89.6	53.8	51.3	46.2	53.2
18	$N_1 P_2 K_2$	45.0	61.8	91.3	99.2	47.6	64.8	56.1	29.2
19	$N_2 P_0 K_0$	42.1	39.4	28.9	42.1	24.8	45.2	49.7	38.4
20	$N_2 P_0 K_1$	48.4	51.9	78.6	71.8	51.2	59.2	36.7	46.9
21	$N_2 P_0 K_2$	43.6	54.5	59.8	91.9	45.6	61.8	31.9	51.3
22	$N_2 P_1 K_0$	50.8	43.6	38.4	45.3	43.9	39.2	38.2	54.8
23	$N_2 P_1 K_1$	39.6	61.5	81.7	101.3	61.2	49.6	46.2	39.2
24	$N_2 P_1 K_2$	41.3	70.6	92.6	87.3	53.4	53.8	41.3	53.8
25	$N_2 P_2 K_0$	44.3	29.8	38.2	48.3	43.1	39.4	49.7	45.4
26	$N_2 P_2 K_1$	49.1	71.2	93.1	83.9	59.6	56.8	51.2	47.8
27	$N_2 P_2 K_2$	33.9	66.8	101.2	109.7	48.1	69.7	36.4	60.3

H.D. Horizontal Distance

V.D. Vertical Distance

that there is remarkable variation for the different treatments and also for sampling sites.

The surface soil samples from the first site showed low values of exchangeable K content. It ranges from 30.9 ppm to 51.3 ppm irrespective of the K treatments (K_o, K_1 and K_2). The subsurface soil samples collected from the first site, however showed wide variations in the ontent of exchangeable K. In this case the values range from 29.8 ppm to 79.2 ppm. In the K_o plots the K content range from 29.8 ppm to 49.2 ppm, in K_1 plots, 41.9 to 71.2 ppm and in K_2 plots from 54.5 ppm to 79.2 ppm.

The surface samples of the second site showed significant difference between K_o, K_1 and K_2 plots. In the K_o plots, exchangeable K values range from 37.8 ppm to 42.5 ppm., in the K_1 plots 78.1 ppm to 93.1 ppm and in the K_2 plots 59.8 ppm to 104.6 ppm. The subsurface samples of the second site also showed the same trend. In this case K_o plots showed a range of 29.8 to 48.3 ppm of K-ex. While in the K_1 plots the values were 73.3 to 101.2 ppm and in the K_2 plots the range was from 59.73 to 123.6 ppm.

In the third sampling site, the surface K ex values range from 28.7 to 53.8 ppm. Here, even though a wide range is obtained in the overall analysis, the exchangeable K content of the K_0, K_1 and K_2 plots makes not so much difference. The subsurface samples of the third sampling site showed a very remarkable variation in the exchangeable K content. Here the K ex values range between 39.2 ppm to 81.4. Of this, the K_0 plots showed a K ex range 39.2 to 49.7 ppm, in K_1 plots the same is 49.6 to 71.2 ppm and in K_2, 51.8 to 81.4 ppm.

The exchangeable K content of the surface samples of the fourth site ranges from 21.7 ppm to 56.1 ppm. Here the difference due to the treatment is not so significant. In the case of subsurface samples of the fourth site, the exchangeable K values range from 29.2 to 67.9 ppm. In this case the K_2 treated plots showed a significant increase in K ex values.

Potassium in soil solution tends to equilibriate with K in the adsorbed fraction, so that these two soil fractions of exchangeable and water soluble are closely interdependent. The equilibrium between solution and adsorbed K is controlled to a large extent by the degree of K selectivity of the adsorption sites in the exchangeable fraction. K adsorbed in these sites are in equilibrium with relatively high concentration of solution K^+ (Eblers _et al_ - 1968), on the other hand the clay minerals posses adsorption sites that are much higher in K^+ selectivity and that binds K^+ very strongly.

When a salt like KCl is added to soil, the salt dissolves and the K^+ concentration in the soil solution increases rapidly. K is then removed from the solution by adsorption. This is the reason why the exchangeable K content is higher than the water soluble K of the surface and subsurface samples of the second site which is the site of application of fertilizer. The rate at which this occurs depend on the particular equilibrium contitions in the system. This removal of K^+ from soil solution is accompanied by an increase in the soil solution concentration of other cations. The application of K^+ to a soil may saturate all three fractions of K. However several weeks may be required to reach K^+ equilibrium under field conditions.

4.2.3 Non-Exchangeable - K

Table (3) represents data on the non-exchangeable K (K-non-ex) in ppm for the soil samples used for the investigate. It is interesting to note that the differential doses of applied potassium over the last from the bole of the cocnut tree and at two different depths under various treatments (ppm).

Sl. No.	H.D. / V.D. Treatment	90cm		180cm		270cm		360cm	
		0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
1	$N_0 P_0 K_0$	281.1	253.4	238.3	253.1	279.6	270.8	284.3	291.4
2	$N_0 P_0 K_1$	281.9	239.6	326.3	332.6	298.3	281.3	301.3	248.3
3	$N_0 P_0 K_2$	275.1	245.3	264.2	281.2	254.1	271.4	292.7	281.6
4	$N_0 P_1 K_0$	253.2	278.2	291.2	310.6	253.1	236.3	286.1	242.2
5	$N_0 P_1 K_1$	252.1	283.2	296.4	309.1	292.5	246.6	291.5	246.7
6	$N_0 P_1 K_2$	273.6	263.6	331.5	373.6	248.1	273.6	292.2	289.6
7	$N_0 P_2 K_0$	282.1	293.1	236.9	259.6	286.9	283.7	239.2	298.2
8	$N_0 P_2 K_1$	242.3	245.1	237.7	293.1	248.3	301.8	259.5	267.7
9	$N_0 P_2 K_2$	237.1	299.8	314.9	288.6	264.2	282.9	262.7	283.1
10	$N_1 P_0 K_0$	247.2	292.6	263.8	254.6	271.9	336.4	240.0	239.2
11	$N_1 P_0 K_1$	291.5	249.8	325.3	301.9	278.7	293.1	264.5	249.6
12	$N_1 P_0 K_2$	209.5	310.3	242.4	286.7	232.3	271.4	213.1	246.5
13	$N_1 P_1 K_0$	239.3	237.8	271.5	282.6	256.3	292.6	264.6	258.2
14	$N_1 P_1 K_1$	263.5	301.6	259.7	243.2	235.7	289.1	291.8	236.4
15	$N_1 P_1 K_2$	271.3	239.5	227.5	211.0	294.2	236.3	273.5	246.5
16	$N_1 P_2 K_0$	293.1	268.9	292.6	274.3	269.1	255.0	267.8	239.7
17	$N_1 P_2 K_1$	283.5	247.3	287.3	213.6	275.0	269.5	298.3	267.5
18	$N_1 P_2 K_2$	235.1	291.6	220.5	299.0	272.1	284.3	231.3	298.1
19	$N_1 P_0 K_0$	244.5	253.8	271.3	283.5	257.8	259.8	219.6	289.3
20	$N_2 P_0 K_1$	239.1	278.9	283.2	279.1	249.2	253.0	238.1	301.9
21	$N_2 P_0 K_2$	278.5	286.3	243.0	228.5	291.3	237.9	257.0	296.3
22	$N_2 P_1 K_0$	249.4	294.6	283.1	302.4	284.0	281.4	237.9	253.5
23	$N_2 P_1 K_1$	279.1	247.3	298.1	307.1	287.1	236.7	247.9	254.7
24	$N_2 P_1 K_2$	263.4	239.1	273.4	291.6	286.4	300.6	271.1	279.6
25	$N_2 P_2 K_0$	264.3	271.6	196.6	264.8	232.6	257.3	283.4	271.8
26	$N_2 P_2 K_1$	286.3	316.6	227.8	297.3	284.1	276.8	293.6	297.8
27	$N_2 P_2 K_2$	291.8	236.4	321.4	336.1	310.6	291.6	286.4	303.3

H.D. Horizontal Distance

V.D. Vertical Distance

24 years had no significant influence on the non-exchangeable form of this nutrient in the soil. The K_o treatment sites recorded 230 to 290 ppm of K-non-ex which is comparable with the K-non-ex range for K_1 and K2. (220 to 330 and 250 to 340 ppm respectively) Irrespective of sampling sites the K-non-ex remained more or less static. This happened inspite of the addition of 11.25 and 22.5 kg each of K_2o in K_1 and K_2 plots respectively over the last 24 years. This reveals a definite influence on a growing crop in the rates of various reactions leading to fixation or release of potassium.

The uptake of potassium during the period of experimentation by the coconut palm was evidently higher at higher doses of potassium fertilization. This is justified by the fact that the Kws and K-ex values for K_1 and K_2 are generally higher.

A productive coconut palm absorbs an average 1.8 kg K_2O/tree/year. However a palm during early pre-production years accumulates potassium in the tree drunk. The contribution of K-non-ex to the crop uptake is very meagre compared to other two forms viz. Kws and K ex which are more governed by periodical K application.

It can be inferred from the observations that during the last 24 years the uptake of K by the coconut palms was more or less offseting the fertilizer additions at $K_1$and K_2 levels and depleting the available forms at K_0 levels. This has resulted in the present trend of results where K_1 and K_2 levels contribute more of Kws and K-ex than K_0 where as the K-non-ex forms remain unaltered in all the three levels.

The relationship between K non-ex; K ex and Kws is of course dynamic but the rate of reactions leading to the release of K non-ex to K-ex and/or Kws might be very slow. Same will be the case with the reverse reactions. Therefore the palms with potassium nutrition will show better uptake of K, as well as better growth and yield without upsetting the non exchangeable fraction in the soil. Thus the K non ex of the soil is not an index of the productivity of the soil with respect to this element.

Visual observations of the plots indicated that palms with K_0 treatment show acute pottassium deficiency symptoms and most of them have stopped production after

10 years, neverthless the K_0 plots yield considerable amounts of non-exchangeable K.

Another feature of the data on K-non-ex is that at the surface soil in the second site of sampling, which is also the site of fertilizer application, there are slightly higher levels of K non ex than that at other sites in K_1 and K_2 treatments. This shows that inspite of the observed mobility of K fraction in soil, the bulk of applied K remains in the site of application for a fairly long period and a considerably high concentration in soil solution which will enhance the reaction rates towards the conversion of available forms into non-exchangeable forms. However this enrichment of the K non-ex at the site of fertilizer application is not significantly high compared to other sites.

It is also important to note that higher levels of nitrogen application had improved the K non-ex in the soil. This is probably because the abundance of ammonium ions in soil solution had replaced more of potassium (K^+) from the exchange sites which inturn was converted to non-exchangeable forms.

4.3. Potassium Movement in soil

From the foregoing discussions, it was seen that there is considerable interrelationship between different forms soil potassium at vaious sampling sites and the levels of potassium nutrition to coconut palms. In order to arrive at a scientific conclusion on the movement of soil potassium as effected by the fertility levels, the data generated were reorganised to statistically analyse the interactions between vertical distance at 2 levels (0-30 and 30-60 cm) horizontal distance at four levels (90, 180, 270, and 360 cm from the bole) and potassium application at three levels (0, 450, 900 g/palm/year). In this context the NP treatments were pooled and included as block effects.

4.3.1 Movement of water soluble potassium

Mean values on the movement of Kws towards various distances as well as the two sampling depths as effected by the three levels of potassium, are presented in Tables 4 (a) and 4 (b).

Findings discussed in the preceeding section was confirmed by the results of statistical analysis which reveal that there was significant interaction between the three factors (Vertical distance, horizontal distance

Table 4 (a)

Mean Table For Water Soluble 'K' Content.

H.D.	90 cm		180 cm		270 cm		360 cm		Mean for K Level
V.D. / Treatment of K	0-30	30-60	0-30	30-60	0-30	30-60	0-30	30-60	
K_o	9.6	10.4	9.8	11.0	10.6	9.4	11.7	13.7	10.7
K_1	12.6	26.3	50.3	55.3	13.1	29.8	12.1	14.9	26.8
K_2	11.4	36.6	50.1	54.3	13.4	33.0	11.6	22.8	30.2

H.D. Horizontal Distance

V.D. Vertical Distance

Table 4 (b)

	90	180	270	360	Mean
0-30	11.2	39.73	12.37	11.8	18.78
30-60	24.4	40.2	24.07	17.13	26.43
Mean	17.8	39.97	18.22	14.47	

CD at 5%

A = 1.13; B = 1.60; C=1.33

AB= 2.26 AC = 2.57; BC = 3.63

ABC= 3.63

and K levels) analysed. The mean concentration of Kws was highest (59.1 ppm) in the surface soil at the second sampling site which received highest dose of potassium fertilizer. The subsurface layer for K_1 treatments and K_2 treatments recorded figures on par with the above value (55.3 and 54.3 ppm respectively). In the case of K_1 treatment the surface soil samples also showed significantly higher values than the control plots, (50.3 ppm). However this was statistically inferior to K_2 treatments as well the subsurface sample for K_1.

The second highest set of figures were for the subsurface samples at first and third sampling site in K_2 level (36.6 and 33.0 ppm). Thus, the mean values corroborate the suggestions made earlier that there is a slanding movement of Kws from the site of application. (second sampling site) towards the subsurface layers near as well as far from the bole of the palm along with a downward displacement at the second sampling site through infiltration.

It may also be noticed that the Kws values for the surface samples at the first, third and fourth sampling sites are significantly lower to the figures discussed.

4.3.1.1 Horizondal Movement of water soluble Potassium in soil

Scrutiny of pooled mean figures for the various sampling sites presented in Table 4 (b) revealed that the highest content of Kws (39.97ppm) remains at the site of application (second sampling site) irrespective of vertical movement or the levels of potassium fertilization. The content at this site was statistically superior to all other sites closely followed by the values recorded for the first and third sampling sites (17.8 and 18.2 ppm) respectively which were on par. The fourth sampling site which was farthest from the bole of the palm showed relatively lower mean value (14.47 ppm) which was significantly inferior to that of other sites.

The movement of potassium is closely related to the nature of water displacement in any soil. In a loamy soil with moderate infiltration rate and lower bulk density the extent of horizontal movement for the water soluble fraction of potassium is limited. Moreover the rainfall pattern and the water holding capacity play a major role in the convection and dispersion of potassium in soil. For a rainfed crop, as in the present study, the movement of potassium depends mostly on the annual rainfall. The experimental area receives on an average 150 cm rainfall annually. However quantification of the lateral mobility based on the annual rainfall and soil properties warrants extensive data generation and computations which is beyond the scope of present study.

Lakhiri (1983) noticed enrichment in potassium to at least 40 cm away from the site of application due to lateral movement through irrigation water, in red loam soils, but for a rainfed crop receiving 150 cm of rainfall well distributed over an year, the pattern of lateral movement may depend on the root absorption power and the resultant active transport processes also. Thus it was seen that there was moderate enrichment upto 90 cm away from the site of application It may be noticed that the absorbing roots of coconut palm extends upto 270 cm from the bole. Therefore the lateral movement is also limited to this area showing a steep fall in Kws at the fourth sampling site.

It was also revealed from the data that the different levels of potassium application has significantly affected the extent of lateral movement of Kws. The figures indicate that the application of incremental doses of potassium at the second site showed a corresponding enrichment of Kws at the first and third sampling site together with the site of application. However the pooled mean for K levels showed that the two doses of K fertilizer application yielded Kws values which were statistically on par but both the figures were significantly superior to that of the control plots.

K_2 level recorded 13.27 ppm Kws which was on par with that of K_1 ie 26.8 ppm. The reason for not obtaining proportionate increase in Kws at the K_2 level may be the transformation of water soluble potassium to exchangeable and non-exchangeable forms.

4.3.1.2 Vertical movement of Kws

Potassic fertilizers applied in this experiment over the last 24 years was in the form of KCl which is readily soluble in water. Application of soluble forms of fertilizers naturally results in their downward displacement through rain or irrigation water subject to various transformations in the soil and plant uptake. In the case of potassium, reports as early as 1956 by Warren suggested that the element can move down the soil profile upto a depth of 65 cm under long term fertilizer application. In the present study also a higher level of Kws was noticed in the subsurface layers wherever K was applied as fertilizer. However the inference is not infavour of a vertical displacement alone, it can be proved that potassium salts move down the profile in a slanding manner at a conical pattern from the site of application eventhough a major portion of applied potassium remains vertically down the profile. The pooled mean values for the two depths of sampling revealed that the surface samples contain 18.78 ppm Kws compared to 26.43 ppm (Table 4 (b)) in the subsurface samples which is statistically superior. The same trend can be observed in the data partitioned and presented in Table 4 (a) and in table I. The prediction of a conical movement is justified by the higher concentration of Kws on the subsurface layers of first and third sampling site with a lower level in their surface layers.

In order to assess the influence of rate of application of K on the distribution of different forms of the nutrient in the soil profile, three profiles were examined. Data on Kws of the soil from the three profiles ($N_2P_2K_0$, $N_2P_2K_1$ and $N_2P_2K_2$) receiving highest level of N and P fertilization 0, 450 and 900 g K_2O/Palm/year respectively,

Table 5

Amount of water soluble 'K' in ppm in the three profiles at vatious depths.

Profiles	$N_2P_2K_o$	$N_2P_2K_1$	$N_2P_2K_2$
Treatment depth	1	2	3
0-15	14.12	21.32	19.17
15-30	13.79	43.17	67.62
30-45	10.11	39.73	43.16
45-60	12.32	31.84	44.84
60-75	9.13	26.36	27.32
75-90	10.82	14.39	18.63
90-above	13.98	8.19	10.32

are presented in Table (5)

The red loam soils do not show a clear-cut horizon differentiation and also the physical properties of the soil. Therefore the downward movement of Kws in these soils becomes a function of water displacement and extent of counter ions. The data shows considerable extent of Kws values upto a depth of 75 cm in both K_2 and K_1 levels, the former showing naturally higher values. It is evident that under identical soil physical andchemical characteristics the trend of displacement of Kws remains independant of the level of application showing only slightly higher values at higher levels, eventhough Bosewell and Anderson (1964) reported that K tended to move down to greater depths with higher rate of application. Here the Kws values do not show the same trend due to conversion of Kws to K ex and K non-ex forms.

Here also the Kws shows no marked variation with the levels deeper in the profile. A possible reason may be the higher rate of conversion of Kws in to K ex and K non ex forms at K_2 level during the process of infiltration. The conical pattern of movement is more clear from the graphical representation of data.

The active root zone of coconut palm is reported to be 20 to 70 cm down the profile (Kuzhwah 1976). The Kws values show higher values in this area for K_2 level. Therefore it is suggested that K_2 level of potassium application is better than K_1 in maintaining sufficient amounts of Kws in the root zone of coconut palm.

The distribution of Kws in the soil profile for the control (K_0) plots do not show any definite trend as was observed by Ganeshmurthy and Biswas (1984)

4.3.2 Movement of exchangeable potassium

Table (6) presents the mean figures for the exchangeable K content as affected by sampling sites and potassium levels. As in the case of Kws there is significant interation between depths, distances and potassium applications levels in affecting the extent of K ex in soil. The surface sample in the second site of sampling at the K_2 treatment showed maximum K ex value (102.7 ppm) immediatly followed by subsurface layer of same site (101.2 ppm). Both the figures were on par and significantly superior to all other sampling sites. This shows that a fairly large fraction of applied potassium remains in the exchangeable form throughout the profile at higher levels of potassium application. At K_1 level the same sampling site yielded 83.7 ppm in the surface layer which was on par with the value for subsurface at this site (88.5 ppm) eventhough subsurface values were little higher. The K ex values for the control plots were significantly lower when compared to those receiving fertilizer. The results are supported by the findings of Prudniknow (1980) who found that potassium application increased content of K ex values in the soil.

4.3.2.1 Horizontal movement K ex

Table 6 (b) provides mean values for comparing lateral variation of K ex. At the second sampling site, on an average the K ex was found higher in surface soil (78.57 ppm) which was however on par with the subsurface layer at that site (76.97 ppm). Both these figures were significantly superior to all other horizontal and vertical sampling sites. With periodical enrichment of potassium through fertilizer application such a higher figure at the site of application can normally be expected.

Table 6 (a)

Mean table - Exchangeable 'K' content

H.D. / Treatment 'K'	Ist site 90 cm		2nd site 180 cm		3rd site 270 cm		4th site 360 cm		Mean
V.D.	Surface 0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	
K_o	51.1	41.6	49.3	41.2	45.3	39.4	48.6	43.4	44.99
K_1	45.5	64.2	83.7	88.5	49.1	61.7	41.6	48.5	60.35
K_2	48.4	72.1	102.7	101.2	43.7	69.1	34.2	50.5	65.36

H.D. Horizontal Distance

V.D. Vertical Distance

Table 6 (b)

Depth	90	180	270	360	Mean
0-30	48.33	78.57	46.03	41.67	53.6
30-60	59.3	76.97	56.73	47.8	60.2
Mean	53.82	77.77	51.38	44.64	

CD at 5%

A = 1.46; B = 2.07; C = 1.80;

AB = 2.93; AC = 2.54; BC = 4.72

ABC = 4.72

The K ex values for the subsurface samples at first and third site of sampling (59.3 and 56.73 ppm respectively) provides the trend of mobility. These figures were significantly superior to corresponding surface layers. Hence the mode of mobility for K ex is also predicted to be conical. The pattern is clear from the graphical representation of the data. [Fig.2]

A perusal of mean values for K ex for four sampling site revealed significant statistical variation in K ex. The second sampling site showed highest value (77.77 ppm) which was significantly superior to other sites. This was followed by the first sampling site (53.82 ppm) and third sampling site (51.38 ppm) which were on par. The general trend was a decrease in K ex value towards the farther areas from the palm, but for the site of application. A higher value is obtained nearest to the bole of the palm, possibly because of the contribution from the subsurface layers resulting from the conical movement as suggested earlier.

4.3.2.2. Vertical movement of K ex

The over all mean values in Table. 6 (b) shows significant enrichment of K ex towards the deeper layers of soil. The surface layer showed 53.6 ppm where as the subsurface concentration of K ex was 60.2 ppm.

The profile examination presented in Table. 7 gives a more clear picture.

It may be noted that the profiles were cut at the site of fertilizer application where as the mean values derived from Table 6 (b) are the additive effect of different sites of sampling. Therefore the profile samples in general showed a higher K ex values than the mean values presented for surface and subsurface layers.

In the first profile, ($N_2P_2K_0$) where there was no fertilizer application, for the last quarter of a centuary. There was no remarkable variations in K ex values throughout the profile. However the other two profiles; where potassium was applied at K_1 and K_2 levels reflected the trend of down ward displacement of applied potassium over the years. It can be seen that there is considerable enrichment of K ex in the surface as well as subsurface layers for K_1 and K_2 treatments with higher levels of K ex at deeper layers.

Table 7

Amount of exchangeable 'K' in ppm in the three profiles at various depths

Profile	$N_2P_2K_o$	$N_2P_2K_1$	$N_2P_2K_2$
Depths	1	2	3
0-15	51.28	75.12	79.84
15-30	46.84	86.14	92.19
30-45	43.62	91.89	109.82
45-60	55.22	98.63	102.38
60.75	51.23	86.16	98.19
75-90	52.28	72.56	76.81
90-above	50.68	56.19	58.19

Potassium fertilizers, when applied in conjunction with other major nutrients; is taken up in large quantities by the coconut palm; however long term addition of this nutrient will add to the exchangeable pool, which may also contribute of plant uptake. This observation is supported by the fact that, inspite of downward displacement along with water infiltration, a major portion of K ex remains in the root zone of coconut.

The trend of downward displacement of K was seen independant of the levels of potassium application. The suggestion of Bosewell and Anderson (1964) that K tended to move down to greater depths with higher rate of application is not agreable in the red loam soils under present study. Under K_1 level (450 g K_2O/tree/year) 88 per cent of K ex enrichment remained in the first 75 cm of the profile where as for K_2 level, the computed figure is 87.9 per cent. However the computation is only from the data collected from a total of 105 cm depth; beyond which the levels of nutrients is not expected to contribute towards coconut nutrition.

It can be suggested that the vertical movement of K ex under red loam soil conditions is ideal for coconut cropping since a major portion of K ex remains in the root-zone under normal fertilizer application.

The K ex values for K_1 level showed an increasing trend from 75.12 ppm on the surface to 98.63 ppm at the 45-60 cm layer the immediately lower layer (60-75 cm) also showed appreciable amount of K ex (86.16 ppm). Same was the trend at K_2 level with the surface layer containing 79.84 ppm K ex compared to 109.82 ppm at 30-45 cm and 98.19 ppm at 60-75 cm.

The maximum root activity of coconut is upto 90 cm. The K ex values remained appreciable in this area of the profile whereever potassium was applied as fertilizer; however the downward displacement of fertilizer potassium at a depth below 75 cm is not sufficient to cater to the needs of root activity and plant uptake together with soil enrichment. It seems that a large extent of K ex in this area is contributed towards Kws and thereby plant uptake and therefore the soil levels of K ex is lower than the layers immediately above. On the contrary, the upper soil layers (30-60 cm) were enriched by the fertilizer potassium to a greater extent, that even after the coconut nourishment, soil at this layer retained highest levels of K ex.

There was considerable increase in the K ex values for surface layers (0-15 and 15-30 cm) with incremental doses of potassium. In the surface layer the K_0 profile showed 51.28 ppm K ex compared to 75.12 ppm at K_1, 79.84 ppm at K_2 levels. These results reveal the possibility of an upward movement of applied potassium from the site of application (20-25 cm below the surface) through capillary rise of soil moisture.

4.3.3 Movement of Non-exchangeable K

Data presented in Table (3) was rearranged as described elsewere for statistical analysis, eventhough there was no marked variation in K non ex values in the experimental area. The results of statistical analysis showed that the K levels, the horizontal distances or vertical depths did not influence the K-non-ex levels in the soil significantly. Therefore the mean data is not presented. The graphical representation also showed the same trend.

Table (8) presents data on non-exchangeable K in the three profiles. The range values for non-exchangeable K is between 238.4 and 293.6 in Ko plots, 286.4 and 324.2 ppm in K_1 plots and 284.9 to 324.6 ppm in K_2 plots. Thus there has been a marginal increase in non-exchangeable

Table 8

Amount of non-exchangeable 'K' in ppm in the three profiles at various depths

Profile	$N_2P_2K_o$	$N_2P_2K_1$	$N_2P_2K_2$
depth cm	1	2	3
0-15	272.1	301.2	309.8
15-30	293.6	314.2	313.2
30-45	265.9	299.8	324.6
45-60	258.2	324.2	316.7
60-75	259.6	298.6	309.2
75-90	238.4	289.3	296.8
90-above	246.8	286.4	284.9

K in the potassium applied plots over the years. The lowest values of non-exchangeable K are found at 90 cm and above in all the profiles. Significantly higher values of non-exchangeable K is noticed in K_1 and K_2 plots upto a depth of 75 cm. Incidently the region of the soil upto a depth of 75 cm is possibly the most significantly affected by the continuous application of K fertilizer. This was so in the case of Kws and K ex also.

Long term application of KCl for coconut in red loam soils, thus results in a marginal increase of K-non-ex in the coconut root zone. However, this increase is not to be reflected in crop performance; since the K uptake is largely dependant on the Kws and K ex at the root zone.

The horizontal and vertical displacement of fertilizer K in red loam soils have little influence on the levels of non-exchangeable form of this element in soil.

4.4 Potassium movement as affected by soil properties

To findout the impact of soil properties on movement of various forms of potassium, correlation studies were conducted. Being an easily mobile element, K movement is affected by various soil properties. The adsorbed fraction and mobility of potassium in soils are being strongly affected by pH.

4.4.1. Water soluble potassium

Table (9) presents the correlation between water soluble K content in different horizontal sites and vertical depths of soil sampled from the bole of coconut tree with various soil characteristics. It can be seen that the coarse sand and clay fraction generally have a significant positive and negative correlation respectively. Thus both vertical and horizontal movement of Kws from the site of application appears to be favoured positively by coarseness of sand fraction. The clay content on the other hand has a negative effect on the migration of potassium. The silt fraction also showed negative effect on migration of potassium, but for the sampling sites at 90 cm from the bole on the palm.

CEC appears to be positively correlated with migration of Kws in all sampling sites except the second site of sampling.

A clear positive correlation of Kws to Mg content is seen in second site of sampling at both depths. In the third site, the subsurface layer also showed same trend.

Calcium content, in the first site, is positively correlated with migration of Kws.

Table 9

Correlation coefficient between water soluble K and soil characteristics

Distance	Coarse sand	Fine Sand	Silt	Clay	O.m	p^H	CEC	Ca	Mg
90cm 0-30 cm	0.4094*	0.2432*	0.2058	$\bar{0}$.3928*	$\bar{0}$.1232	$\overset{+}{0}$.2438*	0.1719	0.2392*	0.0914
90 cm 30-60 cm	0.3062*	0.3428*	0.2222	$\bar{0}$.2518*	$\bar{0}$.2163	$\bar{0}$.2139	0.0324	0.2419*	0.1702
180 cm 0-30 cm	0.3090*	0.4944*	$\bar{0}$.2170	$\bar{0}$.1673	$\bar{0}$.2950*	$\bar{0}$.2423*	$\bar{0}$.0583	$\overset{+}{0}$.1280	0.3767*
180 cm 30-60 cm	0.2416*	0.2124	$\bar{0}$.1620	$\bar{0}$.4059*	$\bar{0}$.0625	$\overset{+}{0}$.1370	0.0461	0.1370	0.3767*
270 cm 0-30 cm	0.2437*	0.1242	0.2656*	$\bar{0}$.2359*	$\bar{0}$.0070	0.0194	0.3450*	0.1185	0.1966
270 cm 30-60 cm	0.4577*	0.2912	$\bar{0}$.3546*	$\bar{0}$.2986*	0.1140	$\bar{0}$.0595	0.4018*	0.0750	0.2416*
260 cm 0-30 cm	0.2437*	0.2253	$\bar{0}$.2349*	$\bar{0}$.2565*	$\bar{0}$.2041	0.3450*	0.1289	0.2049	0.1665
360 cm 30-60	0.4938*	0.3298	$\bar{0}$.2986*	$\bar{0}$.3309	$\bar{0}$.4734*	0.2162	0.2706	0.3319*	0.2412*

r = 0.2319 at 5%

As the potassic fertilizer, applied, contains entire K in water soluble form, all the Kws in the applied fertilizer will be converted to solution K. If the coarse sand fraction in more, it will help in the translocation of K^+ ion both vertically and horizontally. This will be accelerated by the rainfall in the monsoon periods. Thus, Kws content increased in lower horizon of K_1 and K_2 treatments. If the clay fraction is more, some of the Kws will be adsorbed in the exchangeable K sites.

Greenham (1971) reported that movement of K was increased by the sand fraction of loamy soil. Similar trend was reported by Prasad et al (1981). Volk (1944) reported that the coarser soils lost about three to four times as much of applied K from the surface 20 cm of soil. It may be noted that, from the chemical analysis of the soil samples, the movement of Kws is conical resulting in highest levels at the subsurface layers of first three sampling sites and the surface layer of second sampling site. From the results of correlation it emerges that the level of Kws in these sampling sites affected positively by coarse sand and fine sand fraction of soil, CEC and content of divalent cations. On the other hand an increase in organic matter in the soil may adversely affect the migration of Kws. The influence of soil reaction on Kws content is not direct but it will be the indirect effects of its influence in the balance of other nutrient elements. The extent of Kws in root zone of coconut is significantly influenced by concentration of secondary nutrients like Ca and Mg, through their involvement in the CEC phenomena resulting in release of potassium into soil solution.

4.4.2 Exchangeable K

As in the case of Kws the various soil properties were found to influence the exchangeable fraction of potassium at different sampling sites. The correlation coefficients are presented in Table (10).

The textural characteristics of the soil is one of the main factors influencing the K ex as evidenced by the significant relationship obtained between soil fractions and K ex values. The coarse and five sand fractions bear positive correlation with the K ex where as the silt fraction showed negative correlation at certain sampling points Increase in clay content may decrease the movement of K ex significantly.

The soil has a low organic matter content. The CEC

Table 10

Correlation coefficient between exchangeable K and soil characteristics

Distance	Coarse sand	Fine sand	Silt	Clay	o.m.	p^H	CEC	Ca	Mg
90 cm 0-30 cm	0.2950*	0.2355*	$\bar{0}$.2497*	$\bar{0}$.3345*	$\bar{0}$.4571*	$\bar{0}$.1453	0.2438*	0.1719	0.0914
90 cm 30-60	0.4264*	0.2856*	$\bar{0}$.2222	$\bar{0}$.4987*	0.3851*	0.0750	$\bar{0}$.2304	$\bar{0}$.4890*	0.3124*
180cm 0-30 cm	0.3249*	0.2483*	0.3432*	$\bar{0}$.4924*	0.2645*	$\bar{0}$.1329	0.4018*	$\bar{0}$.2231*	0.2416*
180 cm 30-60 cm	0.2932*	0.4944*	0.3881*	$\bar{0}$.4954*	$\bar{0}$.1623*	$\bar{0}$.2950	$\bar{0}$.2423*	$\bar{0}$.1280	0.2767*
270 cm 0-60 cm	0.2198*	0.3455*	0.2437*	$\bar{0}$.4307*	0.2213	0.1370	0.0461*	0.2428*	0.0614
270 cm 30-60cm	0.2540*	0.2253	$\bar{0}$.3042*	$\bar{0}$.2349*	0.2905*	0.2041	0.3460*	0.1293	0.1966
360 cm 0-30 cm	0.4014*	0.2301	$\bar{0}$.3293*	$\bar{0}$.2986*	0.1551	0.1554	$\bar{0}$.2706*	$\bar{0}$.3319*	$\bar{0}$.1419
360 cm 30-60 cm	0.2086	0.2173	$\bar{0}$.3783*	$\bar{0}$.3378*	$\bar{0}$.1019	$\bar{0}$.3262	$\bar{0}$.2572*	0.2438*	0.0914

$r = 0.2319$ at 5%

is also relatively low. These may be the reasons for the variable relationships at various sites of sampling between K ex and these two soil properties. The CEC seems to affect the K ex fraction positively at the migration sites of this form of nutrient namely surface and subsurface layers of the sampling site of fertilizer application, ie second site of sampling and subsurface layer of the third sampling site.

It is interesting to note that the Ca content, at the site of fertilizer application, negatively correlated with K ex values. Continuous application of super phosphate over a long period has resulted in high content of Ca at the sampling sites. The relative abundance of exchangeable Ca in a soil with low CEC has resulted in the observed negative relationship. The divalent cation when in abundance may occupy the exchange sites releasing most of the K^+ from the complex.

Gramonova and Pannikova (1980) obtained a similar relationship while studying the mobility of applied K in soil amended with lime.

The relatively low amounts of exchangeable Mg in the sampling sites showed positive relationship with K ex values. At higher concentrations they have a negative influence on K ex.

The fixation and release of potassium in the soil is affected by the combined effect of soil properties rather than the direct effect of individual parameters. Therefore it is often difficult to draw conclusions from individual experiments. A comprehensive exploration of the multivarious factors is beyond the scope of present study. Thus it is projected as a future line of work.

4.4.3. Non-exchangeable K

Table (11) gives the correlation between the K non-ex with physical and chemical character of soil. From the result it is evidence that none of the soil properties has exhibited a clearcut pattern of correlation with non-exchangeable K content. Evidently this result is mainly due to dynamic state of equilibrium between K ex and on one hand and K non-ex on the other. Further under situations where K ex and Kws have been continuously applied, depleted by utilisation by the crop as in Ko treatments. As far as K non-ex is concerned, there is no significant difference whether the soil sample has originated

Figure - 2

Concentration of Exchangeable Potassium

(ppm)

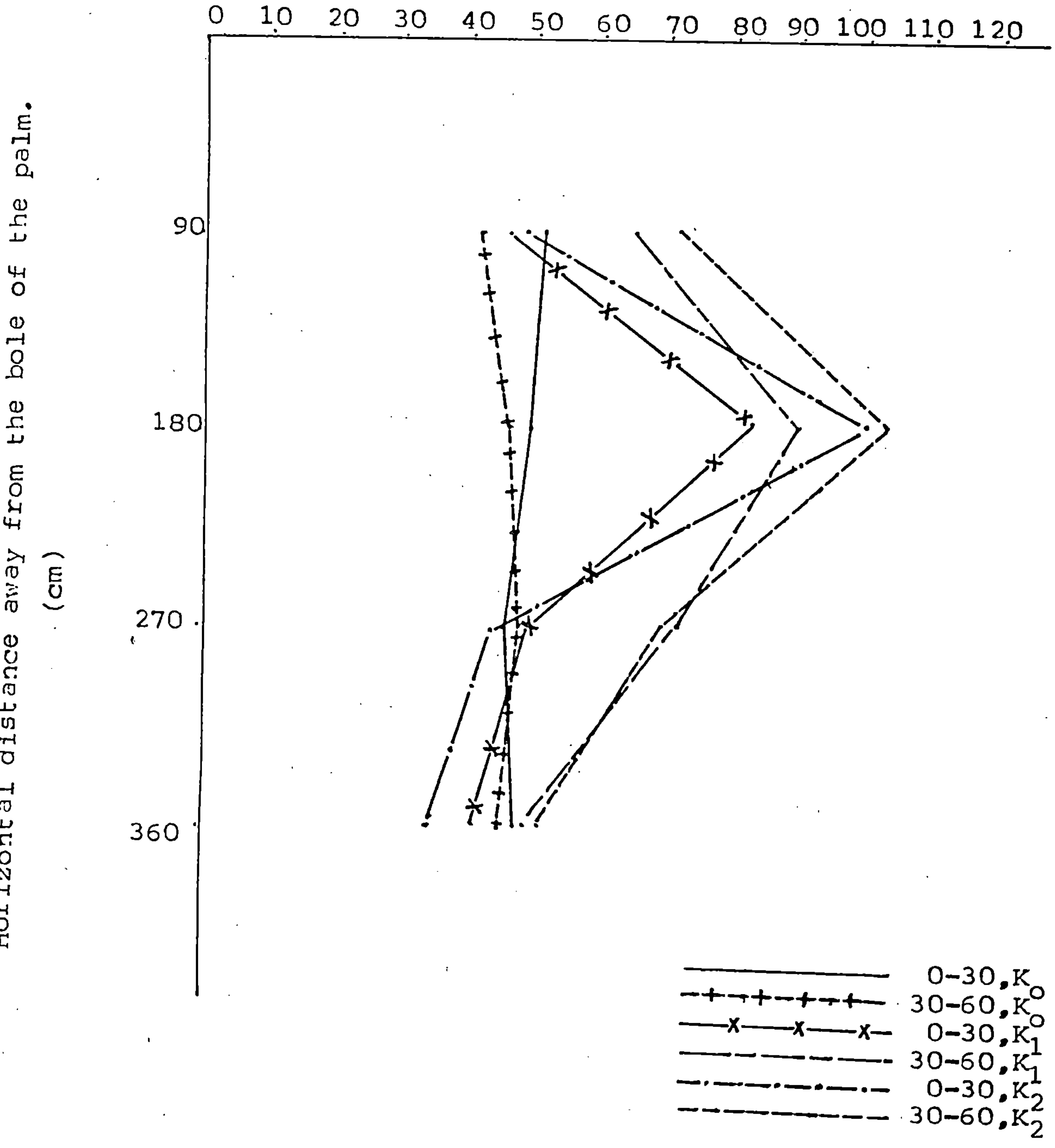


Table (11)

Correlation coefficient between non-exchangeable 'K' and soil characteristics

Distance	Coarse sand	Fine sand	Silt	Clay	o.m	p^H	CEC	Ca	Mg
90cm 0-30 cm	$\bar{0}.1122$	$0.295\overset{*}{0}$	$\bar{0}.1024$	$\bar{0}.0697$	0.0188	$\bar{0}.0041$	$\bar{0}.1167$	$\bar{0}.311$	$\bar{0}.0970$
90 cm 30-60	0.0286	0.0951	0.0336	$\bar{0}.1294$	0.1280	0.0284	0.0778	$\bar{0}.2262$	$\bar{0}.0776$
180 cm 0-30 cm	0.1306	0.1990	$0.248\overset{*}{3}$	$\bar{0}.0753$	$\bar{0}.0521$	$\bar{0}.2019$	$\bar{0}.1329$	$\bar{0}.0081$	$\bar{0}.2231$
180 cm 30-60	$\bar{0}.1739$	$\bar{0}.0593$	0.0498	0.0388	0.0383	$0.332\overset{*}{6}$	$\bar{0}.1341$	$0.277\overset{*}{1}$	$\bar{0}.394\overset{*}{3}$
270 cm 0-30 cm	$\bar{0}.1432$	0.2198	$\bar{0}.1093$	$\bar{0}.243\overset{*}{7}$	0.1317	0.1332	0.2041	$\bar{0}.1059$	$\bar{0}.2248$
270 cm 30-60 cm	$\bar{0}.1608$	0.0135	$\bar{0}.0934$	$0.304\overset{*}{2}$	$\bar{0}.0508$	$0.290\overset{*}{5}$	$\bar{0}.1821$	$\bar{0}.0349$	$\bar{0}.1293$
260 cm 0-30 cm	0. 1360	$\bar{0}.0632$	0.1064	0.0269	0.1913	$\bar{0}.1853$	$\bar{0}.1415$	$\bar{0}.1122$	0.0944
360 cm 30-60	$\bar{0}.0466$	$\bar{0}.0183$	0.1019	$\bar{0}.0828$	$\bar{0}.1829$	$\bar{0}.1170$	$\bar{0}.257\overset{*}{2}$	$\bar{0}.0312$	0.0258

$r = 0.2319$ at 5%

from a plot which is under 24 years of potassium fertilizer application. The K non-ex content under both these conditions proves the dynamic nature of relationship with both K ex and Kws on one hand and mineral K on the other hand.

4.5 Potassium levels in the index leaf in relation to potassium content in soil samples from different sites.

With a view to examine variations in available potassium at different sampling sites as reflected in index leaf of coconut palm, the 14th frond from each palm under sampling was analysed for total K content and the data are presented in Table (12). Irrespective of levels of application of other nutrients, it is seen that, there is remarkable variation in the potassium level of leaf in the three incremental fertilizer doses. The concentration in 14th leaf increased with fertilizer K doses.

The critical level of K in the 14th frond of coconut as fixed by IRHO (1972) is 0.8 to 1 per cent. Some of the palms in this case showed concentrations below 1 per cent. The treatments were $N_oP_oK_o$, $N_oP_2K_o$, $N_1P_oK_o$ and $N_2P_2K_o$. These treatments were not receiving potassium for the last 24 years. Visual observation of the palms in the K_o treated plots showed a different trend. It is

Table 12

Concentration of K in 14th frond of coconut palm (%)

Treat	% K	Treat	% K	Treat	% K
N_o P_o K_o	0.93	N_1 P_o K_o	0.99	N_2 P_o K_o	1.02
N_o P_o K_1	1.28	N_1 P_o K_1	1.03	N_2 P_o K_1	1.31
N_o P_o K_2	1.34	N_1 P_o K_2	1.29	N_2 P_o K_2	1.62
N_o P_1 K_o	1.01	N_1 P_1 K_o	0.89	N_2 P_1 K_o	1.06
N_o P_1 K_1	1.29	N_1 P_1 K_1	1.23	N_2 P_1 K_1	1.35
N_o P_1 K_2	1.32	N_1 P_1 K_2	1.58	N_2P_1 K_2	1.59
N_o P_2 K_o	0.86	N_1 P_2 K_o	1.01	N_2 P_2 K_o	0.98
N_o P_2 K_1	1.28	N_1 P_2 K_1	1.29	N_2 P_2 K_1	1.25
N_o P_2 K_2	1.58	N_1 P_2 K_2	1.46	N_2 P_2 K_2	1.33

to be noted that the palms in $N_oP_oK_o$ plots continuous to bear nuts eventhough at negligible numbers but in plots where $N_2P_2K_o$ and $N_1P_2K_o$ are treatments, the palms ceased production and most of the palms in these treatments have stopped yielding longback, even some palms were dead. Their crown sizes are also too small.

Thus it emerges that the concentration ratio of K with other elements is of prime importance as well as the direct effect of this element wherever there is a higher concentration of other nutrients in the plants there is a demand for K supplementation. Under K deficiency this element can induce toxic effects of other nutrients regardless of their low levels in the leaf. It may be noted that potassium assumes higher priority in the essentiality rating for coconut nutrients (Van Uoxkull and Cohen, 1978). Therefore it is often difficult to realise optimum yields without sufficient supplement of potassium.

4.6 Sampling sites in soil as reflected in the index leaf.

With a view to evolve a scientific soil sampling technique with respect to K nutrition of coconut palms, an attempt was made to correlate the available potassium content at the eight sampling points with the corresponding index leaf level potassium. Multiple linear regression analysis was carried out with the leaf nutrient concentration as a dependant variable and the available K at sampling sites as independant variable The model used is in the following form

$$Y = bo + b_1x_1 + b_2 x_2 + \ldots\ldots\ldots + b_8x_8$$

Table (13) provides the correlation coefficients computed from the above analysis. The results revealed that there is significant positive correlation between index leaf concentration of K and available K at the first second third sampling sites. Incidently there are three sites which showed maximum migration of applied K over the years. These sites also corresponds to the active root zone of coconut palm. The coefficient of determination obtained from multiple linear regression is 0.8324. Thus 83.24 per cent of leaf K is determined by the soil available potassium. Out of this 58.15 per cent of the index leaf level of potassium is due to the available K content at the ubsurface layer (30-60 cm) of the second site of sampling (180 cm from the bole)

Table 13

Correlation coefficient between leaf K and available 'K'

at various depths and distances

No	90 cm 0-30 cm	90cm 30-60cm	180cm 0-30 cm	180cm 30-60cm	270cm 0-30cm	270cm 30-60cm	360cm 0-30cm	360 cm 30-60 cm
1	0.0574	..	..	..	..	..	..	..
2	0.1238	0.8355**	..	..	..	..	...	..
3	0.2054	0.7590**	0.9334*	..	..	..	..	..
4	0.1057	0.1401	0.1531	0.1127	..	..	..	..
5	0.2143	0.7763**	0.9134**	0.9202**	0.0280	..	..	..
6	0.1756	0.1890	0.1845	0.2067	0.2649	0.2417	..	..
7	0.0780	0.4058*	0.1872	0.1042	0.0754	0.1858	0.3873*	..
8.	0.0552	0.6862**	0.8463**	0.7840**	0.0186	0.8700**	0.1233	0.2433

r 25 = .3801 at 5%

r 15 = .4869 at 1%

These findings give credential to the suggestion that the best sampling site for the assay of K in the soil in view of coconut nutrition is between 30-60 cm from the surface at about 180 cm from the bole of the palm. The maximum root activity of adult palm is also concentrated in this region. This finding must help in clearing the confusion that exists among scientists and farmers with respect soil sampling, for fertility evaluation, in case of coconut as for as K nutrition is concerned.

SUMMARY

SUMMARY

From the foregoing discussion on various aspects of potassium movement, a clear pattern is obtained in case of exchangeable and water soluble K. The movement of water soluble and exchangeable K showed more or less a conical form. A perfect horizontal movement of potassium is not observed. But a slanding movement of potassium (water soluble and exchangeable form of K) from the site of application is noticed. A perfect downward movement of K is seen in the present investigation. This fact is clear from the high content of K ex and Kws in the subsurface layer of second site of sampling and from profile studies.

The vertical downward movement of potassium is due to leaching of K^+ along with rain water. This is also facilitated by the loamy nature of the soil. This movement is slightly prevented by clay content in the various layers of soil. The rainwater movement pattern, is not having a perfect vertical downward one. It has a slanding path. Thus resulting in transport of certain amount of Kws and K ex to soil sites away from the line of application of potassium horizontally. A partial enrichment of K is seen in the subsurface layers of first and third sampling site. It may partially due to mass flow and diffusion resulted from the concentration gradient created by the root activity of coconut.

The main driving force for potassium movement, towards plant root surface is diffusion, driven by ion uptake and a corresponding decline in the ion concentration at the root surfaces (depletion zone.) The importance of diffusion and its role in potassium supply to plant roots depends upon soil and plant factors. Among soil factors.the water content is of distinct importance for effective diffusion. In case of nutrients like potassium, whose concentration in the soil solution are low compared to demand of plants, transport by mass flow to the root surfaces is of minor importance. In contrast in many soils mass flow is considered to be more than sufficient for Ca and Mg transport to the roots (Barber, et al 1963)

The decrease in soil moisture affect the movement of K and other solutes in various ways. This is important in the short spells of dry period. The main effects are decrease in mass flow to roots, decrease in diffusion and increase in concentration of other ions like chloride nitrate, Ca and Mg. So the mobility of potassium in the soil is influenced mechanically as well as physically by rain water in the present condition becuase of rainfed nature.

In the case of K ex and Kws, their availability is maximum in the viscinity of roots. Potassium leached upto 90 cm, from the site of application, in the last 24 years. There is a cumulative accumulation of K in the subsurface layers. The leached K is within the absorbing range of the coconut palm. So it cannot be considered as lost. This aspect is more important while considering the fertilizer use efficiency.

The K ex and Kws content of profile samples give the clear picture of the extent of leaching of K. The soil properties influence this phenomena to a greater extent rather than rainfall. A fairly large fraction of applied K remains in the K ex form through out the top layers of profile at higher level of potassium application. K fertilizers when applied in conjuction with other major nutrients is taken up in large quantities by the coconut palm, however long term addition of this nutrient will add to the exchange pool, which may also contribute to plant uptake.

Different soil properties found to influence the mobility of applied K. The major factors are coarse sand and clay fraction, CEC etc. The final distribution pattern of the applied K within the soil is a function of their interactions.

The increase in available K in the root zone is found to increase the index leaf K. From the correlation studies, it is clear that the content of available K at the subsurface layer of second sampling site influence more than any other sites. A clear cut absorption pattern of K by coconut is difficult to find out because of the storing of K in the tree trunk in the early periods of growth of coconut palm. Multiple linear regression analysis of this correlation helps to locate the site of sampling suited for coconut regarding K nutrition.

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* Original not seen.

APPENDICES

APPENDIX - I.a

Coarse sand (%)

No.	Treatment \ H.D. / V.D.	90 cm		180 cm		270 cm		360 cm	
		0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
1	N_o P_o K_o	41.3	40.3	40.5	41.5	40.0	40.1	40.3	40.4
2	N_o P_o K_1	42.5	41.3	40.1	40.0	41.5	40.0	39.1	37.5
3	N_o P_o K_2	41.3	40.5	40.0	40.1	40.3	40.4	39.0	37.2
4	N_o P_1 K_1	41.3	40.1	40.1	40.0	40.1	39.5	39.0	39.1
5	N_0 P_1 K_1	40.3	41.5	40.1	40.0	40.3	40.4	40.4	39.1
6	N_o P_1 K_2	39.1	37.1	37.3	37.0	37.3	37.0	37.0	36.1
7	N_o P_2 K_o	41.5	40.2	41.6	39.1	39.0	39.1	37.5	37.1
8	N_o P_2 K_1	41.1	41.1	40.0	40.0	40.1	39.1	37.1	37.3
9	N_o P_2 K_2	42.4	41.4	40.3	41.1	40.8	40.1	39.8	39.1
10	N_1 P_o K_o	43.4	41.1	41.0	40.7	39.3	37.1	39.1	37.1
11	N_1 P_o K_1	39.4	39.0	39.1	37.1	37.2	37.5	37.0	36.4
12	N_1 P_o K_2	40.4	40.1	39.1	40.4	39.5	39.1	37.2	36.3
13	N_1 P_1 K_o	41.4	41.2	41.0	39.3	41.0	40.1	39.4	39.6
14	N_1 P_1 K_1	43.7	41.4	41.2	40.7	40.8	39.8	38.7	39.4
15	N_1 P_1 K_2	37.6	37.0	39.1	38.3	38.4	36.4	41.3	40.9
16	N_1 P_2 K_o	41.2	41.5	37.6	37.9	37.9	39.1	38.3	38.7
17	N_1 P_2 K_1	37.3	37.2	39.3	38.4	41.3	40.1	39.7	38.1
18	N_1 P_2 K_2	37.7	37.3	37.1	37.5	37.0	38.1	39.8	38.6
19	N_2 P_o K_o	41.3	40.1	40.0	41.5	40.0	40.4	40.1	40.7
20	N_2 P_o K_1	41.1	37.1	37.3	37.0	37.1	36.1	39.0	37.1
21	N_2 P_o K_2	39.5	39.1	37.1	37.2	39.2	38.6	37.1	37.8
22	N_2 P_1 K_o	37.2	37.1	39.3	38.1	40.1	41.3	41.6	40.3
23	N_2 P_1 K_1	41.5	40.0	41.6	39.3	39.1	37.5	37.1	36.0
24	N_2 P_1 K_2	41.2	41.5	37.7	37.9	39.1	38.3	38.1	38.2
25	N_2 P_2 K_o	40.4	40.1	39.4	37.2	36.2	37.0	39.1	36.0
26	N_2 P_2 K_1	41.3	40.0	40.7	40.4	37.1	37.9	38.3	36.5
27	N_2 P_2 K_2	41.2	40.1	41.5	39.4	39.1	38.1	38.1	37.2

H.D. Horizontal Distance

V.D. Vertical Distance

APPENDIX I.b

fine sand (%)

No	Treatment \ H.D. / V.D.	90 cm		180 cm		270 cm		360 cm	
		0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30- cm	30-60 cm
1	N_0 P_0 K_0	25.4	23.1	22.0	22.0	21.9	21.1	23.1	21.1
2	N_0 P_0 K_1	24.7	25.3	23.3	22.5	21.1	21.8	25.1	23.5
3	N_0 P_0 K_2	25.4	21.5	22.8	23.4	22.5	23.0	21.8	21.3
4	N_0 P_1 K_0	25.3	23.0	21.5	21.8	21.4	25.4	26.1	25.1
5	N_0 P_1 K_1	23.0	23.1	21.4	21.9	23.1	21.1	21.1	25.1
6	N_0 P_1 K_2	26.0	22.7	22.1	20.3	20.6	20.5	20.7	21.5
7	N_0 P_2 K_0	25.4	23.0	25.0	21.3	25.1	23.0	23.1	23.4
8	N_0 P_2 K_1	25.5	23.2	21.7	20.8	21.4	25.8	25.1	23.5
9	N_0 P_2 K_2	25.3	25.5	23.1	21.3	21.3	21.1	25.2	26.3
10	N_1 P_0 K_0	24.5	25.5	23.2	21.0	23.1	20.8	25.1	25.1
11	N_1 P_0 K_1	25.5	26.1	25.1	25.3	24.1	23.2	24.1	24.0
12	N_1 P_0 K_2	21.1	25.2	21.4	25.1	25.4	26.1	24.1	23.1
13	N_1 P_1 K_0	25.5	23.0	25.0	21.1	22.5	23.1	25.5	24.1
14	N_1 P_1 K_1	22.5	22.5	22.0	20.1	21.3	21.5	20.5	19.0
15	N_1 P_1 K_2	18.3	20.7	21.3	20.1	21.3	23.2	20.2	21.3
16	N_1 P_2 K_0	23.1	21.3	21.7	20.3	21.3	21.4	20.3	20.1
17	N_1 P_2 K_1	18.6	20.0	21.4	20.8	21.1	20.3	21.9	20.7
18	N_1 P_2 K_2	21.6	20.9	24.2	23.3	24.1	21.8	24.1	23.9
19	N_2 P_0 K_0	25.4	23.3	22.5	21.0	23.1	21.1	21.1	20.3
20	N_2 P_0 K_1	23.2	25.3	23.5	24.1	23.7	24.5	25.8	24.2
21	N_2 P_0 K_2	25.7	26.0	25.1	24.1	23.9	21.7	20.8	21.3
22	N_2 P_1 K_0	24.1	22.3	21.1	22.0	23.0	22.6	21.3	22.0
23	N_2 P_1 K_1	25.4	23.2	25.4	21.1	25.0	23.1	24.0	24.4
24	N_2 P_1 K_2	23.1	21.3	21.6	20.1	21.3	21.4	20.3	20.2
25	N_2 P_2 K_0	21.5	21.4	25.5	24.1	23.2	24.1	26.6	24.4
26	N_2 P_2 K_1	25.4	23.1	21.0	21.1	25.3	20.3	20.1	24.1
27	N_2 P_2 K_2	23.1	21.3	20.3	20.8	24.8	23.1	24.1	22.2

H.D. Horizontal Distance

V.D. Vertical Distance

APPENDIX - I.c

Silt (%)

No.	H.D. / V.D. Treatment	90 cm		180 cm		270 cm		360 cm	
		0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
1	$N_o P_o K_o$	19.3	21.0	21.5	23.5	22.8	23.4	22.5	23.0
2	$N_o P_o K_1$	19.4	19.4	21.0	21.0	23.5	22.9	20.0	22.1
3	$N_o P_o K_2$	19.3	21.5	22.8	23.4	22.5	23.0	21.8	21.3
4	$N_o P_1 P_o$	19.0	21.3	22.9	23.1	20.7	20.6	20.8	23.0
5	$N_o P_1 K_1$	21.6	23.1	22.5	22.8	22.5	23.0	22.5	20.0
6	$N_o P_1 K_2$	20.1	22.7	22.1	20.3	20.6	20.5	20.7	21.5
7	$N_0 P_2 K_o$	19.0	21.7	19.4	23.9	20.0	19.1	22.5	22.3
8	$N_o P_2 K_1$	19.0	21.0	23.1	23.9	23.1	19.0	22.3	22.2
9	$N_o P_2 K_2$	19.4	19.2	21.2	23.1	22.6	23.4	20.0	20.1
10	$N_1 P_o K_o$	18.4	19.0	21.1	23.0	21.7	21.8	20.0	22.3
11	$N_1 P_o K_1$	20.7	20.6	20.0	22.1	21.4	22.1	20.6	21.5
12	$N_1 P_o K_2$	23.0	25.2	20.2	22.5	20.7	19.6	21.3	22.5
13	$N_1 P_1 K_o$	19.0	21.0	19.6	23.7	21.3	21.8	19.7	20.0
14	$N_1 P_1 K_1$	18.4	19.0	21.1	21.6	21.3	20.1	21.3	19.1
15	$N_1 P_1 K_2$	20.1	18.2	21.1	21.3	19.6	19.1	18.1	21.3
16	$N_1 P_2 K_o$	20.3	20.6	18.3	20.1	21.7	19.7	21.4	21.2
17	$N_1 P_2 K_1$	20.0	18.5	23.1	21.2	18.3	19.1	20.1	18.3
18	$N_1 P_2 K_2$	18.4	20.1	21.4	22.1	20.3	22.1	20.0	21.1
19	$N_2 P_o K_o$	19.0	21.0	21.5	23.5	22.5	23.0	23.4	24.1
20.	$N_2 P_o K_1$	20.1	22.7	22.1	20.3	20.9	21.0	21.1	21.4
21	$N_2 P_o K_2$	20.4	20.6	22.3	21.3	20.3	21.8	21.8	20.6
22	$N_2 P_1 K_o$	21.4	20.5	17.7	18.3	19.3	18.9	19.8	20.1
23	$N_2 P_1 K_1$	19.1	21.1	19.0	23.7	19.1	22.9	20.3	21.5
24	$N_2 P_1 K_2$	20.6	20.5	18.4	20.3	21.7	19.7	21.4	21.5
25	$N_2 P_2 K_0$	23.1	25.3	20.4	21.3	22.1	20.6	19.1	21.1
26	$N_2 P_2 K_1$	19.0	21.3	23.2	23.1	22.7	20.1	21.2	21.0
27	$N_2 P_2 K_2$	20.3	19.5	22.7	22.2	20.2	22.3	21.3	22.1

H.D. Horizontal Distance

V.D. Vertical Distance

Clay (%) APPENDIX 1.d

No	H.D. / V.D. Treatment	90 cm		180 cm		270 cm		360 cm	
		0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-60 cm	30-60 cm	0-30 cm	30-60 cm
1	N_0 P_0 K_0	14.6	14.6	16.0	14.1	15.3	15.4	15.1	15.5
2	N_0 P_0 K_1	13.4	14.0	14.6	16.5	14.0	15.3	15.8	16.9
3	N_0 P_0 K_2	14.0	16.0	15.3	15.4	15.1	15.5	15.0	17.4
4	N_0 P_1 K_0	14.4	14.6	14.5	15.3	15.4	14.4	14.3	15.0
5	N_0 P_1 K_1	14.0	14.5	16.0	15.3	15.1	15.5	16.0	15.8
6	N_0 P_1 K_2	14.3	15.9	17.2	18.6	18.3	19.0	18.3	19.0
7	N_0 P_2 K_0	14.1	15.1	14.0	15.7	15.9	16.8	16.9	17.9
8	N_0 P_2 K_1	14.4	14.7	15.2	15.3	15.4	16.1	15.7	17.0
9	N_0 P_2 K_2	13.7	14.1	14.4	14.5	15.3	15.4	15.1	14.5
10	N_1 P_0 K_0	13.7	14.4	14.7	15.3	15.0	21.3	15.8	15.5
11	N_1 P_0 K_1	14.4	14.3	15.8	15.7	17.3	17.2	18.3	19.1
12	N_1 P_0 K_2	15.5	16.3	15.8	16.0	14.4	15.2	17.4	18.1
13	N_1 P_1 K_0	14.1	14.8	14.4	15.9	15.2	15.0	15.4	16.3
14	N_1 P_1 K_1	15.4	17.1	16.7	17.6	18.6	19.5	16.6	22.5
15	N_1 P_1 K_2	24.0	24.1	18.5	20.3	20.7	21.4	20.4	16.5
16	N_1 P_2 K_0	15.4	16.6	22.4	21.7	17.9	20.6	20.2	20.0
17	N_1 P_1 K_1	24.1	24.3	16.2	19.6	19.3	19.5	18.3	22.9
18	N_1 P_2 K_2	22.3	21.7	17.3	17.2	18.6	18.0	16.1	16.4
19	N_2 P_0 K_0	14.3	14.6	16.0	14.1	15.1	15.5	15.4	14.9
20	N_2 P_0 K_1	15.6	15.9	17.2	18.6	18.3	19.0	15.0	17.3
21	N_2 P_0 K_2	14.4	14.3	15.7	17.4	16.5	17.9	21.3	20.3
22	N_2 P_1 K_0	17.3	20.1	21.9	21.6	17.6	17.2	17.3	17.6
23	N_2 P_1 K_1	14.0	14.7	14.0	15.9	16.8	16.5	18.6	19.1
24	N_2 P_1 K_2	15.1	16.1	22.3	21.7	17.9	20.6	20.2	20.1
25	N_2 P_2 K_0	15.0	16.2	14.7	17.4	18.5	18.3	15.2	19.5
26	N_2 P_2 K_1	14.3	14.6	15.1	15.4	15.9	21.7	24.4	19.4
27	N_2 P_2 K_2	15.4	17.7	16.9	19.6	16.1	18.5	16.7	18.5

H.D. Horizontal Distance

V.D. Vertical Distance

APPENDIX I.e

Organic carbon (%)

No	Treatment \ H.D. / V.D.	90 cm		180 cm		270 cm		360 cm	
		0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
1	N_0 P_0 K_0	0.49	0.45	0.48	0.53	0.51	0.48	0.41	0.40
2	N_0 P_0 K_1	0.51	0.50	0.49	0.49	0.63	0.38	0.33	0.31
3	N_0 P_0 K_2	0.49	0.45	0.53	0.51	0.56	0.52	0.53	0.51
4	N_0 P_1 K_0	0.51	0.50	0.49	0.49	0.53	0.51	0.63	0.39
5	N_0 P_1 K_1	0.63	0.49	0.39	0.41	0.52	0.33	0.53	0.61
6	$N_0 P_1$ K_2	0.56	0.45	0.47	0.46	0.63	0.51	0.47	0.38
7	N_0 P_2 K_0	0.50	0.49	0.46	0.43	0.45	0.47	0.39	0.31
8	N_0 P_2 K_1	0.46	0.43	0.45	0.41	0.39	0.48	0.31	0.39
9	N_0 P_2 K_2	0.49	0.46	0.53	0.51	0.49	0.48	0.37	0.46
10	N_1 P_0 K_0	0.49	0.46	0.45	0.53	0.62	0.49	0.51	0.59
11	N_1 P_0 K_1	0.31	0.51	0.69	0.46	0.50	0.49	0.31	0.32
12	N_1 P_0 K_2	0.63	0.61	0.48	0.48	0.53	0.31	0.57	0.39
13	N_1 P_1 K_0	0.51	0.53	0.49	0.58	0.39	0.39	0.40	0.61
14	N_1 P_1 K_1	0.28	0.61	0.36	0.41	0.45	0.51	0.53	0.21
15	N_1 P_1 K_2	0.46	0.44	0.47	0.45	0.51	0.50	0.47	0.43
16	N_1 P_2 K_0	0.50	0.43	0.49	0.41	0.59	0.47	0.41	0.38
17	N1 P_1 K_1	0.51	0.49	0.63	0.53	0.51	0.49	0.48	0.26
18	N_1 P_2 K_2	0.46	0.45	0.49	0.41	0.43	0.48	0.56	0.51
19	N_2 P_0 K_0	0.63	0.49	0.59	0.45	0.51	0.33	0.56	0.39
20	N_2 P_0 K_1	0.49	0.46	0.51	0.43	0.51	0.61	0.63	0.69
21	N_2 P_0 K_2	0.50	0.49	0.46	0.41	0.42	0.48	0.39	0.28
22	N_2 P_1 K_0	0.51	0.50	0.49	0.46	0.38	0.41	0.37	0.43
23	N_2 P_1 K_1	0.50	0.49	0.33	0.67	0.49	0.51	0.49	0.42
24	N_2 P_1 K_2	0.51	0.32	0.48	0.37	0.61	0.43	0.32	0.33
25	N_2 P_2 K_0	0.47	0.45	0.43	0.39	0.46	0.48	0.30	0.62
26	N_2 P_2 K_1	0.49	0.47	0.33	0.63	0.61	0.43	0.58	0.51
27	N_2 P_2 K_2	0.52	0.49	0.33	0.39	0.53	0.68	0.61	0.28

H.D. Horizontal Distance

V.D. Vertical Distance

p^H - Value

No.	H.D. / V.D. Treatment	90cm		180cm		270 cm		300cm	
		0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
1	N_o P_o K_o	5.1	5.1	5.3	4.9	5.2	5.1	4.9	4.9
2	N_o P_o K_o	4.9	4.9	5.0	5.1	4.7	4.9	5.1	4.9
3	N_o P_o K_2	4.9	4.8	5.3	5.2	4.8	4.6	5.1	4.7
4	N_o P_1 K_o	4.8	4.8	5.2	5.2	5.0	4.9	4.8	4.8
5	N_o P_1 K_1	5.0	4.8	5.1	5.1	4.9	5.3	4.8	5.3
6	N_o P_1 K_2	5.2	5.4	5.3	4.1	5.1	5.2	5.1	4.8
7	N_o P_2 K_o	5.1	5.0	5.3	5.1	5.1	4.9	5.2	5.1
8	N_o P_2 K_1	5.1	4.8	4.7	5.1	4.9	4.7	4.3	4.7
9	N_o P_2 K_2	5.3	5.9	6.0	4.9	6.0	5.1	5.3	5.2
10	N_1 P_o K_o	5.1	5.0	5.3	5.1	5.5	5.1	4.9	4.8
11	N_1 P_o K_1	5.1	5.0	4.9	4.9	5.1	5.2	4.8	5.3
12	N_o P_o K_2	5.1	4.9	4.6	4.7	5.1	5.0	5.1	5.1
13	N_1 P_1 K_o	5.3	5.1	5.2	5.1	5.1	5.0	5.2	5.1
14	N_1 P_1 K_1	5.4	5.2	4.9	4.6	4.8	4.8	5.0	5.1
15	N_1 P_1 K_2	5.2	5.0	4.6	4.9	5.2	4.8	5.1	5.0
16	N_1 P_2 K_o	5.1	5.0	5.3	5.1	4.9	4.9	5.3	5.2
17	N_1 P_2 K_1	5.1	5.0	4.7	4.8	4.9	5.1	5.0	5.2
18	N_1 P_2 K_2	5.3	4.9	4.6	4.7	4.6	5.1	5.0	5.1
19	N_2 P_o K_o	5.3	5.1	5.0	5.0	5.3	5.1	5.2	5.1
20	N_2 P_o K_1	5.3	5.1	4.7	4.9	5.0	4.8	5.1	5.3
21	N_2 P_o K_2	5.3	5.1	4.6	4.8	5.0	5.1	5.1	5.2
22	N_2 P_1 K_o	5.3	5.1	5.4	5.1	4.9	4.8	5.3	5.1
23	N_2 P_1 K_1	5.1	5.0	4.9	4.7	4.8	4.9	5.1	5.0
24	N_2 P_1 K_2	5.2	5.1	4.7	4.8	4.6	4.9	5.3	5.1
25	N_2 P_2 K_o	5.1	5.3	5.0	5.1	5.4	5.2	5.1	5.4
26	N_2 P_2 K_1	5.1	5.1	5.0	4.9	4.6	5.6	5.1	5.3
27	N_2 P_2 K_2	5.4	5.1	4.6	4.7	4.9	4.7	5.0	5.1

H.D. Horizontal Distance

V.D. Vertical Distance

CEC (C mol Kg^{-1})

No.	H.D. / V.D. Treatment	90 cm		180 cm		270 cm		360 cm	
		0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
1	$N_o P_o K_o$	4.32	6.14	4.73	5.21	3.20	4.59	4.11	4.37
2.	$N_o P_o K_1$	7.12	4.67	5.13	6.34	8.03	5.92	6.17	5.05
3	$N_o P_o K_2$	7.82	5.10	8.36	6.94	5.12	7.93	5.30	6.48
4	$N_o P_1 K_o$	4.12	4.33	5.09	6.26	6.57	7.01	3.66	5.91
5	$N_o P_1 K_1$	7.12	6.34	5.82	8.06	4.36	5.18	6.12	5.08
6	$N_o P_1 K_2$	7.81	6.32	7.91	8.04	6.19	5.84	4.32	3.91
7	$N_o P_2 K_o$	6.12	5.48	8.10	7.93	6.32	4.51	3.98	6.12
8	$N_o P_2 K_1$	5.31	8.02	6.13	6.10	7.01	4.32	6.12	5.92
9	$N_o P_2 K_2$	6.21	5.32	4.13	5.46	3.66	6.16	4.78	4.58
10	$N_1 P_o K_o$	6.81	7.13	5.12	5.19	6.82	7.19	3.82	5.16
11	$N_1 P_o K_1$	6.42	6.51	7.18	7.82	5.48	7.18	4.80	5.32
12	$N_1 P_o K_2$	5.12	4.80	6.12	6.38	7.82	6.42	4.18	6.19
13	$N_1 P_1 K_o$	6.32	6.40	5.12	5.80	7.32	7.16	5.82	8.10
14	$N_1 P_1 K_1$	6.72	5.36	7.81	5.12	6.36	4.82	5.86	6.36
15	$N_1 P_1 K_2$	5.81	4.32	6.28	5.18	6.32	7.18	8.06	7.92
16	$N_1 P_2 K_o$	5.82	4.13	5.71	7.42	5.61	7.36	6.92	6.37
17	$N_1 P_2 K_1$	4.92	6.31	4.72	8.13	7.92	6.71	4.82	7.12
18	$N_1 P_2 K_2$	5.91	7.13	8.10	6.92	7.36	5.78	5.31	6.84
19	$N_2 P_o K_o$	5.16	6.91	6.42	5.96	6.00	5.80	5.32	6.40
20	$N_2 P_o K_1$	4.92	6.15	7.93	8.00	6.90	5.35	6.10	7.92
21	$N_2 P_o K_2$	6.25	7.12	8.40	6.82	5.64	8.01	7.64	6.36
22	$N_2 P_1 K_o$	7.61	5.22	4.30	6.12	7.22	6.80	5.92	8.06
23	$N_2 P_1 K_1$	5.18	4.96	6.73	6.48	5.72	6.89	7.83	6.30
24	$N_2 P_1 K_2$	4.82	4.11	5.60	6.12	7.30	7.11	6.82	5.19
25	$N_2 P_2 K_o$	5.12	4.61	6.32	5.18	6.92	6.12	5.80	5.10
26	$N_2 P_2 K_1$	6.42	8.16	8.06	7.91	5.43	6.52	7.13	8.16
27	$N_2 P_2 K_2$	5.18	7.13	9.21	6.30	3.81	5.20	4.76	6.38

H.D. Horizontal Distance

V.D. Vertical Distance

APPENDIX - I.H.

Ex - Calcium (ppm)

No.	Treatment (H.D. / V.D.)	90 cm		180 cm		270 cm		360 cm	
		0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
1	N_o P_o K_o	39.83	44.81	37.81	39.18	22.17	29.38	51.34	46.71
2	N_o P_o K_1	22.17	39.38	33.34	29.62	46.14	32.83	24.39	36.74
3	N_o P_o K_2	26.32	29.12	34.21	18.67	43.17	36.12	31.55	26.72
4	N_o P_1 K_o	59.25	53.23	72.87	77.89	46.16	51.32	44.83	39.64
5	N_o P_1 K_1	53.31	58.62	81.16	74.89	88.62	72.56	46.61	43.22
6	N_o P_1 K_2	31.64	71.24	73.13	39.12	26.83	21.24	36.20	44.13
7	N_o P_2 K_o	38.61	44.83	72.18	81.34	31.64	39.43	29.12	39.81
8	N_o P_2 K_1	39.64	48.23	89.84	79.63	31.24	47.84	31.93	46.15
9	N_o P_2 K_2	22.17	81.64	112.6	69.71	29.23	61.84	28.32	26.84
10	N_1 P_o K_o	21.73	39.16	31.79	41.32	36.66	24.89	39.64	31.37
11	N_1 P_o K_1	22.17	29.13	30.01	32.56	18.23	37.83	39.81	25.89
12	N_1 P_o K_2	30.00	21.17	51.08	21.78	31.81	19.17	29.38	41.31
13	N_1 P_1 K_o	25.13	45.36	78.31	74.17	54.58	32.30	24.80	28.19
14	N_1 P_1 K_1	32.34	37.81	53.84	51.08	32.39	46.66	29.32	31.92
15	N_1 P_1 K_2	31.12	39.45	58.19	64.08	28.12	20.64	32.10	24.18
16	N_1 P_2 K_o	41.32	54.83	88.12	72.50	32.50	29.17	19.20	36.54
17	N_1 P_2 K_1	38.42	46.39	98.53	136.20	46.39	37.84	36.81	21.23
18	N_1 P_2 K_2	31.37	81.84	109.24	79.81	51.04	67.81	46.66	32.59
19	N_2 P_o K_o	26.12	31.23	21.84	19.63	23.28	29.19	32.13	36.86
20	N_2 P_o K_1	26.84	19.39	21.64	15.79	39.84	38.16	46.16	25.89
21	N_2 P_o K_2	21.64	32.19	19.64	21.83	36.91	46.84	21.91	29.49
22	N_2 P_1 K_o	29.12	39.43	53.84	69.82	76.12	39.43	44.72	39.13
23	N_2 P_1 K_1	39.81	41.64	71.89	66.73	36.84	41.96	53.83	51.08
24	N_2 P_1 K_2	24.21	29.64	48.72	59.64	36.13	23.81	21.81	36.92
25	N_2 P_2 K_o	36.84	71.23	116.8	81.33	36.43	49.12	24.21	61.32
26	N_2 P_2 K_1	48.21	53.84	76.89	84.19	46.73	38.18	29.64	39.32
27	N_2 P_2 K_2	32.18	46.19	75.87	96.83	56.12	71.64	36.31	29.84

H.D Horizontal Distance

V.D Vertical Distance

APPENDIX - I.1.

Ex. Magnicium (ppm)

No.	H.D. / V.D. Treatment	90 cm		180 cm		270 cm		360 cm	
		0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm	0-30 cm	30-60 cm
1	N_0 P_0 K_0	19.13	14.75	18.56	23.32	25.83	27.51	38.13	31.62
2	N_0 P_0 K_1	30.39	12.51	14.17	12.59	31.28	19.39	22.81	32.14
3	N_0 P_0 K_2	36.61	43.32	19.73	21.28	31.32	24.67	35.82	26.72
4	N_0 P_1 K_0	30.01	36.57	31.59	25.82	44.39	21.51	27.50	26.80
5	N_0 P_1 K_1	36.1	19.53	43.3	26.64	31.81	33.82	30.04	29.81
6	N_0 P_1 K_2	30.12	21.81	19.84	17.91	14.17	18.54	15.32	26.67
7	N_0 P_2 K_0	19.18	36.67	21.32	25.89	14.17	18.9	29.12	36.92
8	N_0 P_2 K_1	31.20	38.21	23.10	17.84	23.63	12.58	18.02	36.51
9	N_0 P_2 K_2	14.75	15.80	18.67	13.26	29.38	22.16	32.83	30.64
10	N_1 P_0 K_0	17.62	21.39	28.72	36.43	19.21	19.27	13.84	26.13
11	N_1 P_0 K_1	21.67	26.83	12.56	20.33	23.67	14.35	15.83	11.83
12	N_1 P_0 K_2	15.84	14.75	19.86	18.56	12.56	43.10	14.96	19.18
13	N_1 P_1 K_0	12.58	18.32	26.67	18.80	14.20	23.67	15.60	12.68
14	N_1 P_1 K_1	14.82	27.51	15.83	26.67	20.33	18.64	29.18	30.05
15	N_1 P_1 K_2	24.59	19.84	23.20	29.81	17.64	18.80	12.52	19.71
16	N_1 P_2 K_0	11.84	21.47	36.14	39.79	29.84	23.57	20.53	36.10
17	N_1 P_2 K_1	18.19	23.40	18.64	19.12	36.83	19.24	31.32	19.90
18	N_1 P_2 K_2	26.53	23.67	18.50	36.43	21.28	25.89	33.73	25.59
19	N_2 P_0 K_0	20.53	16.84	13.82	19.98	16.91	18.94	23.21	29.36
20	N_2 P_0 K_1	19.17	12.54	20.33	18.50	13.81	21.67	31.64	34.92
21	N_2 P_0 K_2	16.83	21.64	9.84	13.19	14.75	24.60	18.94	12.56
22	N_2 P_1 K_0	30.64	31.67	23.57	18.60	15.70	26.82	39.18	25.89
23	N_2 P_1 K_1	31.67	36.62	25.89	43.30	21.67	19.18	21.24	18.16
24	N_2 P_1 K_2	18.19	19.64	31.80	18.81	16.69	19.84	36.13	41.10
25	N_2 P_2 K_0	36.64	23.51	21.34	18.32	21.89	19.83	26.64	29.12
26	N_2 P_2 K_1	19.63	21.84	16.32	13.82	8.94	14.98	29.62	24.31
27	N_2 P_2 K_2	30.00	19.18	20.32	12.56	15.84	14.32	18.60	12.78

H.D. Horizontal Distance

V.D. Vertical Distance

APPENDIX - II

ANOVA TABLE (Water Soluble Potassium)

Source	D.F.	S.S.	M.S.S.	F.
N P (Block)	8	211.42	26.42	1.46
Treatments	23	57299.51	2491.28	138.17*
A	1	3189.57	3189.57	176.90*
B	3	22125.33	7375.11	409.04*
C	2	15530.06	7765.02	430.66*
A x B	3	1007.22	465.97	35.94*
B x C	6	12084.27	2014.05	111.70*
A x C	2	1442.27	721.13	39.99*
A B C	6	1530.05	255.00	14.14
Error	184	3317.57	18.03	
TOTAL	215	60828.63		

S E = 1.415

APPENDIX - III

ANOVA TABLE (Exchangeable Potassium)

SOURCE	D.F.	S.S.	M.S.S.	F
NP (Block)	8	723.32	90.41	2.97
Treatments	23	57873.23	2516.23	82.86*
A	1	2538.13	2538.13	83.58*
B	3	25703.69	2567.186	283.15*
C	2	11879.69	5939.84	195.60*
A x B	3	940.18	313.39	10.32*
B x C	6	15212.41	2535.40	83.49*
A x C	2	998.53	499.26	16.44*
A x B x C	6	600.65	100.10	3.29
Error	184	6587.36	30.36	
	215	64183.97		

S E = 1.83

APPENDIX IV

ANOVA TABLE (Non-exchangeable potassium)

SOURCE	D.F.	S S	M S S	F
N P (Block)	8	9766	1220.75	2.04
TREATMENTS	23	19705	356.73	1.43
A	1	39	39	5.54
B	3	4371	1457	2.44
C	2	4064	2032	3.40
A x B	3	346	115.33	0.19
B x C	6	9529	1588.16	2.66
A x B C	2	736	368	0.61
Error	184	109690	596.14	
TOTAL	215	139161		

ANOVA TABLE

SOURCE	D.f	S.S.	M.S.S.	F
Total	26	1.290337	4.9628 E-02	
Regression	8	1.074175	0.13427	11.18094
Error	18	0.216162	0.012009	

Testing of regression coefficient

SE (6-1) = 31.61482, SE (b-2) = 17.2408, SE (b-3) = 19.4533
SE (b-4) = 14.50384, SE (6-5) = 23.6185, SE (b-6) = 20.86004
SE (b-7) = 32.98803, SE (b-8) = 33.23681.

T (1) Values

T (1) - 1.023649, T(2) = -1.380815, T (3) = 1.877182

T (4) = -1.106389, T (5) = .399195 T (6) = 2.805158

T (7) = - .771389 T (8) = 1.458085

$$Y = 0.6712 - 32.3635x_1 - 23.8064x_2 + 36.5174x_3 - 160469x_4 + 9.4284x_5 + 58.5157x_6 - 25.4463x_7 + 48.4521x_8$$

HORIZONTAL AND VERTICAL MOVEMENT OF POTASSIUM IN THE NEYYATTINKARA-VELLAYANI SOIL ASSOCIATION FROM A LONG TERM FERTILIZER EXPERIMENT UNDER COCONUT

BY
PREMAKUMAR.S.

ABSTRACT OF A THESIS
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ABSTRACT

The present study aims at finding out the movement pattern of applied potassium in the long term fertilizer trial under coconut. The other targets are to find out the suitable site for soil sampling from coconut garden for nutritional studies. The investigation is done by taking surface and surface samples from four sites away from bole of the coconut palm at 90 cm interval. Of this the second site coincides with the site of fertilizer application (180 cm away from bole). In addition to this, for finding out the extent of leaching, three profiles were dug at the site of fertilization in the K_0, K_1 and K_2 treatments with highest dose of N and P combination. Soil samples are collected at 15 cm interval from the profiles upto 105 cm. Leaf samples from 14th frond also collected simultaneously. These samples are collected from a permanant fertilizer trial under coconut which is on going in the coconut Research station, Balaramapuram. This is a 3^3 NPK, factorial confounded experiment with two replications.

Exchangeable, water soluble and non-exchangeable potassium is determined in all the soil samples collected. In addition to this soil seperates, CEC, organic matter,

pH, Calcium content and Magnisium content also found out.

The water soluble, exchangeable and non-exchangeable K values are compared among different sites of sampling and depths in order to broughtout the effect of application of potassic fertilizer for the last 24 years in the soil. The values of different forms of K is correlated with soil characteristics to find out the impact of various characters in the mobility of potassium. A multiple linear regression analysis is carried out with the leaf nutrient concentration as a dependant variable and the available K at sampling points as independant variable.

A clear conical movement pattern is obtained in case of watersoluble and exchangeable K. The non-exchangeable K didnot show an increase in concentration as a result of addition of potassium fertilizer. The water soluble and exchangeable K were distributed within the root zone of the palm. The leaching of K is upto 75 cm from the surface. It cannot be considered as lost because coconut has sufficient root distribution in this zone. Higher doses of application of K did not move to greater depths than that of medium dose.

The mobility of applied K is affected by soil properties like coarse sand fraction, clay fraction, CEC and organic matter. Increase in sand fraction increased the movement K to subsurface layers. But clay fraction has a negative correlation.

The index leaf K level has a positive correlation with the available K at various sampling points. The leaf K content is influenced most by the available K level at the subsurface layer of second sampling site (180 cm from bole). Thus, the soil sample for nutrient analysis should be derived from the 30-60 cm layer of 180 cm away from the base of the palm.