NUTRITIONAL REQUIREMENTS OF OILPALM *(Eleais guineensis jacq)* SEEDLINGS

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CERTIFICATE

Certified that this Dissertation entitled "Nutritional Requirements of Oilpalm (Eleasis Guineensis Jacq.) Seedlings" embodies the results of Research work carriedout by Mr.D.R.KULKARNI under my guidance and supervision, and that no part of Dissertation has been submitted for any other degree. I further certify that such help or source of information as has been availed of in this Dissertation is duly acknowledged.

(C.C. BIDDAPPA)

Date: 15 /April, 1989.

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INTRODUCTION

I. INTRODUCTION

The importance of edible oils is reflected in the deficit between supply and demand which is of the order of 15 lakh tones. This is being met by imports of oil which results in drain of valuable foreign exchange to the tune of Rs.1200 crores. Concerted efforts are being made at various levels to plug the drain of foreign exchange spent on importing edible oils. This is done by rising high oil yielding crops such as oil palm, judicious and controlled application of fertilizers, efficient use of irrigation and adopting multiple cropping system.

In rising high oil yielding varieties, the basic need is the knowledge of soil, plant and environmental interactions. When the conditions are favourable, the use of fertilizers can give complete control over plant nutrition and increased yield. Soil nutrients supply then ceases to be important and growth rate of crop will be limited only to water supply and incident radiation. Therefore, on good soil in a humid tropical climate and with adequate pest and disease management nutrition of the crop like oil palm would not be a problem. However under such conditions, problem becomes one of profitability. The plants nutrient requirement must not simply satisfied but satisfied without wastage, using as little fertilizer as possible.

It is well known that so called purely biological agriculture without using fertilizer will never be possible. Fertilizers can be saved by making more efficient (i) choice of fertilizers (choice between anions and cations in the salts used as fertilizer, use of harvest waste and all replacement products). (ii) Control of losses (by leaching and irreversible fixation in the soil). (iii) Soil consernvation (Agriculture technique of preparation and upkeep of fight in improvement of organic matter and acidification). (iv) efficiency of absorption (planting material, root system development). (v) biological fixation of atmospheric nitrogen by using legum cover crop. (vi) Reduction of mineral imports in the harvest (planting material and product processing technology.) Hence, in the light of fertilizer economy and high yield, one must know the soil characteristics and environmental effect on both the soil and plant growth.

Oil palm (Elasis Guineensis) a native of West Africa is now intensively grown in Malaysia, Nigeria, Republic of Zaire and Ivory Coast and to a limited extent in India. It is a highest oil yielding crop per unit area, the world production of palm oil is 8.5 million metric tones. Oil palm has vast scope in irrigated areas of Kerala, Karnataka, Andhrapradesh, Tamil Nadu, Maharashtra, West Bengal and Orissa States in our Country. Cultivation of Oil palm may fulfil the deficit of edible oils and palm oil which contains the rich amount Vitamine 'A' and Vitamine 'E' prevents

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night blindness a major problem in the country. Besides it has many other properties.

Oil palm can be grown where the annual temperature varies between 20° to 35° C and well distributed rainfall of 2500 to 4000 mm per annum. It is known to withstand high rainfall as well as three to four months of drought. Soils which are rich in humus with good water permiability suit the palm best.

It was long before realised that the oil palm makes heavy demands on the nutrient supplies of the soil, and responses to fertilizers are readily obtained when soils are deficient and the nutrient need is soon visibly expressed by foliar symptoms. Although the nutrient requirement can be indicated by chemical composition which has not been generally accepted, however it can have some valuable use when the crop is bulky as in the case of oil palm where the long term nutrients supplying power of the soil is poor as in many cases of tropical soils.

To increase the efficiency of fertilizer usage, a deep knowledge and appreciation of several key factors affecting oil palm nutrition and productivity is essential. Thus, nutrient uptake can be related to palm development and dry matter production. The natural nutrient supply both immediate and long term would be governed by soil physico-chemical properties and mineralogical characteristics with particular reference to potassium, symbiotic nitrogen fixation reduction of leaching losses of applied nutrients by

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regulating frequency of applications according to soil types and rainfall intensity, choice of the most effective and economic nutrient carriers, root system development and nutrient absorption and nutrient inter-relationships including micronutrients makes fertilization more profitable. To enhance growth rate and to achieve greater productivity, adequate nutrients are essential which otherwise implies a need for the knowledge of nutrient balance concept and its major components under different soil and environmental conditions.

Basic growth and productivity of oil palm crop primarily depends on the seedling vigour and growth, the nutrient management of seedlings of oil palm appears to be a more vital component. Information available on the nutrient requirement of oil palm seedlings under Indian conditions is meagre. Thus an attempt has been made to develop an integrated extrinsic nutrient management system to oil palm seedlings under tropical humid conditions of the south India. Besides, the nutrient intraction on the uptake and utilization has also been attempted. Apart from these studies a piece of work has been carried out on the uptake and utilization efficiency of nitrogen through N^{15} tracer technique. All the information on the above aspects have been summarised in relation to growth and productivity of oil palm seedlings in this dissertation.

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

2.1 A NEED TO STUDY THE NUTRIENTS REQUIREMENT IN OIL PALM :

Quantitative data on nutrients involved in growth and reproductive processes of the oil-palm at the developing stage were lacking till 1965. The work of N_g and co-workers (1967, 1968) established that the oil-palm was nutrient demanding crop and further they brought to light that there was sharp rise in nutrient uptake from second year of planting.

Though the functions of many nutrients were understood, even then knowledge of functions of nutrients are often a subject of controversy and it is possible that further major roles for some elements are as yet undiscovered. Similarly, the mechanism of ion uptake is not fully understood, there are probably different mechanisms for different ions and perhaps for the same ion under different conditions.

CLASSIFICATION OF NUTRIENTS ACCORDING TO THEIR ROLE IN PLANT METABOLISM.

A nutrient element is termed as essential if it is a part of the molecule of an essential plant constituent without which plant is unable to complete its life cycle. It must fulfil three criteria viz., (i) The deficiency should make it impossible for the plant to complete the vegetative or reproductive stages of its life cycle (ii) The deficiency should be specific to it and (iii). It should be directly involved in the nutrition and metabolism of the Plant Jogindersingh and Kler D.S. (1975).

So far, seventeen elements are considered as essential for plants. Other elements are also absorbed by plant because they just happen to be in the soil. These elements might exist

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in variety of forms which are grouped into two categories (i) insoluble forms which includes primary and secondary minerals, salt precipitates, complex organic compounds and strongly adsorbed ionic forms and are less active therefore not readily available to plants. (ii) Simpler easily soluble forms include soluble ionic salts and weakly adsorbed ions. These are readily available for plant use.

2.3 PHYSIOLOGICAL ASPECTS OF NUTRITION :

Essential nutrients perform certain structural and functional roles in plants. Nitrogen is a chief constituent of protoplasm, proteins, nucleotides, phosphatides, alkaloides, enzymees, harmones, vitamins and chlorophyill etc., phosphorus plays an important role protein, fat and carbohydrate metabolism and has a key role in the energy transformation processes and cell division. Besides it is an important part of nucleotide phosphatides, phospholpids, phytin and some aminoacids and enzymes. Potassium never plays a structural role but it functions for synthesis of aminoacids, sugar, starch and in maintenance of osmatic pressure. It catalyses the enzymes like diastase, kinase and formylase. It also increases crop resistance to certain diseases and lodging.

Calcium is present as calcium pectate in middle lamellae of cell wall and therefore important for cell division. It detoxifies excessive acids in plants. Magnesium occupies a key position in chlorophyill pigment. It plays a vital role in phospho-relating reactions

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and transport of carohydrates and phosphates. Sulphur is essential constituent of many oils and protien. It also activates coenzymes thiame 'A' and biotin.

Iron is required for chlorophyill formation many oxidatation reduction reactions in plants depend upon iron and Manganese. Manganese is involved in activity of enzymes. Zinc is chief constituent of some enzymes like peptididase and is also involved in synthesis of growth hormones. Copper is an activator of oxidising enzymes, It is also an electron carrier in enzymes and helps to regulate respiration activity in plants.

Boron was found to regulate the uptake of calcium, potassium and nitrogen. It also helps in transportation of sugar and starch . Protein synthesis and cell division are also its vital functions. Concentration of neuclic acid, chlorophyill, polyphenoles and carbohydrates was found to vary significantly in the oil-palm seedlings developed in solution culture. Further a characteristic symptom of 'little leaf' was also recorded by Rajaratnam (1972).

Molybdenum is involved in nitrogen metabolism, because it is a part of the enzyme like nitrate reductase. It is essential for symbiotic and non-symbiotic nitrogen fixation. Cobalt is a constituent of vitamine B_{12}, which is required for formation leghaemoglobin in nitrogen fixing nodules.

2.4 EFFECT OF NUTRIENT ELEMENTS ON THE GROWTH OF PLANT :

Nitrogen fertilizer increased leaf area, leaf weight, and leaf production and higher net assimilation rate.

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characteristic yellowing symptom in the plant failure condition was attributed to nitrogen deficiency corley and MOK (1972), on the other hand Green (1972) was observed responses to nitrogen in the first two years. Nitrogen might increase yields in the presence of liberal applications of potassium, phosphorus and Magnesium. On soils of low nutrient status in the Ivory coast the nitrogen deficiency symptoms were developed. Application of ammonium sulphate recovered the deficiency of nitrogen in oil palm calvez etal (1976). Further Taillez (1982) was able to show the nitrogen deficiency in oil palms less than a year after planting on poor soils. Application of urea promoted the growth.

Nair and Sreedharan (1983) reported significiant increase in leaf Nitrogen concentrations. The nitrogen level gave a higher tissue Nitogen concentrations. There was also a significant increase in the leaf phosphorous concentration by Nitrogen application. Similarly Nitrogen application had increased leaf Potassium, Calcium and Magnesium. Symptoms of phosphorus deficiency can be developed in pot culture under rigorus systems of sand water purification. Although phosphorus deficiency is unusual in oil palms, significant responses to phosphorus fertilizers were obtained over tertiary sands and granites Vossen (1970). Corley and MOK (1972) reported that results of responses to phosphorus were harder to interpret. Production of vegetative dry matter attained a fairly constant level at the higher rates of fertilizer application. In another

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experiment there was a response to phosphate and it was confirmed that the need for phosphate was important on sandy soils. Application of more soluble and quickly available fertilizer phosphate was desirable Green (1972). Martin (1974) reported that phosphorus fertilization in combination with potassium was essential to increase the crop yield. Ataga (1978) studied phosphorus status of acid soils and responses to phosphorus and grouped into three phosphorus response areas viz., (i) soils in which phosphorous level is very low and considerable responses to phosphorus fertilization could be expected (below 5 ppm) (ii) soils in which phosphorous level is moderate and medium to little responses to phosphorus could be expected (5-10 ppm Phosphorus) (iii) soils in which phosphorus levels are relatively high and little or no responses to phosphorus was likely (P > 10 ppm). Response to phosphorus was found by Dandy etal (1982) in terms of enhanced vegetative growth to the increasing phosphorus levels. Phosphorus application was found to increase Nitrogen and Phosphorus concentrations in leaf tissue. There was also an increase in leaf tissue calcium and Magnesium concentrations (Nair and Sreedharan, 1983). Responses to phosphorus by oil palm were related to soil types, palm-age and leaf phosphorus content (Ng - 1986).

Specific role of potassium is in opening of stomata and the stomal resistance increased considerably when potassium was deficient (Corley 1975). Corley and Mok (1972) found that

Potassium application increased yields mainly by increasing leaf area. Significant differences had been recorded in the leaf level and yield of potash fertilized and that of unfertilized oil plam plantations (Green 1972). Ochs and Ollagnier (1977) reported that yield responses were often obtained when Potassium was applied by differing in bunch weight. A range of leaf yellowing and necrosis was attributed to potassium deficiency and fertilizer responses showed up within a short period. Kcl application prevented double deficiency of potassium and Boron (Taillez 1982). The increase in leaf tissue potassium concentration consequent to potassium fertilization had reduced the leaf concentration of calcium and magnesium was reported by Nair and Sreedharan (1983).

Oil palms with no water deficit found to contain low leaf potassium levels which enables to excellent yield and correction of this deficiency had no significant effect on overall production. Responses to potassium were strong under high water deficit conditions and weak when irrigation was given. This provides a confirmation of the extent of role played by potassium nutrition in drought resistance phenomena (Olllagnier etal 1987).

Magnesium was found to cause decreased chlorophyill content and hence decreased photo-synthesis as it is essential component of chlorophyill molecule. Responses to Magnesium were harder to interpret (Corley and Mok 1972). Walker and Melsted (1971) reported application of Magnesium did not reveal significant

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effect on the yield and growth of the oil palms. In another experiment, although there had been many results of responses to magnesium fertilizers it remained very difficult to interpret those results based on foliar analysis data (Green 1972).

Epstein (1972) pointedout that major function of calcium was to maintain cell membranes in functional state and hence maintaining cell membrane isolation besides other functions. In some cases the calcium was found to increase with age of oil palms but in rare cases it was found to decrease (Knecht etal 1977). Oil plam plantations were showed nitrogen and sulphur deficiencies after one year of planting, the growth was as poor as for non-fertilized plants and the application of ammonium sulphate increased nitrogen as well as sulphur contents (Calvez etal 1976). Sulphur deficiency in oilpalm nursery was described by Turner etal (1983) as interveinal chlorosis turning youngest leaves to pale yellow. Deficiency was recovered after 4 to 5 weeks by application of sulphur or ammonium sulphate.

Zinc, copper and Molybdenum are components of several enzymes. Copper is involved in respiratory pathway while zinc functions in protein synthesis and molybedenum deficiency prevents utilization of the nitrate and symptoms of nitrogen may develop. 'Peat yellow' symptoms were observed in the oil plams growing on acid peat soils and no responses were observed due to severity of deficiency Foliar analysis showed that the plams were deficient in copper, zinc and manganese (Hew etal 1973).

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Foliar spray of copper as Copper sulphate had a greater effect on pinna length and width with increasing leaf copper concentration (Ng etal 1974). Striking effects of copper on leaf colour and leaf area show that copper is involved in protein synthesis as well as chlorophyill formation. Boron, Iron, manganese,copper appeared to be essential for normal growth of the oil palms developing in culture technique (Dufour etal 1979).

Application of copper to the plams could restore the situation to normal and stopped developing abnormalities known as 'mid crown chlorosis' Dufour etal (1982), N_g etal (1974), The growth was reduced when the copper content in leaf on young palms was under 3 ppm. Molybdemum has its role in nitrogen nutrition as it is a constituent of nitrate reductase. The absence of Molybdenum in the nutrient, Solution increased the dry weight with a sharp drop in the leaf levels in deficient plants. Zinc deficiency reduced photosynthesis rate and activity of carbonic anhydrase. Zinc is a constituent of numerous deshydrogenases, hence it might play a part in the protein synthesis (Eschbach 1980). Small chlorotic patches at the end of young leaves which turned yellow showing necrosis. The vertical growth was stopped completely. From foliar diagnosis the symptoms were attributed to copper deficiency by Dacheco etal (1986). Studies in Africa Indonesia and South America showed the Importance of chlorine in oilplam nutrition where low leaf chlorine levels were found. The correction of deficiency

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was found to increase the oil yield, the optimum leaf chlorine concentration had been suggested as 0.5 to 0.6% of Dry matter (Ollagniar etal 1971).

2.5 MINERAL ION UPTAKE BY PLANTS :

Generally, mineral ion uptake by plants is an active energy requiring process and not simply a matter of diffusion. Nutrient uptake was selective process and chemically similar ions would be taken up quite different rates. The rate of potassium uptake was found to be Independent of the presence of sodium in the solution. Uptake of catioins was also independent of anion. Potassium uptake occurs at similar rates whether the anion in the solution is chloride or sulphate (Epstein 1972).

If the nutrient concentration in the soil or solution is not limiting the rate of nutrient uptake by the roots depends upon the demands for nutrients. Russell (1971) noted that under optimal conditions, quite severe root pruning might have little effect on the plant growth since remaining roots would absorb nutrients and water. Under favourable conditions it would be possible that an excessive quantity of assimilates might be diverted to the system and possibility of selection for a root system appropriate to prevailing conditions night be considered. Uptake of nitrogen and phosphorus was increased significantly by addition of fertilizers and providing a supplementary irrigation (Ataga etal 1981).

2.6 DIAGNOSIS OF NUTRIENT REQUIREMENT :

Primary objective in diagnosis of nutrient needs is to identify the factors limiting growth or yield of the crop.

In the oil-palm few attempts have been made to study the effects of climatic factor and fertilizer together. Ruer (1966) Correlated yield and potassium level of leaf only when the effective sunshine exceeded a certain level. Rusell (1972) further quoted work on various crops showing that responses to Nitrogen fertilizer was greater with irrigation. Halfman and Samish (1971) showed that an amine putresein accumulated in several species in condition of either potassium deficiency or potassium excesses but not when potassium status was optimal and this compound did not accumulate under other Nutrient deficiencies or excesses. Corley and Mok (1972) suggested that the rate of vegetative drymatter production might be a reliable indicator of whether the nutrient supply is limiting factor. However more convenient would be some specific aspects of vegetative growth such as leaf area, leaf weight or petiole cross sectional area. Rajaratnam etal (1974) suggested the concentration of leucocynidin in leaf tissue might be a useful index of boron status in the oil-palm. Rajaratanam (1972) considered the rate of increase of boron concentration with leafage would give

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a better indication of boron status then the absolute concentration in any leaf. Further he found that boron movement was towards extremities of leaflets where it become immobile. Ochs and Olivin (1975) used foliar diagnosis to control the nutrition of oil-palms. He was enable to collect the samples according to the leafage and for sampling procedures for routine monitoring.

Foster and Swee (1977) predicted the relationships between yield and leaf nutrient levels by response functions, maximum yield could be obtained with only one specific combination of leaf nutrient levels, but moderate yields could be obtained over wide range of nutrient levels. Nair etal (1982) proposed path coefficient analysis to determine the direct and indirect effects of leaf nutrient concentrations on the yield of oil-palm. They further found that anionic elements in the leaf tissue such as Nitrogen Phosphorous and Chlorine had positive effect whereas cationic elements such as Potassium, calcium and Magnesium had a negative effect. However combination of anionic elements (N+P+Cl) and cationic (K+Ca+Mg) had a negative and positive direct effects respectively.

2.7 SOIL NUTRIENT REQUIREMENTS OF THE OIL-PALM :

Soils should be assessed in terms of their abilities to supply plant needs. In specifying such plant requirements it is necessary to state them quantitatively and precisely. Plant nutrition is a dynamic process, in which the ability of soil in rapidly supplying water and nutrients to the particular root system is important, but not merely how much amount of available nutrients does it contains? Thus the rate limiting processes are seen to reside in the soil, the plant or both. Ng (1970) showed responses to Phosphorous and Potassium on the leached inland soils and Magnesium requirements on the sandy loam soils. On coastal alluvial soils there was no response to phosphrous or magnessium but potassium had a significant effect. Walker etal (1971) found that soil phosphrous was significantly correlated with fertilizer phosphate. There had effects of mineral nutrients and soil variability on the yield of oil-palms. Poon (1977) reported leaching losses on acid sulphate soils and attempt made to avoid leaching was not successful inturn resulted in acidification of soils. Ochs (1977) reviewed the climatic and soil requirements of oil-palm and suggested that palm grows well on desaturated ferralitic soils of low fertility, it is sensitive to coarse elements. Root elongation and pralifaration are strongly affected by many physical and chemical properties of the soil. Chew etal (1977) reported responses on a coastal clay soil with coarse structure and imperfect to poor drainage. Nitrogen was main limiting nutrient and responses to potassium were also noted. The highest yields were recorded when nitrogen and potassium were applied. Soils derived from granite and other coarsely crystalline rocks or sandy sediments are usually excellent for easy penetration and branching of roots and

and root development would be less easy on heavily endurated soils containing much concretionary material or on poorly areated soils.

Ataga (1978) utilised absolute yield response, relative yield and uptake of phosphorous as a response criteria. Relative yield and phosphorous uptake correlated with soils test for all the methods. Agamuthu etal (1986) showed that soils covered with legumes increased nitrogen levels and reduced soil surface temperature thereby strongly affecting the growth. A similar observation also made by Aisueni (1987).

2.8 NUTRIENT DEMAND BY OIL-PALMS IN RELATION TO SOIL NUTRIENT CONTENT :

Mainly three types of demands could be distinguished :

(i) Nutrients removed from the area indirectly.

(ii) Nutrients taken up and not returned to the palm since they are immobilised in the plam itself.

(iii) All the nutrients recycled to the soil in the leaf litter, dead leaves and male inflorescence. The first two are the measure of the long term depletion of the soil whereas all the three are of immediate rate of supply to the roots which the soils must be able to provide.

Baucy (1968) surveyed the main results of experiments carried-out by IRHO: firstly on nitrogen responses on young palms but did not in old palms unless poor internal or external drainage leads to denitrification. Secondly heavy demand for potassium on most sedimentary and some granitic soils. Particularly when the texture is very coarse, thirdly occasional requirements for phosphorous on granitic soils.

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Ng (1970) reported a responses to potassium. However, nitrogen demand in practice was observed in seedlings plams more frequently than the adult plams. A direct comparison of the total requirement of the palm with the amount of available nutrient in the top soil is simple. Nutrients would also be supplied from available forms in the sub-soil by slow release processes from non-available forms in the whole soil. A full comparison of palm demand and soil nutrient content should therefore aim to setup a total nutrient balance sheet (Hartley 1977).

Taillez (1982) tabulated the results on importance of balanced fertilizer application in young oil-palms. Symptoms of N.P.K. Mg and B were observed in a period of less than one year on the poor soils. There was a close relationship between growth, the symptoms observed and nutrient status evaluated by leaf analysis. The fertilizer response was showed up within a short period.

2.9 APPLICATION OF SOIL ANALYSIS FOR DIAGNOSTIC PURPOSE :

It is necessary to decide what is expected from a soil analysis either the long term supplying power of soil or the immediate fertilizer requirement. Tinker (1964) suggested that top soil analysis in plantation was in some ways analogous to leaf analysis. In that soil nutrient content changed only with time and should be quite closely related to plam nutrient status due to the continuous cycling of nutrients in canopy leaching and litterfall and thus regarded as being part of the same system.

Hence it would appear that the soil solution concentration of nutrient would be the best measure. NG (1970) Green (1972) suggested that foliar analysis alone is not entirely reliable and in principle application of both foliar analysis along with soil analysis to be more reliable. Ollagnier etal (1970) concluded that deficiency detection by soil analysis was imprecise and limited to a few cases but they quoted 0.15 to 0.20 m eg/100 g. of exchangeable potassium as a level below which the potassium deficiency was certain.

Ataga and Omoti (1978) correlated phosphate sorption characterstics of some acid soils from oil-plam plantations and sorption isotherms were used for evaluating the phosphate requirements of oil-palm. The values obtained from phosphate adsorption isotherms were significantly correlated with relative yield data obtained from both green house and field experiment. On Island soils, variable responses to phosphorous was observed on the basis of phosphate sorption Isotherms. (Dandy etal 1982). In one case enhanced vegetative growth was observed with increasing phosphorous levels whereas in another trial no response to phosphorous was recorded.

2.10 FACTORS AFFECTING FERTILIZER RECOVERY :

In the oil-palm nutrition work, shape of fertilizer response in various ecosystem would be characterised by the soil and climatic factors which affect the shape. Secondly the relationships between yields and soil or tissue analysis should be investigated.

Duhnam and Nye (1974) reported that uptake of ion was influenced by soil water content. At higher soil water contents chloride uptake was greater. While Ng (1977)suggested that essential factors of the mineral element balance were absorption by the plant and leaching losses on one hand and quantities supplied by the soil and the fertilizer dressings on the other. Fertilizer efficiency depends on their satisfactory absorption by the roots as well as on the maintenance of a proper balance between the major elements and careful adjustment of the minor element requirement.

2.11: METHODS OF FERTILIZER APPLICATION :

Fertilizers should be applied where they can be most rapidly taken up by the feeding roots of the crop. Ruer (1968) & Taillez (1971) had shown that in the oilpalm only quarternary roots and non-lignified tips of other roots are important in the absorption of nutrients. Feeding roots were still highest near the plam bases for mature plams. Optimal methods for application of fertilizers might be expected to differ with fertilizer and the soil type. On the soils of high cation exchange capacity potassium availability was not-appreciable if the fertilizer was broad-casted, but the same amount of fertilizer if placed in a restricted area availability and hence uptake might be increased in that area (Tinker 1964). Similarly for soils of high in free sesquoxides, phosphate availability might be increased by

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applying a large amount of phosphate fertilizer in narrow band. On sandy soils having low absorbing capacity for ammonium and potassium ions, leaching losses of these nutrients would be less if they were broad-casted. Ollagnier and Ochs (1972) reported that Sulphur deficiency in oilpalm had not recovered by application of elemental sulphur but it was associated with cultural practices. Rajaratanam (1973) reported good results when boron was applied broadcast onto the soil or applied to leaf axils. Boron uptake was inhibited by heavy potassium fertilization.

Recovery of nutrients by the oilpalm might be most efficient if they were applied not to the ground rather than spraying on the foliage. Foliar spraying of copper sulphate was found to increase leaf length and leaf copper concentration as compared to that of untreated healthy looking palms whereas soil application had no obstensible effects (Ng etal 1974).

2.12 COMPARISON OF DIFFERENT SOURCES OF NUTRIENTS :

2.12.1: CROP UPTAKE :

(1) Nitrogen :- Ammonia was found to be lost ammonium from fertilizers by volatilization in soils with pH greater than 7 but no loss would be expected from highly acidic soils. However application of urea increases the pH due to hydralysis and losses from this fertilizer was quite possible. Nitrate nitrogen is highly suceptible to loss by denitrification and leaching. Application of ammonium sulphate at higher rate was also reduced growth of the oilpalm due interaction between Nitrogen and Magnesium resulting nitrogen deficiency (Medham (1971).

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Rajaratanam etal (1973) showed that volatilization losses from applied urea was positively related to the soil moisture level. Urea was found to be less effective as compared to ammonium sulphate in increasing the yield. Growth and mineral composition of oilpalm seedlings grown in sand culture was found to enhanced when nitrogen was applied as ammonium nitrate. The growth was found to be in order of Ammonium Nitrate, Nitrate and Ammonia Nitrogen. The mineral element contents of leaves were differentially affected by the source and the level of nitrogen Okoye (1974). However, increased yield were obtained by Cheong and Ng (1977) by the application of murriate of potash and lime-stone dust on deep acid peat soils of oilpalm plantations whereas sulphate of ammonia and rock phosphate produced depressive effects on the growth and yield. Recovery of nitrogen is therefore likely to be highest when ammonium fertilizers are applied to heavy clay soil. On sandy soils loss of nitrogen from urea and fertilizers containing nitrate might be large depending on weather conditions (Corley 1975).

ii) <u>PHOSPHOROUS:</u>

Recovery of phosphorous was found to be less than 10% of the added phosphorus. On poor soils Martin (1972) found that an increase in the phosphorous content of oil-palm leaves by 18 to 26%.

Martin (1974) showed that application of superphosphate or rock phosphate to oilpalm seedlings planted in a yellow latsoil doubled the crop yields when fertilizer accompanied by potassium. Crop utilization of phosphorous derived from rock phosphate in the soil found to depend upon composition and degree of grinding of rock on the method of its application and on the chemical properties of soil. Evaluation of soil phosphate of the oilpalm growing soils were lacking of both available and reserve phosphorous. Yield responses were related to soil types, plam age and leaf phosphorous content (NG 1986).

iii) **POTASSIUM:**

Active uptake of potassium by plants would be greater in the presence of chloride than in the presence of sulphate. Though potassium would likely to suffer leaching in presence of chloride than in presence of sulphate (Epstien 1963). Corley and Mok(1972) had noticed that on a red-yellow sandy loam latsol, experimental results were difficult to interpret in case of Magnesium and Phosphorous whereas potassium increased yields

by increasing leaf area, while Nitrogen increased leaf area and net assimilation rate. Dry matter yield increase levelled off at higher fertilizer rates.

Nair and Sreedharan (1983) recommended N, P_2O_5 and K_2O at 800:400:1800 g/palms for maximum palm growth. Further the application of calcium and Magnesium had no significant effect on the palm growth.

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2.13 SIDE EFFECTS OF DIFFERENT FERTILIZERS :

2.13.1 : Effect of Subsidary Constituents :

Addition of major nutrient fertilizers also supplies an additional nutrients which could be advantageous to the crop. Sulphur is supplied by ammonium sulphate, superphosphate etc. Whilst chlorine is supplied by potassium chloride and ammonium chloride. Daniel and Ochs (1975) found that application of Magnesium chloride increased the yield of oilpalm whereas application of Magnesium sulphate did not increased the yield. Foliar analysis showed that increase in chlorine levels from 0.038% to 0.23% indicating that the increase in yield was not only due to magnesium but also due to chlorine. Breure and Rosequit (1977) noticed that the application of urea on Volcanic ash soils of Guinea reduced Ph, CEC, Organic carbon and exchangeable calcium, Magnesium and potassium. In oilpalm fertilizer experiment on sandy soils 50% of the applied potassium was found to be lost in 6 months when fertilizer was localised but very little loss occured when the fertilizer was broad-casted.

2.14: Tissue analysis and diagnosis of nutrient status :

Tissue analysis is widely used in the oilpalm for diagnosis of nutrient status and assessment of fertilizer requirements. Ochs and Olivin (1975) explained the use of foliar analysis to enable correct sampling according the leafage and sampling procedures for routine monitoring.

2.14: CHOICE OF TISSUE FOR ANALYSIS :

Nutrient concentrations which have been found to increase with

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leafage include calcium, magnesium, Boron, Manganese and Iron (Ng etal 1969) and later trace elements were relatively the immobile. Hence, it would be better to determine in a young leaf..Foster and Swee (1977) had shown that the most appropriate leaf to sample is obiviously that in which nutrient levels are best related to yield. In a given environment, maximum yield could be obtained with only one specific combination of leaf nutrient levels. Nutrient levels in the 17th leaf was affected by fertilizer and related to yield and nutrient level. Knecht etal (1977) obtained significant linear correlation for nitrogen and potassium with mineral content of leaf 17 and with the age of plams. Calcium content increased with age in two plantations but decreased in third one. Nair and Sreedharan (1983) showed positive relationship for nitrogen, phosphorous and potassium of tissue with yield. Rajaratanam etal (1973) suggested selection of leaf 17 which gave satisfactory guide to yield preference.

2.15 FLUCTUATIONS IN LEAF NUTRIENT LEVELS :

2.15.1: SEASONAL FLUCTUATIONS :

Where the climate is highly seasonal, marked leaf nutrient fluctuations in oilpalm have been reported. Foster and Swee (1977) were found that response of Nitrogen and phosphorous in oilpalm were positively related to annual rainfall on coastal soils. On Inland soils phosphorous and potassium responses were positively related to soil pH, potassium was also found to be negatively related to soil clay content. Nitrogen and potassium responses in inland soils were greately affected by intensity of leaching and frequency of fertilizer applications. Quencez and Taffin (1981) found that high water deficit was associated with low potassium level and levels in routine monitoring should be judged in relation to the water deficit . In conditions of adequate water supply the sampling date was of less importance. Nair and Sreedharan (1983) showed that the seasonal changes in the leaf concentrations of Nitrogen, phosphorous and potassium affected by the various treatments.

MATERIAL AND METHODS

III. MATERIALS & METHODS

3.1 COLLECTION OF SOIL SAMPLES :

Profile soil samples of distinct soil type such as: Laterite, red sandy loam, Hilly (Forest) soils were collected for the present study.

After usual Laboratory processing such as air drying in shade and passing through 2 mm sieve, the samples were stored in polythene containers and used for the subsequent analysis.

3.2 METHODS OF SOIL ANALYSIS :

3.2.1: Chemical analysis:- (Jackson, 1957, Piper 1966; Black 1965; Chapman 1964)

(i) pH: Soil pH was measured in 1:2.5 soil water suspension by using glass electrode on Beckman zeromatic pH meter.

(ii) Available nitrogen :- Available nitrogen in soil samples was determined by following alkaline permangamate method proposed by Subbiah and Asija (1953).

(iii) Total Nitrogen:- Total Nitrogen in soil samples was determined by Kjeldhal's method of Black(1965).

(iv) Available Prosphorous :- Available prosphorous content in the soil was evaluated by extracting it with Bray No.1 (0.03N NH_4F in 0.025 N Hcl) (Bray & Kurtz 1945). Thereafter phosphorous in the extract was estimated colourimetrically by chloro-stannous reduced molybdo phosphoric acid blue colour method. Blue colour was read on Boush and Lomb spectronic 21 sphectro photometers at a wave length of 660 nm. Jackson (1958)

(v) Available Potash:- Potash in soils was determined by extracting it with 1:5 soil:1N neutral ammonium acetate and using corning 400 model flame photometer.

(vi) Phosphate adsorption studies :- It was aimed to **determine** the quantity of phosphorous adsorbed as a function of amount of phosphorous added to the soil. Three soils viz., laterate, red sandy soil and hilly soil were used for the study.

Five grams of laterite, Red sandy loam and Forest (Hilly) soils were equilibriated with phosphate solution having concentrations of 0, 25, 50 and 100 ppm for 72 hours. Solution was centrifuged and unadsorbed phosphorous was estimated colorimetrically while adsorbed phosphorous was computed.

Results are fitted into the Langmuir adsorption equation for evaluating adsorption co-efficients (Olsen etal 1957)

Langmuir's Adsorption equation $\frac{c}{x/m} = \frac{c}{b} + \frac{1}{kb}$

Where C = equilibrium concentration of phosphorous µg/g

x/m = quantity of phosphate adsorbed by clays µg/g

b = adsorption maximum

k = a constant related to the bonding energy of the adsorbent for the adsorbate

The constants k and b were computed from the intercept and the slope of the adsorption maximum (Biddappa (1972).

(vii) Adsorption of Potash:-

The above three soils were saturated with potash solution at the rate of 0, 50, 100 and 200 ppm K in a 50 ml plastic tubes and equilibriated for 72 hours. Then centrifuged and unadsorbed potash was determined by flame photometer whilst adsorbed potash was computed. Data were fitted into the langmuir adsorption equation as described above and adsorption co-efficients were obtained.

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(ix) Selective distribution Studies :- To study the distribution of added p and k in soils, saturated soils with 200 ppm phosphorous and 500 ppm potasium were fractionated.

Phosphorous was fractionated following the method of chong and Jackson (1958). The selective distribution of potash was studied by sequential extraction using water, 0.01 M calcium chloride, 1N NH_4OAC (Ammonium Acetate) and boiling 1N HNO_3 (Khan etal 1982). Percentage of different forms of phosphorous and potassium corresponding to the fractions were calculated.

3.3 EXPERIMENTAL DETAILS OF POT CULTURE STUDIES :

Pot culture studies were carried out in three different experiments on oilplam seedlings.

1. Major and secondary nutrient deficiency and nutrient interaction on the uptake and biomass production of oilplam seedlings.

A sand culture experiment where oilpalm seedlings were planted (2 months old) on ten kg of acid washed sand in pots. A normal nutrient solutions were prepared having the concentration as below :

Ammonium Nitrate	50 ppm N
Sodium dihydrogen phosphate	10 ppm P
Potassium chloride	25 ppm K
Calcium chloride	20 ppm ca
Magnesium chloride	20 ppm Mg
silicic acid	5 ppm si
Fe-EDTA	2 ppm Fe

Boron	0.27 ppm B
Manganese	0.274 ppm Mn
Zinc	0.131 ppm Zn
Copper	0.034 ppm Cu
Molybdenum	0.0096 ppm Mo

From the stock solution fresh nutrient solution was prepared and applied at seven following different treatments.

1. Treatment; complete with all the nutrients
2. Treatment; All nutrients except nitrogen
3. Treatment; All complete nutrients except phosphorous
4. Treatment; All complete nutrients except potassium
5. Treatment; All complete nutrients except calcium
6. Treatment; All complete nutrients except Magnesium
7. Treatment; All complete nutrients except Zinc

Each treatment was carried out in three replications. Nutrient solution was given once in every month till nine months. At the end deficiency was described, the monthly growth and leaf production was also recorded.

After nine months seedlings were harvested and separated the roots and shoots, washed with tap water and deionised water and processed. Biomas was recorded after oven drying and the samples were analysed for nutrient content in each part. Total nutrient uptake was then computed and interpreted.

2. <u>EVALUATION OF N, P, K requirement of Oilpalm Seedlings</u> :-

A pot culture experiment with ten kg of red sandy loam soil filled in pots was conducted. Oilpalm seedlings were planted and eight different treatments were given. Monthly growth and leaf production of the seedlings was recorded.

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The experiment was carried out for 9 months with three replications for each treatments. At the end of the experiment soil samples were collected and seedlings were harvested, washed with deionised water and separated into root and shoot parts.. After processing biomass was recorded and nutrient contents in each part was assessed after analysis. Total nutrient uptake was then computed.

The Treatments were as follows :-

Treatment No.	Dose g/pot	Rate	
1	0	Control for entire period	
2	10	120 ppm	12:12:7 N:P:K For every month
3	20	240 ppm	
4	30	360 ppm	
5	30	120 ppm	12:12:7 N:P:K Once in three months
6	60	240 ppm	
7	90	360 ppm	
8 (Normal Dose)	8 gms.of (15:15:6) N:P:K mixture in 5 litres of water applied equally to 100 seedlings		Monthly once 12 mgm/pot

3. STUDIES ON PARTIAL PRODUCTIVE EFFICIENCY OF NITROGEN IN OILPALM SEEDLINGS.

A soil culture experiment was conducted on oilpalm seedlings to study nitrogen fertilizer use efficiency. Nitrogen was applied at graded levels in three treatments as below:

Treatments	Grade	Rate
1	N_0	0
2	N_1	2X150 ppm N (1.5 g. N^{15})
3	N_2	2X300 ppm N (3.0 g. N^{15})

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Six replications were taken for each treatment. Treatment was given in solution form once at the beginning and once after the fifth month of the experiment. Soil samples were collected after initial treatment and at the end of the experiment. Seedlings were harvested and processed after the separation of root and shoot portions. All the parts were analysed for total nitrogen. Uptake was then computed and partial productive efficiency was worked-out.

3.4 PLANT ANALYSIS FOR NUTRIENT CONTENT :-

3.4.1. Preparation of Samples:- Separated parts of the seedlings were aried in an oven at 70 to 80°C. The tissue samples were then ground well in mechanical mill with stainless steel blades. The ground samples were then stored in a clean polythene bags after proper labelling.

3.4.2. METHODS OF ANALYSIS :

(i) TOTAL NITROGEN :- A known weight of dry tissue sample was digested in Kjeldhal digestion flask with concentrated sulphuric acid in presence of a catalyst (copper sulphate + potassium sulphate, in 1:10 ratio). Then nitrogen content in the digest was estimated by micro-Kjeldhal method trapping ammonia into 2.5% boric acid at pH 4.5 and then back titrating, the amount of Ammonia absorbed was calculated (Black 1965).

(ii) TOTAL PHOSPHOROUS:- A known weight of dried tissue samples were digested with diacid mixture (HNO_3, $HclO_4$, 2:1) after cold digestion for overnight then on hot plate until

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white fumes of per chloric acid disappeared and the solution becomes colourless. Then contents were diluted to 100 ml with distilled water, the clear solution was used for estimation.

In an aliquote of the digested clear solution, phosphorous was determined by the vando-Molybdo phosphoric acid yellow colour method in nitric acid system. Intensity of yellow colour was measured on spectronic 21 (Boush and Lomb) spectro photometer at a wave length of 470 nm (Jackson 1958)

(iii) ESTIMATION OF K, Ca, Mg AND MICRO NUTRIENTS :

The diacid extract of the tissue sample were used for the estimation of total K, Ca, and Mg. Potassium in the samples was estimated by flame photometer, whilst calcium, Magnesium and micronutrients were estimated using atomic absorption spectro photometer model No. Varian Tectron 975. (Jackson 1958).

RESULTS

IV. RESULTS

4.1: Adsorption Studies :

4.1.1: Phosphate adsorption on the soils :

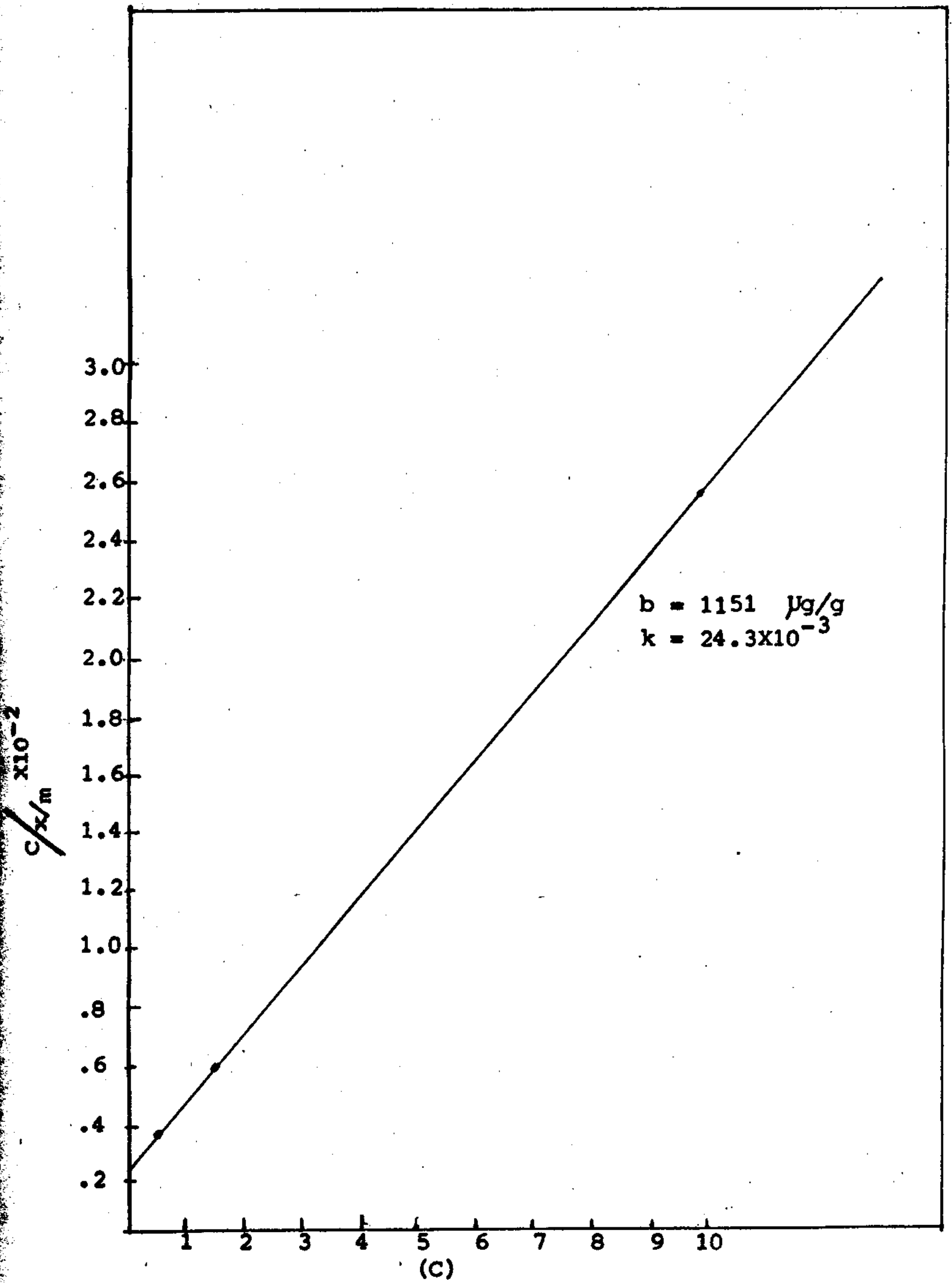
Data on the quantities of phosphate adsorption by different soils on the addition of phosphate in increasing concentration are presented in the table I and the Langmuir adsorption isotherms showing the ratio of equilibrium concentration to the quantity adsorbed per unit weight of the soil as a function of equilibrium concentration are shown in the fig. (1), (2) & (3)

The quantity of phosphate adsorbed increases as the concentration of equilibriating solution increases in all the three soils. Adsorption of phosphate is higher in the red sandy soil followed by forest soils and laterite soils.

The Langmuir's constants worked out for phosphate adsorption are given in the table 2. The constant 'b' as a measure of maximum adsorption is higher in the red sandy loam (1151 $\mu g/g$) and lower in the laterite soil (310 $\mu g/g$). The energy of adsorption as indicated by the Langumuir's 'K' value is higher in the Laterite soil (251.3) and lowest in the red sandy soil (24.3) from the results of Langmuir's constants it can be seen that adsorption of phosphate by soils increased where 'K' value is lower and 'b' value is higher. Energy of adsorption increases as the adsorption capacity decreases in the soils.

4.12: POTASH ADSORPTION ON THE SOILS :

The quantities of potash adsorbed with respect to the addition of potash solutions having different concentrations by soils are presented in the table (3). The Langumuir adsorption isotherms



P Concentration in equilibriating solution µg/ml

FIG.I. LANGMUIR ADSORPTION ISOTHERM FOR P IN RED SANDY SOIL

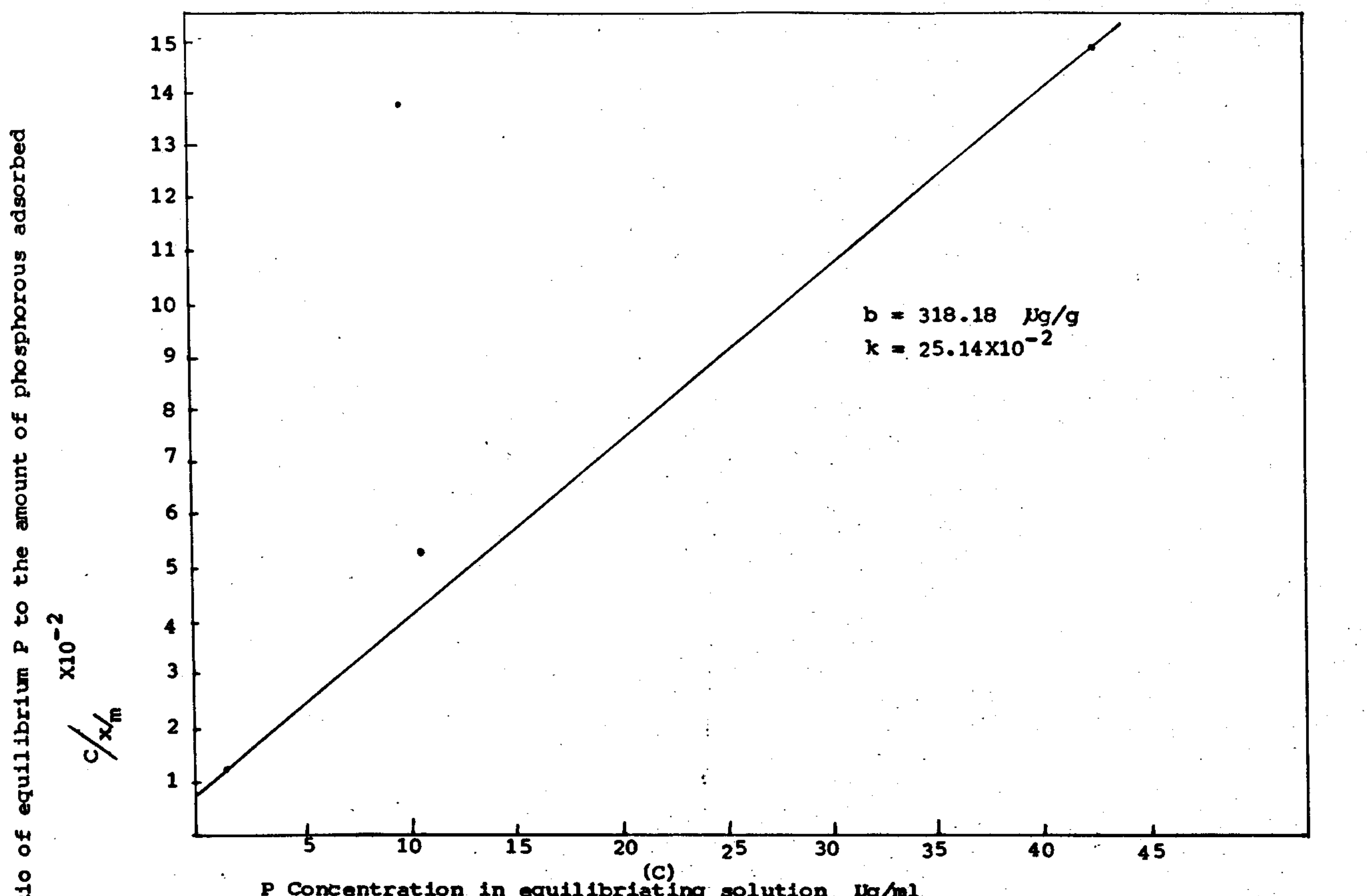


FIG.II. LANGMUIR ADSORPTION [illegible]

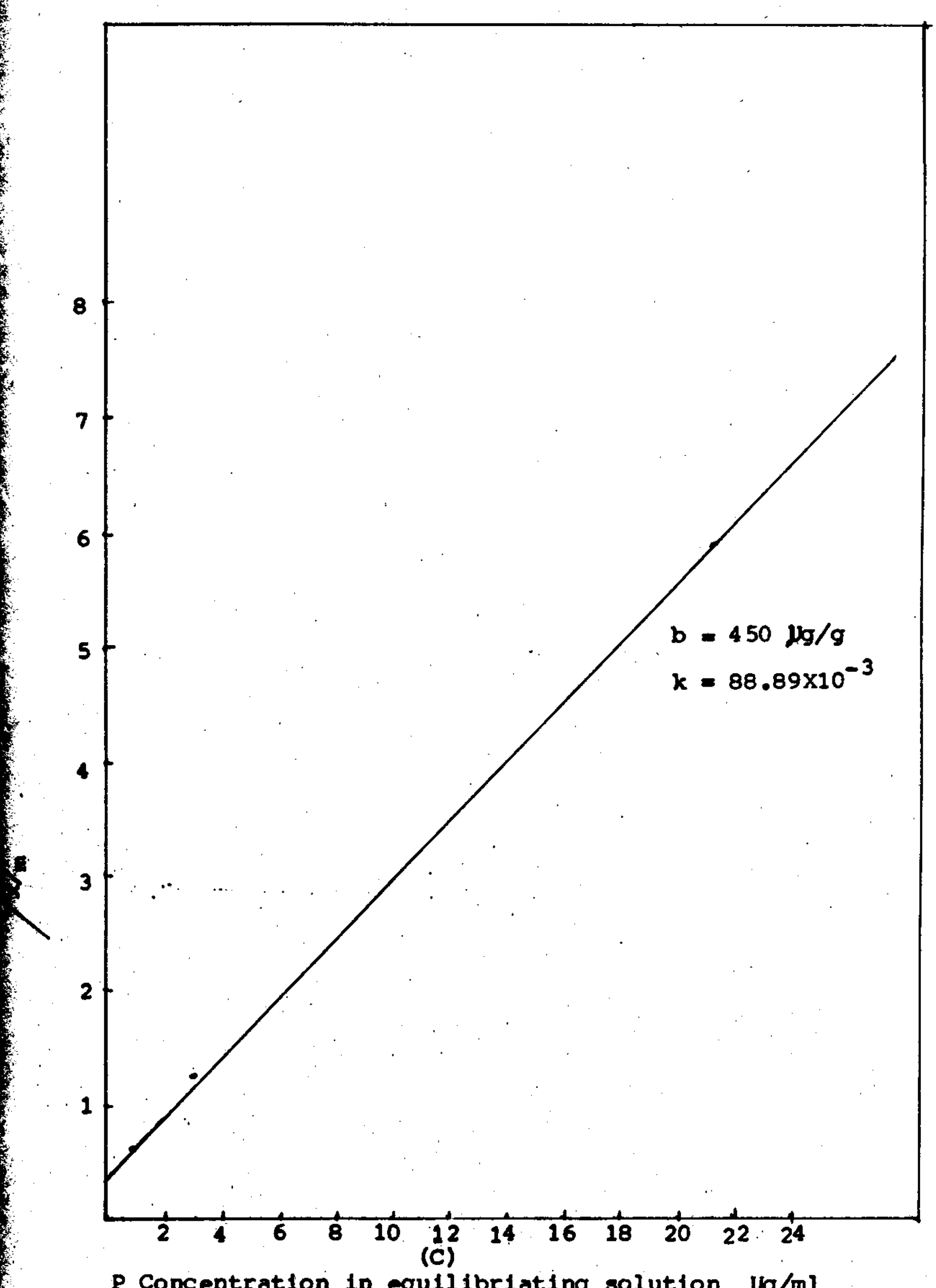


FIG.III. LANGMUIR ADSORPTION ISOTHERM FOR P IN FOREST SOIL

TABLE-1

ADSORPTION OF PHOSPHOROUS BY SOILS (µg/g)

Soil No.	Soil Type	Phosphate added initially µg/g		
		625	1250	2500
		Phosphate Adsorbed by Soils		
1.	Red Sandy Soil	122	243	450
2.	Laterite Soil	117	197	290
3.	Forest Soil	120	234	394

TABLE - 2

LANGMUIR's CONSTANTS FOR THE ADSORPTION OF PHOSPHOROUS BY THE SOILS

Soil No.	Soil Type	'b' µg/g	K X 10^{-3}
1.	Red Sandy Soil	1151	24.3
2.	Laterite Soil	310.18	251.3
3.	Forest Soil	450	88.89

plots are given in the figures 4, 5, 6. As in the case of phosphate quantities of potash adsorbed increases with increase in the concentration of equilibriating solution in all the three soils.

The Langumuir's constants for potash adsorption are given in the table (4) maximum adsorption capacity of soil as indicated by 'b' value is highest for the red sandy (550 µg/g) soil followed by Forest soil and laterite soil. The energy values as indicated by 'k' values are found to increase in the order as Red sandy > laterite > Forest Soil. Energy of adsorption as indicated by 'k' value is highest for the forest soil (290.55) and lowest in the Red sandy soil (47.27). Energy of adsorption decreases as the adsorption capacity increases in the red sandy and laterite soils except in Forest soil where higher adsorption is associated with higher bonding energy.

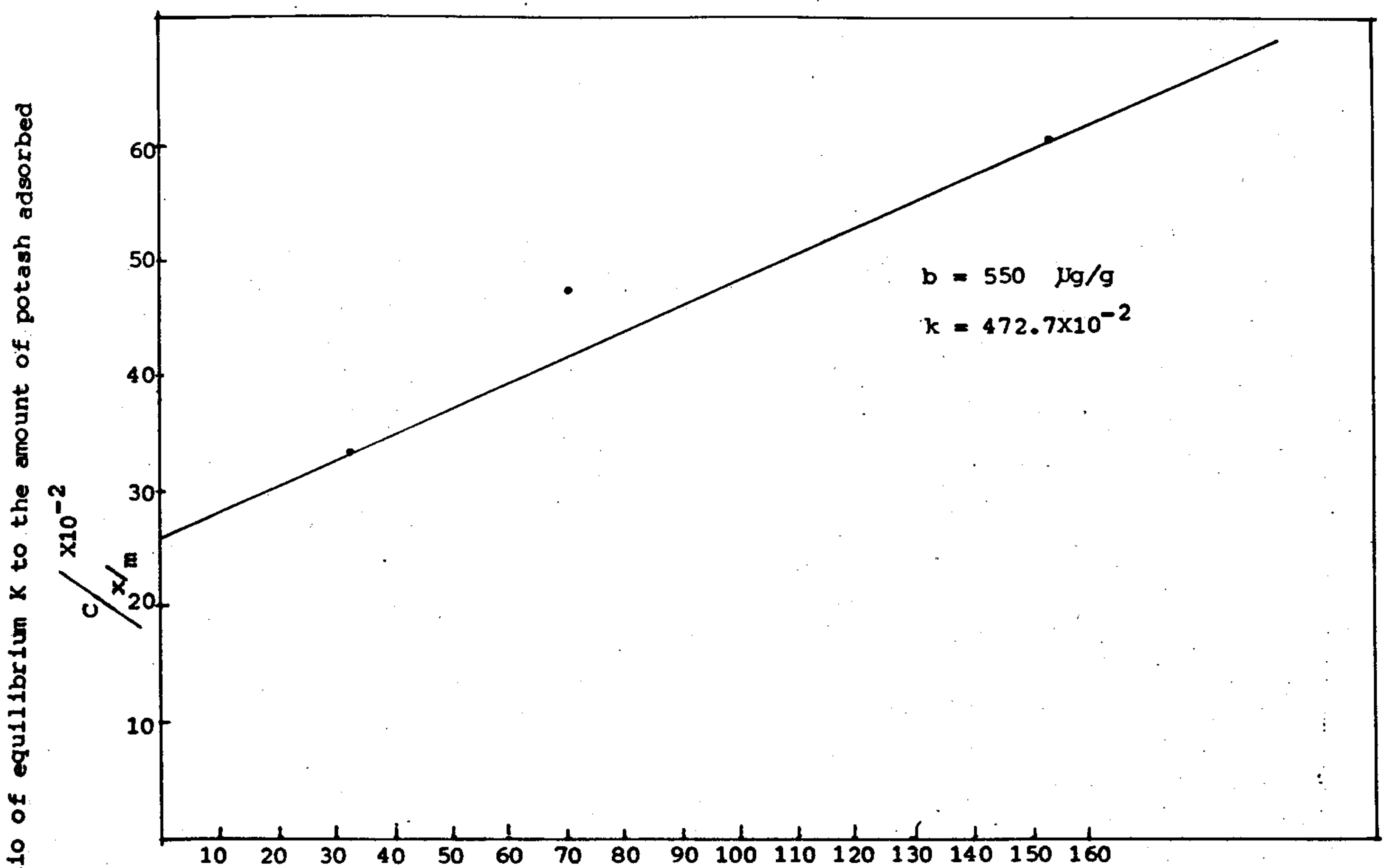
4.2 DESORPTION STUDIES:

Retention and releasing capacity of soils is studied and Desorption patterns of soils for phosphate and potash are presented.

4.2.1: PHOSPHATE DESORPTION :

Three soils have different ability to release the adsorbed phosphate is summarised in figure (7). Laterite soil showed high capacity to release the added phosphate at the first extraction (250 µg/g). Most of the added phosphate released at the fifth extraction only.

Red sandy loam soil did not release most of the added phosphate at the first extraction but the quantity of phosphate released at the second extraction is higher (225 µg/g.) However capacity to release is found to be low for this soil as there is gradual release of phosphate at each extraction.



(C)

K Concentration in equilibriating solution µg/ml

FIG. IV LANGMUIR ADSORPTION ISOTHERM FOR K IN RED SANDY LOAM SOIL

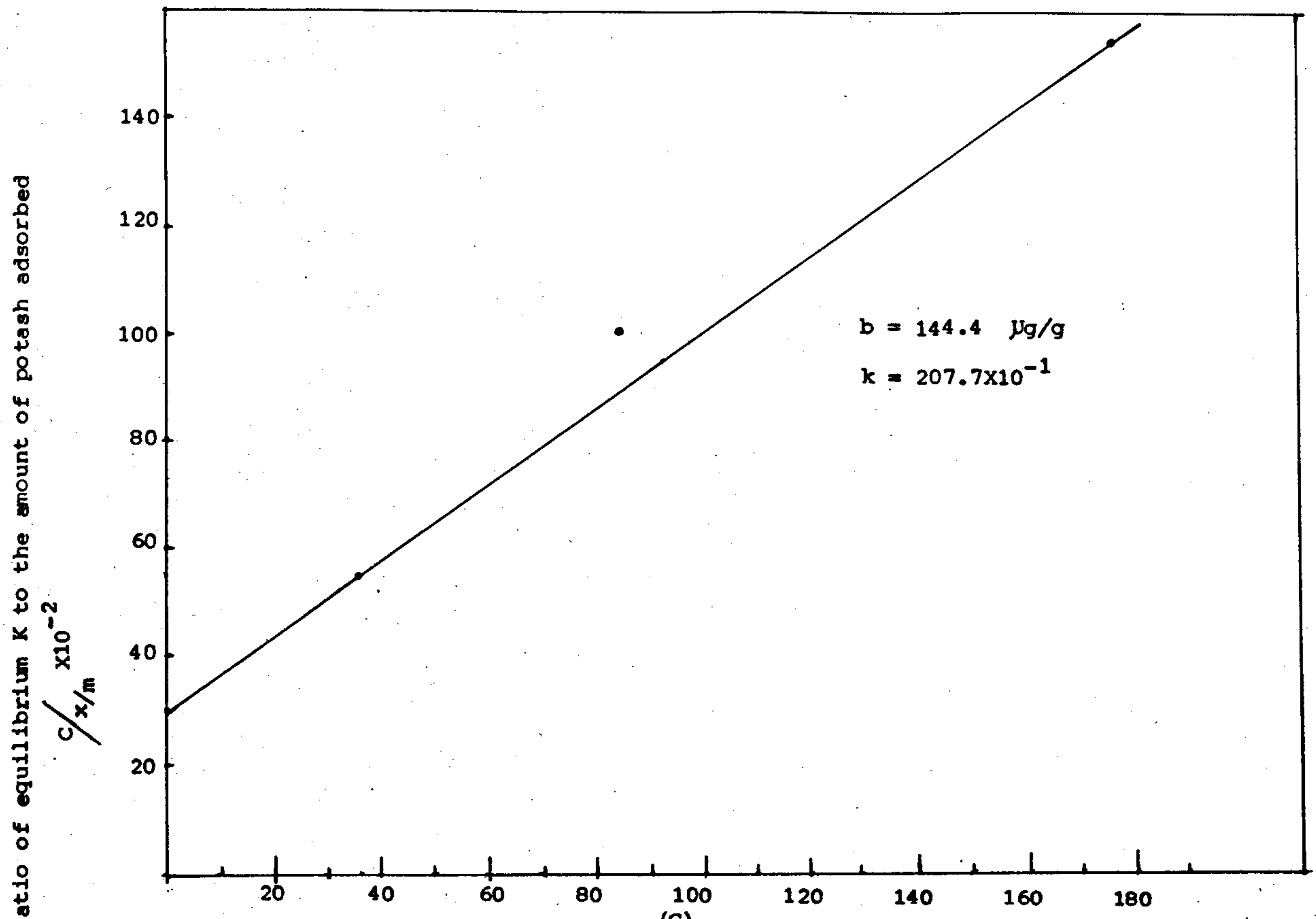


FIG.V. LANGMUIR ADSORPTION ISOTHERM FOR K IN [illegible]

Ratio of equilibrium K to the amount of potash adsorbed

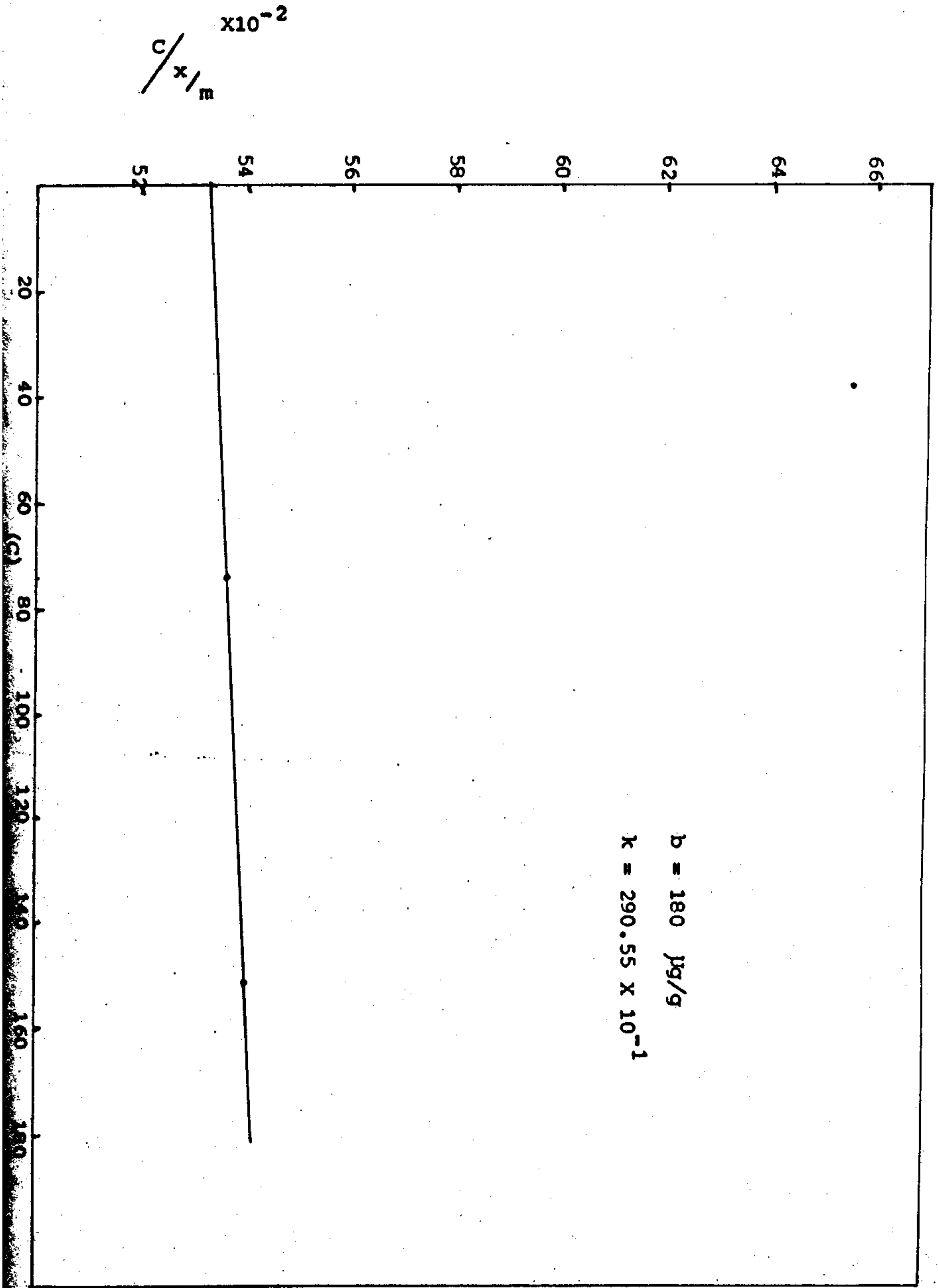


TABLE-3

ADSORPTION OF POTASH BY SOILS (µg/g)

Soil No.	Soil Type	Potassium added initially µg/g		
		1250	2500	5000
		Potassium adsorbed by Soils		
1.	Red Sandy Soil	95	148	230
2.	Laterite Soil	68	83	115
3.	Forest Soil	60	135	275

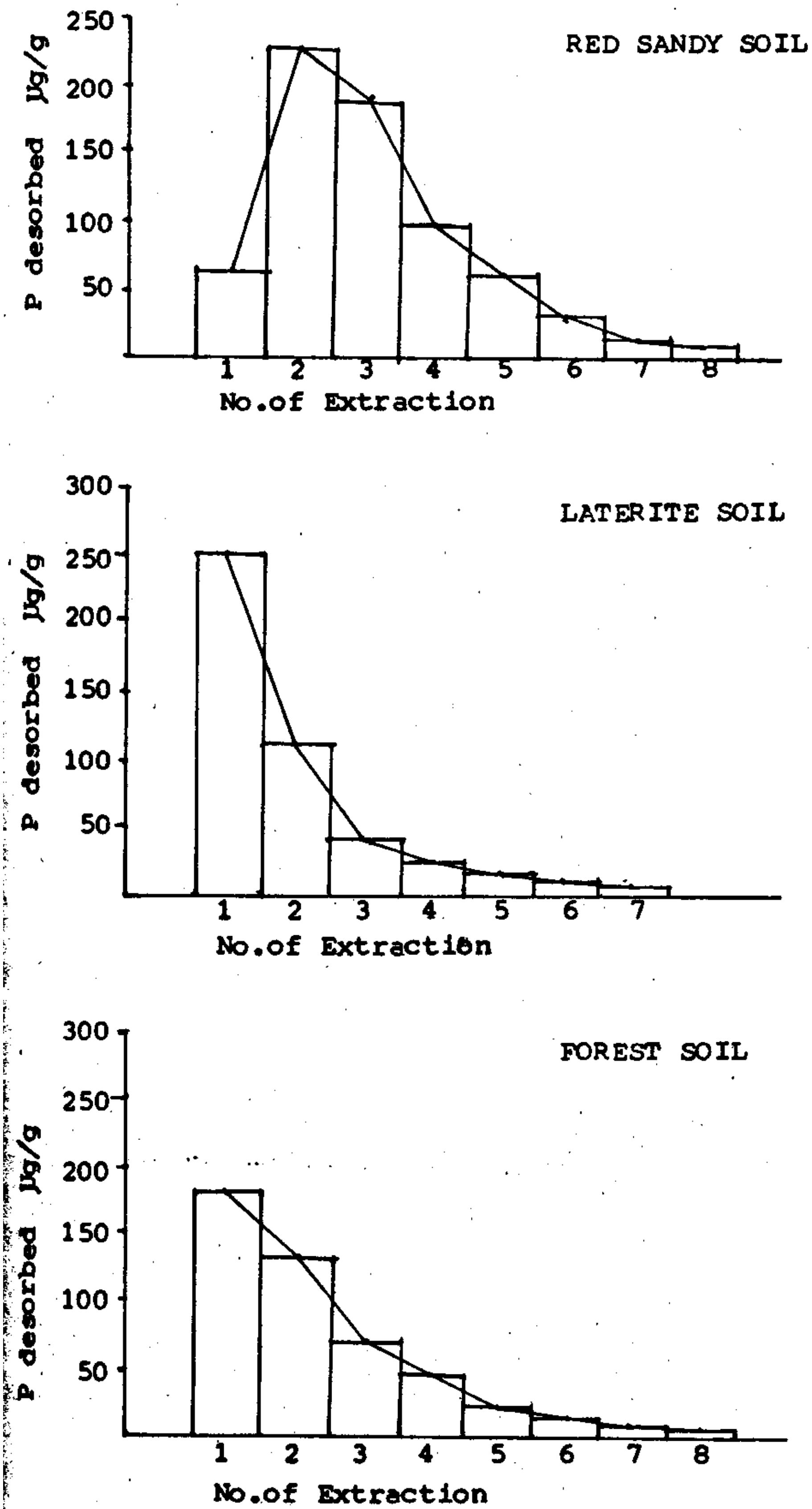


FIG. VII. DESORPTION PATTERN OF P IN THREE TYPICAL OILPALM GROWING SOILS

TABLE-5

PHOSPHATE DESORPTION BY SOILS (µg/g)

Soil No.	Soil type	Phosphorous added initially 2500 (µg/g) Phosphorous desorbed by Soils at Extraction 1	2	3	4	5	6	7	8
1.	Red Sandy soil	63	225	185	94	65	33	18	11
2.	Laterite soil	252	134	43	29	16	10	9	7
3.	Forest Soil	179	134	70	39	23	16	14	11

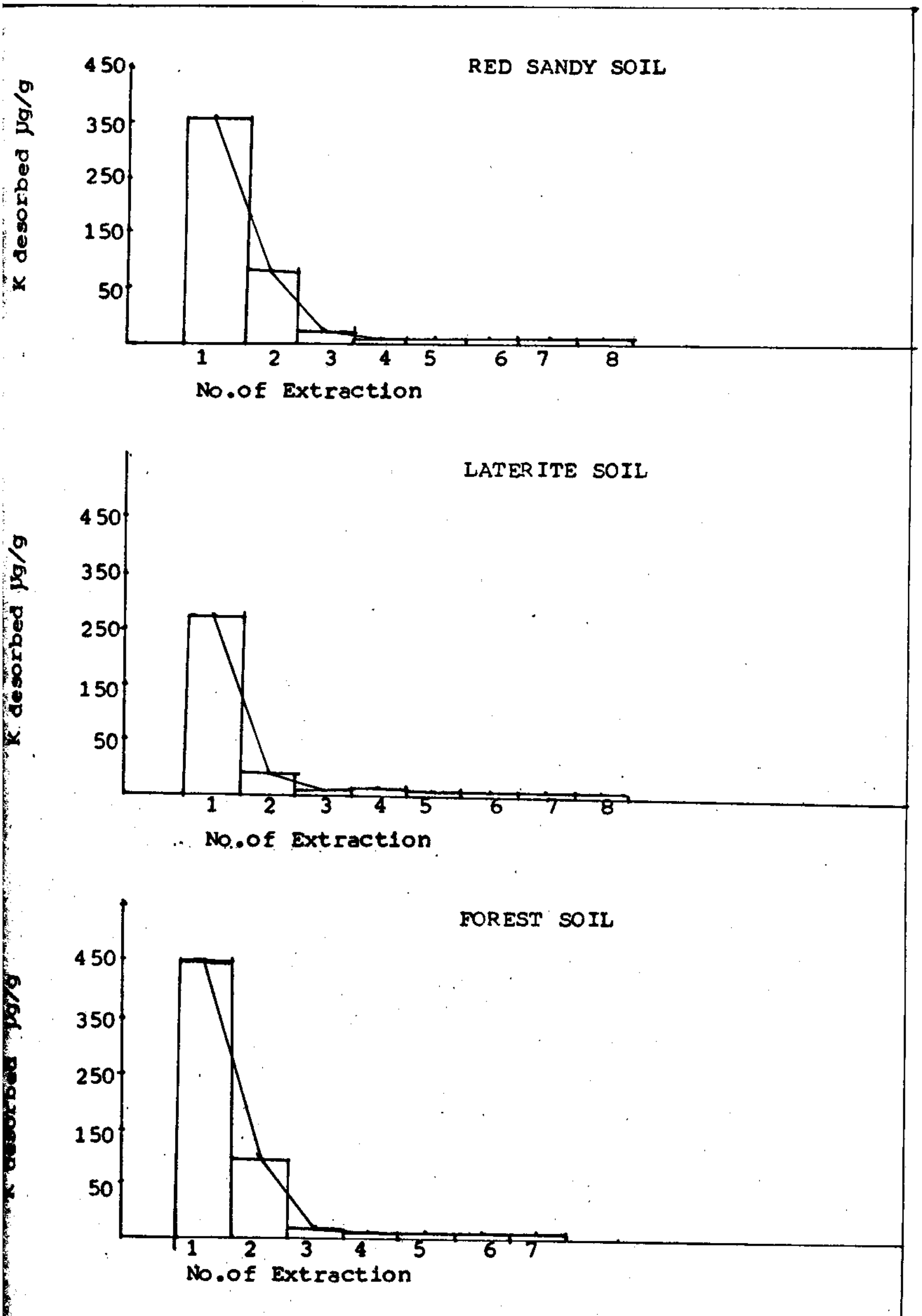


FIG.VIII. DESORPTION PATTERN OF K IN THREE TYPICAL OILPALM GROWING SOILS

TABLE 6

POTASH DESORPTION BY SOILS (µg/g)

Soil No.	Soil type	Potassium added initially 5000 (µg/g)							
		Potassium desorbed by Soils at Extraction							
		1	2	3	4	5	6	7	8
1.	Red Sandy Soil	343	75	21	5	5	3	5	4
2.	Laterite soil	273	39	9	14	3	2	3	5
3.	Forest soil	441	71	16	18	5	2	5	2

of soils for sorption and desorption of phosphate is laterite soil $<$ Forest soil $<$ Red sandy loam soil and for potash is forest soil $<$ Red sandy loam $<$ laterite soil.

4.3: SELECTIVE DISTRIBUTION STUDIES :

Ability of soils to distribute the added phosphate and potash among the various forms is revealed and most predominant forms to which the added fertilizer gets bound are indexed.

4.31: PHOSPHATE DISTRIBUTION :

In all the three soils most of the added phosphate is bound with Alluminium (Al-p) highest being for red sandy loam (65%) and lowest for Forest soil the data on quantities of distributed phosphate to various forms are depicted in the table (7).

It can be seen from the table that there is gradual decrease in the distributed phosphate in the order as Al-p, SB-p, Fe-p and Ca-p for laterite and forest soils. However for red sandy loam soil, Fe-p was dominant than SB-p. Calcium bound phosphate being lowest in all the three soils ranging from 4 to 6% of the total adsorbed phosphate.

4.32 : DISTRIBUTION OF POTASSIUM :

In all three soils added potassium is retained as water saluble potassium ranging from 245 to 355 $\mu g/g$. The quantities of potassium distribution among the water soluble, calcium chloride extractable, exchangeable or ammonium acetate extractable and fixed or boiling nitric acid extractable are presented in the table (8). Percent of potassium distributed

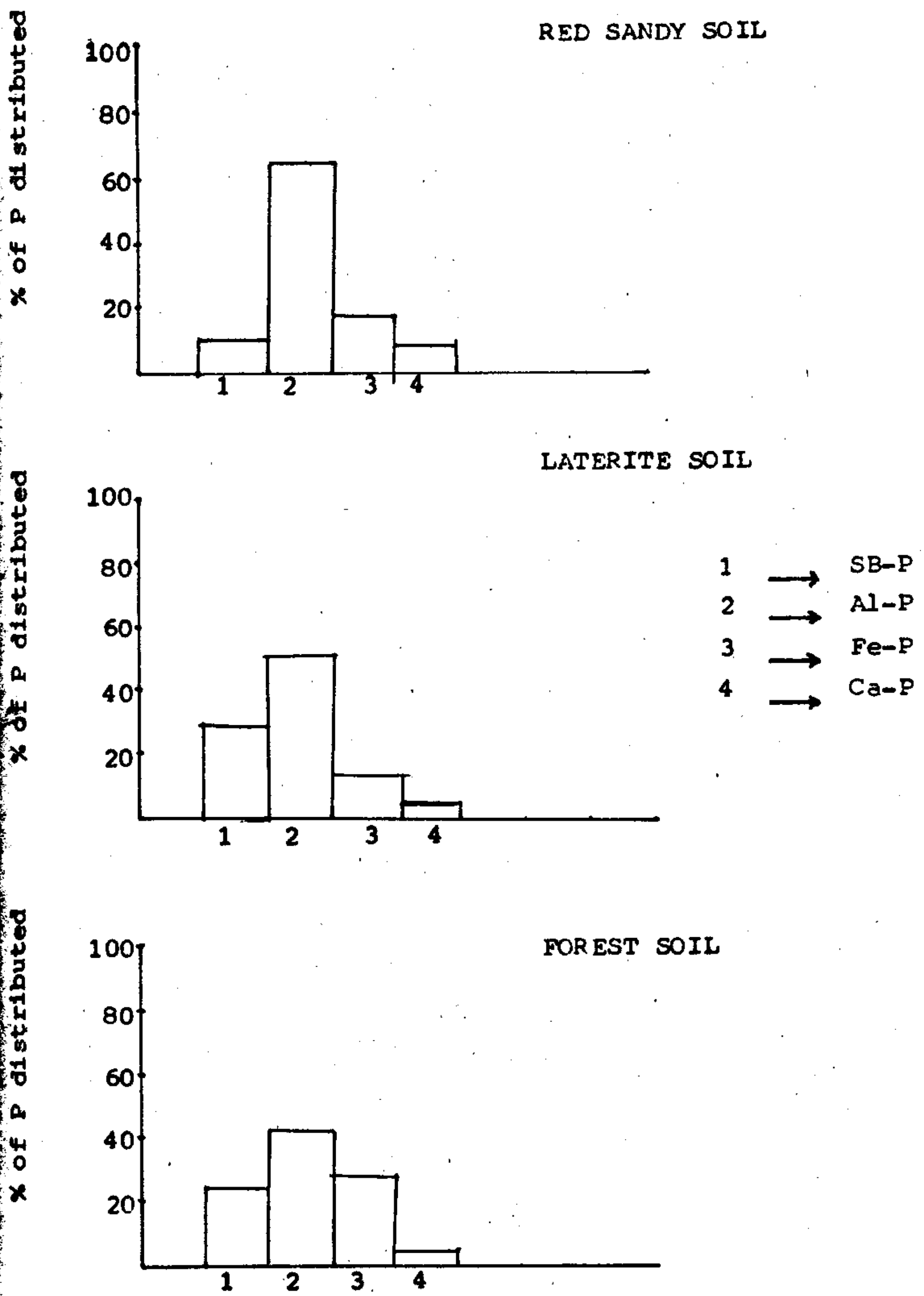


FIG.IX. PERCENTAGE DISTRIBUTION OF ADSORBED P IN DIFFERENT FRACTIONS IN DIFFERENT SOILS

TABLE-7

SELECTIVE DISTRIBUTION OF PHOSPHATE IN DIFFERENT SOILS

Soil No.	Soil type	Phosphate added initially 5000 µg/g Phosphate distributed as µg/g.			
		SB-P	Al-P	Fe-p	Ca-p
1.	Red Sandy soil	339	2257	650	216
2.	Laterite soil	573	978	249	99
3.	Forest Soil	935	1746	1201	183

in the various forms are shown in the figure (10).

Red sandy loam soil shows maximum distribution of potassium in all the forms than the other two soils. About 50% of the potassium is found to be water soluble 30% as calcium chloride extractable, 15% as exchangeable and 6% as fixed potassium.

Like Red sandy loam soil, laterite soils also shows maximum distribution of potassium as a water soluble but quantity is lower than the red sandy soil and higher than forest soil. Calcium chloride extractable potassium is comparatively higher than the red sandy soil but lower than the forest soil percent of Exchangeable potassium in sandy and laterite soils did not differ markedly whereas forest soil retained maximum potassium in the exchangeable form. The quantity of fixed potassium ranged from 4 to 6% of the total adsorbed potassium though there is not much difference in the quantity of fixed potassium among the three soils it is higher in red sandy loam followed by laterite and forest soils.

Unlike Red sandy and laterite soils, Forest soil has very low quantity of water soluble potassium and high percentage of calcium chloride extractable and exchangeable potassium. Percent of fixed potassium is lowest than the other two soils.

In general, quantity of potassium distributed in the decreasing order is water soluble > Calcium chloride extractable> exchangeable or Ammonium Ac extractable > fixed or boiling Nitric acid extractable for Red Sandy loam and laterate soils. For Forest soil, calcium chloride extractable potassium is dominant followed by water soluble, exchangeable and fixed potassium.

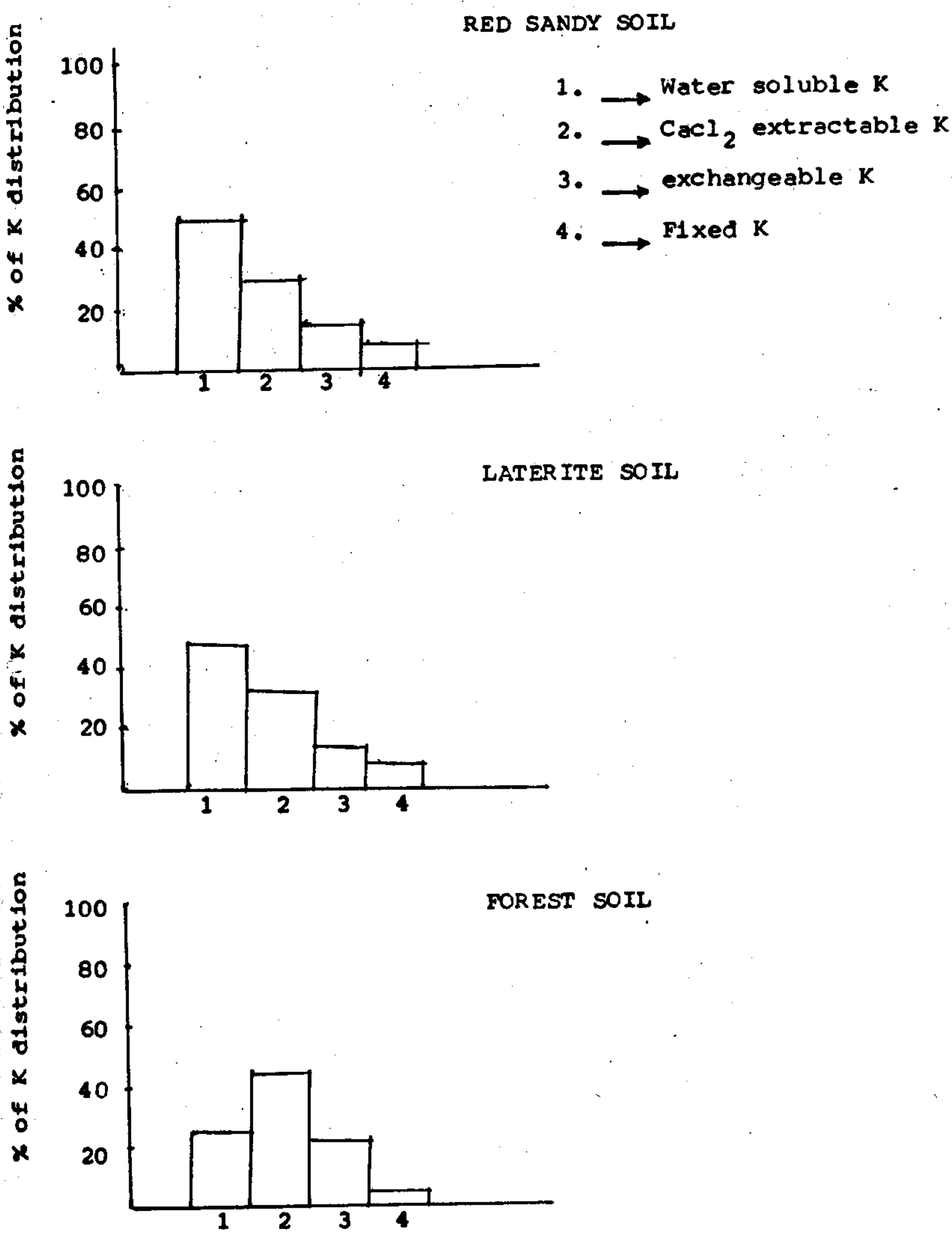


FIG. X. PERCENTAGE DISTRIBUTION OF ADSORBED K INTO DIFFERENT FRACTIONS IN DIFFERENT SOILS

TABLE-8

SELECTIVE DISTRIBUTION OF POTASSIUM

IN DIFFERENT SOILS

Soil No.	Soil type	Potassium added initially 7500 μg/g Potassium distributed as μg/g			
		Water Saluble	0.1M $CaCl_2$	1N NH_4Ac	1N Boiling HNO_3
1.	Red Sandy soil	356	211	111	46
2.	Laterite soil	250	166	74	30
3.	Forest Soil	245	401	198	43

4.4 INFLUENCE OF WITHHOLDING NUTRIENTS ON THE OILPALM SEEDLINGS :

4.4.1: Effect of Withholding the nutrients on the growth of the oilpalm seedlings :

Growth of the seedlings is effected by nitrogen when the nutrient solution was lacking from nitrogen. Vertical growth and leaf production is very low as compared to control plants where all the nutrients were available. After five months the vertical growth stopped completely and symptoms of nitrogen deficiency are observed. Leaves turning yellow through pale green are developed which are associated with nitrogen deficiency. The datas of vertical growth and leaf production are presented in the table (9). The symptoms of nitrogen deficiency are shown in the Plate-I. Lack of phosphorous in the nutrient solution also decreased the vertical growth and leaf production compared to control and other treatments except second one which was lacking from nitrogen. Though there is a decrease in the vertical growth and leaf production, it did not stop completely as in the case of nitrogen. It can be seen that growth is satisfactory till fifth month but thereafter rapid decrease in the growth rate when the nutrient solution was lacking from phosphorous. Potassium deficiency in oilpalm seedlings is also found to affect the growth and leaf production. As can be seen from the table that growth rate was not that rigorus at the beginning but constant increase in the rate of growth is observed after few months. Calcium, magnesium and zinc did not show any marked effect on the growth rate and leaf production. The growth rate however exceeded in the treatments where nutrients calcium and zinc were not available than in the case of control treatment.

PLATE-1:- EFFECT OF WITHHOLDING NITROGEN ON THE OILPALM SEEDLINGS (NITROGEN DEFICIENCY).

TABLE-9

INFLUENCE OF WITHHOLDINGS THE NUTRIENTS ON THE GROWTH OF OILPALM SEEDLINGS

Treatment	3rd Month		4th Month		5th Month		6th Month		7th Month	
	Number of leaves	Height (cm)	Number of leaves	Height (cm)	Number leaves	Height (cm)	Number of leaves	Height (cm)	Number of leaves	Height (cm)
All Nutrients	6	36	7	42	7	42.5	8	44	8	45.5
-N	5	32	6	33	6	33	7	33	7	33.5
-P	5	30	6	33	6	34	7	35	7	37
-K	5	33	6	37	6	40	7	44	7	45.5
-Ca	6	33	7	39	7	41	8	46	8	46.5
-Mg	6	34	7	37	7	40	8	43	8	45.5
-Zn	6	34	7	38	7	43	8	47	8	49.0

.42 : INFLUENCE OF WITH HOLDING THE NUTRIENTS ON THE PRODUCTION OF DRY MATTER :

The Dry matter production of shoot is ranging from 9.37 to 8.63 g. lowest being in the case of nitrogen deficient seedlings. owever the Dry matter produced was greater in treatment where alcium was not available to the plants than that in treatment ith all the nutrients. The results are significant (4.73) at % level. Dry matter production in the treatment lacking from hosphorous is next highest to that in the case of nitrogen ollowed by Dry matter of the treatments without zinc, magnesium, otassium and calcium.

Dry matter of roots in the oilplam seedlings did not show ny significant variation among different treatments. Dry matter anged from 4.32 to 6.42 g. Lowest being where nitrogen was not pplied. However dry matter produced was less in all the treatments han that of treatment receiving all the nutrients. Total Dry matter roduced was also significant (6.40) at 5% level. It is ranging rom 13.69 to 25.11 g. lowest being in the case of nitrogen eficient treatment and highest in the full nutrient. Unlike the ry matter of shoot, total Dry matter of plants in any of treatments id not exceed that of the normal. Total dry matter produced ncreased in the order of treatments lacking from nitrogen, hosphorous, zinc, magnesium, potassium, calcium, normal. The esults of dry matter production are summarised in the table (10).

4.3: INFLUENCE OF WITHHOLDING THE NUTRIENTS ON THE TOTAL UPTAKE OF NUTRIENTS BY OILPALM SEEDLINGS :

Nitrogen phosphorous and potassium uptake as effected by ifferent withholding of nutrients by the oilpalm seedlings are eported in the table (11).

TABLE-10

INFLUENCE OF WITHHOLDING THE NUTRIENT ON THE DRY MATTER PRODUCTION OF OILPALM SEEDLINGS (Gms.)

Treatments	Shoots	Roots	Total Shoot + Root
All Nutrients	18.59	6.42	25.11
-N	9.37	4.32	13.69
-P	13.77	5.50	19.28
-K	16.50	5.23	21.74
-Ca	18.63	6.23	24.80
-Mg	15.60	5.73	21.33
-Zn	15.29	5.91	21.21
C.D. (5%)	4.73*	-	6.40*

*Significant at 5% level

(i) NITROGEN :

Uptake of nitrogen ranged from 56.82 to 268.7 mg. Nitrogen uptake is reduced to 1/5th of the normal when it was lacking from the nutrient in solution by shoots. However uptake by shoots exceeded than that of normal in the treatments where potassium, calcium and magnesium were withholded. The results are significant (68.57) at 1% level. It is also observed that phosphorus deficiency reduced uptake of nitrogen by Oilpalm shoots.

Unlike shoot, uptake of nitrogen by roots in various treatments is lower than that of the normal, it is ranging from 22.66 to 58.81 (Mg). Nitrogen uptake by roots was reduced to half where it was lacking in the growth media. Phosphorous deficiency also reduced uptake of nitrogen by the Oilpalm roots. Potassium, calcium, Magnesium and zinc deficiency did not effect the uptake of nitrogen by roots.

Total uptake of nitrogen by seedlings reduced to 1/4th of normal when it was not contained in the nutrient solution. The results are significant (86.39) at 1% level. The total uptake ranging from 79.49 to 314.80 Mg. Nitrogen uptake in total by plants also reduced by phosphorus to 204.73 mg. and zinc 290.93 mg. deficiencies. However seedlings with potassium, calcium and Magnesium have very little effect on the total uptake of nitrogen.

(ii) PHOSPHOROUS : Phosphorous uptake by shoots of Oilpalm seedlings is reduced to 1/3rd of normal as can be seen from the table (11). Phosphorous uptake of shoots ranged from 14.08 to 42.25 mg., and data are significant (14.30) at 1% level. Nitrogen

TABLE-11

INFLUENCE OF WITHHOLDING THE NUTRIENTS ON THE TOTAL UPTAKE OF NUTRIENTS BY OILPALM SEEDLINGS (N, P, K, Mgm/POT OF 3 SEEDLINGS)

Treatments	NITROGEN			PHOSPHOROUS			POTASSIUM		
	Shoots	Roots	Total	Shoots	Roots	Total	Shoots	Roots	Total
All Nutrients	246.97	58.81	314.80	42.25	10.03	48.71	148.57	45.67	194.23
-N	56.82	22.66	79.49	21.33	8.17	29.50	68.30	48.29	116.57
-P	158.60	45.71	204.73	14.08	3.93	18.02	91.48	44.60	135.97
-K	255.07	53.03	308.11	39.63	5.60	48.68	39.20	15.92	55.11
-Ca	268.70	56.40	325.03	38.20	8.23	46.36	161.53	46.24	207.74
-Mg	250.10	57.82	305.87	39.03	9.80	48.83	173.77	37.99	211.71
-Zn	239.43	51.68	290.93	36.86	7.20	44.04	167.03	41.57	207.97
C.D. (5%)	68.57**	19.63*	86.39**	14.30**	--	18.09*	49.44**	--	64.62**

*Significant at 5% level

**Significant at 1% level

deficiency is found to decrease the uptake of phosphorous in shoots to about half of the normal. Though potassium, calcium, Magnesium and zinc deficiencies decreased the uptake of phosphorous quantitatively, the difference is not significant.

Phosphorous uptake by roots was decreased to 1/3rd when it was not available in the growth media. Eventhough phosphorous uptake of Oilpalm roots found to be decreased when the media was lacking from various nutrients in accordance with the treatments. The decreasing effects did not show any significant variation.

Unlike phosphorus uptake by shoots and roots of Oilpalm seedlings, total uptake showed varying effects with different treatments. It is found to exceed in the plants with magnesium deficiency (48.83 Mg) than that in the normal. The total uptake of phosphorous reduced below half in the phosphorous deficient treatment and to about half in the Nitrogen deficient treatment.

(iii) <u>POTASSIUM</u>:- Results of potassium uptake by shoots varied significantly (49.44) at 1% level. The uptake is reduced to about 1/4th of potassium content of normal (148.57) in treatment where potassium was not applied and to below half where nitrogen was not applied and to about half when phosphorous was lacking from the growth media. But uptake is increased in the treatments where calcium (161.53 mg.). Magnesium (173.72 mg.) and Zinc (167.03 mg.) were not available. Highest uptake of potassium is observed where Magnesium is deficient followed by treatments lacking from zinc and calcium.

Results of potassium uptake by roots of Oilpalm seedlings did not vary significantly though it is reduced to 1/3rd in seedlings lacking from potassium in the nutrient solution, but there is no remarkable difference among the other treatments.

Like shoots total potassium uptake is found to be greater in the seedlings where calcium, magnesium and zinc were lacking. It is reduced to about 1/4th of the normal in the case where the plant were suffering from potassium deficiency. The total uptake of potassium varied from 55.11 to 211.71 mg, lowest being in the treatment deficient of potassium. Calcium, Magnesium and zinc deficiencies enhanced the total uptake of potassium as indicated by the results. The highest uptake of potassium is associated with the Oilpalm seedlings having no supply of Magnesium (211.71 mg.). The results of potassium uptake with different treatments varied significantly (64.22) at 1% level.

iv) <u>CALCIUM</u> :- Results of calcium uptake by shoots with different treatments varied significantly (9.76) at 1% level. Calcium uptake reduced to ½ of the normal in the seedlings deficient in calcium. The uptake is found to be greater in the potassium deficient plants than that of the normal palms. Quantitative uptake by shoots is found to be a same in the seedlings deficient with phosphorus (10.35 mg) and normal

(10.55 mg.). However, Calcium uptake was reduced in the Oilpalms deficient in nitrogen (7.24 mg) magnesium (6.73 mg.) and zinc (5.09 mg).

Calcium taken up by roots also varied significantly (0.84) at 1% level as can be seen from the table (12). It is ranging from 1.77 to 3.41 mg. As in the case of shoot, uptake of calcium by roots is enhanced when the seedlings were lacking from Potassium (3.11 mg). The uptake also enhanced when magnesium (2.41 mg), Zinc (2.28 mg) and nitrogen (2.37 mg.) were excluded in the soil.

Total calcium taken up by seedlings did not show any significant variation. It is ranged from 6.37 to 21.62 mg., highest being in the magnesium deficient plants. It is found to be greater in the treatments lacking from Magnesium (21.62 mg) and potassium (18.27 mg.) then the normal (12.58 mg.)

(v) MAGNESIUM : Data on magnesium uptake by Oilpalm shoots, are summarised in the table (12) which are found to significant (2.74) at 1% level. It is ranged from 16.79 to 52.13 mg. It can be seen that Magnesium uptake is reduced when zinc was not supplied (16.79 mg) then in the case of plants with magnesium (17.07 mg.) with holded nutrient. Magnesium uptake is found to be enhanced when potassium (52.13 mg.) was not available compared to normal (36.24 mg.) plants. Magnesium uptake is also greater in the potassium deficient (48.45 mg.) seedlings but the quantity is lower then in the case of potassium deficient treatment. The uptake did not differ much in nitrogen deficient (36.46 mg.) and in calcium (30.31 mg.) deficient treatments.

TABLE-12

INFLUENCE OF WITHHOLDING THE NUTRIENTS ON THE UPTAKE OF NUTRIENTS BY OILPALM SEEDLINGS (Ca, Mg, Fe)/POT OF 3 SEEDLINGS

Treatments	CALCIUM			MAGNESIUM			IRON		
	Shoots (mg)	Roots (mg)	Total (mg)	Shoots (mg)	Roots (mg)	Total (mg)	Shoots (mg)	Roots (mg)	Total (mg)
All nutrients	10.55	2.03	12.58	36.24	7.98	44.22	3.55	0.2333	3.77
-N	7.24	2.37	9.60	36.46	7.42	26.33	2.42	0.1066	2.55
-P	10.35	2.12	12.47	28.45	7.86	36.31	5.22	0.1100	5.33
-K	15.15	3.11	18.27	52.13	7.72	59.81	3.02	0.108	3.13
-Ca	4.79	1.77	6.57	30.31	8.98	43.24	3.68	0.1293	3.81
-Mg	6.73	2.41	21.62	17.07	5.09	22.16	4.01	0.1090	4.19
-Zn	5.09	2.28	7.37	16.79	6.05	22.86	3.09	0.1883	3.28
C.D. (5%)	9.76**	0.84**	--	37.03**	2.74**	--	2.45*	0.9970**	--

*Significant at 5% level
**Significant at 1% level

Magnesium taken up by roots of Oilpalms ranged from 5.09 to 8.98 mg. significantly (2.74). The high uptake of magnesium is associated with the palms deficient in calcium (8.98 mg) then that for the normal (7.98 mg) plants. Unlike, shoots, the uptake did not exceed by the roots of plants deficient in potassium and phosphorous. Results of total uptake of Magnesium are not found to be significant. In general it can be seen from the data that total uptake of Magnesium is higher than the normal when potassium was excluded from the composition of nutrient solution.

vi) IRON : Results of Iron uptake by shoot are depicted in the table (12) and found to be significant (2.45) at 5% level. The values of iron uptake by plant shoots varied from 2.42 to 5.22 mg. It can be seen from the results that nitrogen deficiency in plants reduced the iron uptake whereas it is increased in absence of phosphorous and also to some extent in absence of magnesium and calcium.

Uptake of iron by roots is found to be more significant (99.70). Like shoots, none of the treatments showed high uptake of iron than that in normal. However it can be seen from the results that uptake by roots enhanced to some extent in plants lacking from zinc. There is not much difference in the uptake of iron in various treatments.

Though total uptake of iron found to be more in phosphorous, Magnesium and calcium deficient Oilpalms. The result did not show any significant variation.

(vii) COPPER :- Data of copper taken up by shoots, roots and total are presented in the table (13). Copper uptake are not found to be significant. One can see from the table that nitrogen deficient Oilpalm seedlings showed minimum uptake whereas it is higher in the plants with calcium and Magnesium deficient treatments.

(viii) ZINC :- The results of quantity of zinc taken by shoots and roots are not found to be significant and are ranging from 224 to 444 µg in shoots and 151 to 322 µg in roots. The uptake of zinc in shoot as well as in roots is highest in magnesium deficient plants.

Total uptake of zinc showed significant variation (236.23) at 5% level. Non-availability of magnesium to the plants enhanced the uptake of zinc whereas it is reduced to minimum quantity when plants were deficient in nitrogen. In the treatment without zinc showed uptake more than that in the normal.

(ix) MANGANESE :- Like copper Manganese uptake also did not show any significant variation in Oilpalm. The quantity of Manganese uptake ranged from 2188 to 4478 µg and by shoots 2750 to 4826 µg by roots. Nitrogen deficiency resulted in the accumulation of manganese in the roots whereas Magnesium deficient plants accumulated more manganese in shoots. The total uptake of manganese is found to high in the potassium deficient plants.

4.4.4: INFLUENCE OF WITHHOLDING NUTRIENTS ON THE NUTRIENT CONTENT OF OILPALM SEEDLINGS :

Percentage composition of different nutrients as shown in

TABLE-13

INFLUENCE OF WITHHOLDING THE NUTRIENTS ON THE UPTAKE OF NUTRIENTS BY OILPALM SEEDLINGS (Cu, Zn, Mn, µg/pot of 3 seedlings)

Treatments	COPPER			ZINC			MANGANESE		
	Shoots	Roots	Total	Shoots	Roots	Total	Shoots	Roots	Total
All nutrients	233.33	1834.67	2058.00	410.00	235.67	645.67	3524.33	3303.67	6828.00
-N	81.33	1063.67	1145.00	224.67	151.00	375.67	2188.33	4826.33	6005.00
-P	143.00	801.67	944.67	242.67	227.67	470.34	2943.33	2898.33	5841.67
-K	255.00	1798.00	2053.00	397.67	226.67	624.33	3794.00	4191.33	7985.33
-Ca	257.67	1967.00	2224.67	347.33	219.33	566.67	3971.67	3222.00	7193.33
-Mg	264.67	1875.67	2140.33	444.33	322.67	767.00	4478.33	3654.33	8133.00
-Zn	493.33	1853.67	2347.00	369.67	238.33	608.00	3300.67	2750.67	6051.33
C.D. (5%)	--	--	--	--	--	236.23*	--	--	--

*Significant - at 5% level

in accordance with the various treatments are shown in the table (14).

(i) NITROGEN :- Withholding of nitrogen resulted in the reduction of nitrogen content of shoot to about 50%. Percentage composition of nitrogen resulted in the significant variation (0.216). Percentage of nitrogen content increased in the plants deficient in magnesium, potassium and calcium. High content of nitrogen is associated with magnesium deficiency as can be seen from the table (14). Phosphorous deficiency is also found to decrease the nitrogen content.

Nitrogen content of shoots varied from 0.0227 to 0.0588%. It is reduced to half of the normal where nitrogen was excluded from the treatment. Phosphorous is also effected the content of nitrogen in the roots of Oilpalm. Unlike shoot, nitrogen content in any treatment did not exceed the composition of normal plants. In general percentage composition of nitrogen in shoot of Oilpalm seedlings showed marked change.

(ii) PHOSPHOROUS:- Exclusion of phosphorous in the growth media reduced its content in the shoots below 50%. It is ranging from 0.1063 to 0.2512 with the significance (0.0691) at 1% level. Highest accumulation of phosphorous in shoots is observed (0.2512%) where there was no supply of magnesium. It is also enhanced in the treatments with no potassium, zinc and nitrogen. However its composition is lowered in the shoots of plants where supply of calcium has been withholded.

TABLE-14

INFLUENCE OF WITHHOLDING NUTRIENTS ON THE NUTRIENT CONTENT IN SHOOT AND ROOT OF OILPALM SEEDLINGS (N, P, K %)

Treatment	NITROGEN		PHOSPHOROUS		POTASSIUM	
	Shoots	Roots	Shoots	Roots	Shoots	Roots
All Nutrients	1.3720	0.0588	0.2249	0.1533	0.7933	0.7050
-N	0.6067	0.0227	0.2327	0.1901	0.7333	1.1033
-P	1.1387	0.0457	0.1063	0.0720	0.6633	0.8033
-K	1.5253	0.0530	0.2467	0.1728	0.2367	0.3033
-Ca	1.4467	0.0564	0.2045	0.1340	0.8700	0.7600
-Mg	1.6147	0.0578	0.2512	0.1696	1.1133	0.6533
-Zn	1.5587	0.0517	0.2335	0.1191	1.0800	0.6967
C.D. (5%)	0.2016**	0.0196*	0.0691**	0.0368**	0.1404**	0.1746**

*Significant at 5% level

**Significant at 1% level

The prosphorous content in the root in the range of 0.0720 to 0.1901%. Its content is reduced to below 50% of normal plants when no phosphorous was supplied. But nitrogen deficient plants showed high acmulation of phosphorous in the roots. Plants with no supply of potassium and Magnesium also accumulated phosphorous in the roots but relatively lower then in the case of nitrogen.

(iii) POTASSIUM :- Potassium content of shoot is reduced to below 1/3rd in the plants without its supply. Deficiencies of phosphorous and nitrogen have seem to decrease the potassium content of shoot. Further, the data revealed that there is high content of potassium associated with magnesium, zinc and calcium deficient plants; highest percentage is found in shoots of Oilpalm seedlings with no supply of magnesium (1.1133%).

Unlike shoots there is high content of potassium is found to be associated with nitrogen and phosphorous deficient roots. Calcium deficiency also resulted in the increase of potassium content of roots. The variation in potassium content of roots is found to be significant (0.1746) at 1% level. When there was no supply of potassium, its percentage composition is reduced to one half of the normal plants. However plants without supply of magnesium and zinc showed a decrease in the potassium content of roots.

(iv) CALCIUM :- Calcium content of shoots in the various treatment did not show significant variation. It is ranging from 0.0255 to 0.1207% highest content of calcium being associated with magnesium deficient plant. Unlike shoots calcium content of roots is found to be significant (0.0139) at 1% level. The content is ranging from 0.0288 to 0.0612% highest content is associated with the roots of potassium deficient plants. Percentage composition of calcium is reduced when it was not included in the nutrient solution. It is seen that nitrogen deficiency and magnesium deficiency resulted in the accumulation of more of calcium in the roots.

(v) MAGNESIUM:- Data of Magnesium content of shoots are not of significance. Magnesium content did not show any variation in different nutritional treatments.

Results of root magnesium content had shown significant effect (0.0341). It can be seen from the table (15) that magnesium content of roots is reduced to about 50 percent to that of the normal where it was excluded from the nutrient solution.

Magnesium is found to be influenced highly by nitrogen deficiency in the plants and to some extent by calcium potassium and phosphorous deficiencies. Variation in percentage composition of magnesium in the roots of above deficiencies is not much but differ markedly from that of nitrogen deficiencies. While non-availability of zinc for plants seems to reduce the magnesium content of roots well below the normal plants.

(vi) IRON :- Iron was not shown significant variation among various treatments. Its percentage composition in shoots ranged from 182 to 411 ppm. It is seen that high content is associated with shoot having lack of phosphorous. However

TABLE-15

INFLUENCE OF WITHHOLDING THE NUTRIENTS ON THE CONTENT OF SHOOT & ROOT OF OILPALM SEEDLINGS

(Ca, Mg, Fe)

Treatments	CALCIUM % Shoots	CALCIUM % Roots	MAGNESIUM % Shoots	MAGNESIUM % Roots	IRON (ppm) Shoots	IRON (ppm) Roots
All nutrients	0.0568	0.0330	0.1932	0.1278	191	35
-N	0.0735	0.0540	0.1898	0.1709	254	25
-P	0.0817	0.0384	0.2210	0.1441	411	19
-K	0.0887	0.0612	0.3080	0.1492	182	21
-Ca	0.0255	0.0288	0.1620	0.1483	196	22
-Mg	0.1207	0.0426	0.1078	0.0871	252	19
-Zn	0.0306	0.0390	0.1021	0.1016	201	30
C.D. (5%)	--	0.0139**	--	0.0341**	--	--

**Significant at 1% level.

Magnesium, zinc and nitrogen deficiencies are also influencing the content of shoot iron in Oilpalm seedlings. Unlike shoots, roots have not shown high content of Iron then that of the normal but the content is found to be low in the roots of phosphorous and magnesium deficient plants.

(vi) COPPER :- Copper content of shoots of Oilpalm seedlings in various treatment ranged from 5 to 17 (ppm) and significant (5) at 1% level. The result shows that nitrogen and Magnesium have greater effect on the copper content of shoots. Nitrogen deficiency greately decreased the copper content whereas magnesium deficiency improved the content. It also found to be influenced by potassium, zinc and calcium deficient treatments. Root content of copper in plants are of not significance, Except phosphorous and nitrogen deficient roots.

(viii) ZINC :- Zinc content of shoots and roots of Oilpalm seedlings are not found to be significant. The shoot content of zinc is ranging from 18 to 37 (ppm) highest being in the phosphorous deficient shoots. Root zinc content ranged from 35 to 55 (ppm). It is found to be highest when there was lack of magnesium in the nutrient media.

(ix) MANGANESE:- Manganese content also had no significant variation among the different treatments given to the seedlings. Shoot Manganese content varied from 184 to 287 ppm

TABLE-16

INFLUENCE OF WITHHOLDING NUTRIENTS ON THE NUTRIENT CONTENT IN SHOOT AND ROOT OF OILPALM SEEDLINGS (Cu, Zn, Mn, ppm)

Treatments	COPPER		ZINC		MANGANESE	
	Shoots	Roots	Shoots	Roots	Shoots	Roots
All Nutrients	12	294	22	37	184	512
-N	5	243	24	35	236	414
-P	11	147	37	42	217	531
-K	16	342	24	45	229	833
-Ca	14	326	18	35	211	518
-Mg	17	316	29	55	287	630
-Zn	13	319	21	40	218	459
C.D. (5%)	5**	--	--	--	--	--

**Significant at 1% level.

highest content is found in magnesium deficient plants whereas its content is increased in all the deficient treatments then that in normal plants. Root Manganese content ranged from 414 to 833 ppm, its content is found to highest in potassium and Magnesium deficient plants.

4.5: EFFECT OF N,P,K DOSE AND TIME OF APPLICATION ON OILPALM SEEDLINGS :

4.5.1: EFFECT OF DOSE OF N,P,K AND TIME OF APPLICATION ON THE GROWTH AND LEAF PRODUCTION :

Results of growth and leaf production as effected by the various levels of N,P,K dose are presented in the table (17). Time and rate of application effected the growth as well as leaves production of the Oilpalm seedlings. Plants in the treatment without fertilizer application have not shown desired growth. It is enhanced with the increasing the dose when the fertilizer dose was given in every month. At the beginning gms.of 12:12:17 N:P:K ratio per pot per month showed highest growth and leaf production rate but thereafter rate has been decreased. Middle dose i.e., 20 gms. of 12:12:17: N:P:K ratio per pot per month has shown more desirable and constant growth rate throughout the period of investigation when compared to the control and other treatments.

Trimonthly application of fertilizer doses in two cases resulted in the undesirable effects but in one treatment with 30 gms. of 12:12:17, N:P:K per pot per 3 month showed constant increase in the growth rate. Though it was lower then in the treatment with 20gms. of NPK per pot per month, when compared to lowest dose of 10 gms per pot per month. In the highest trimonthly

TABLE-17

EFFECT OF DOSE OF N,P,K AND TIME OF APPLICATION ON THE GROWTH AND LEAF PRODUCTION OF OILPALM SEEDLINGS (PER POT OF THREE SEEDLINGS)

Sl. No.	Dose/Pot of 10 kg. soils(gms)	3rd month		4th month		5th month		6th month		7th month		8th month	
		No.of Leaves	Height (cm)	No.of leaves	Height (cm)	No.of leaves	Height (cm)	No.of leaves	Height (cm)	No.of leaves	Height (cm)	No.of leaves	Height (cm)
1.	0	5	29	6	29.5	6	30.5	6	31.5	6	32	6	32.5
2.	10 (M)	6	39	7	40.5	7	41	8	44.5	8	48.5	8	53.5
3.	20 (M)	6	38	7	41.5	8	45	8	49.5	8	53.	9	59.5
4.	30 (M)	6	39.5	7	40.5	7	42.5	7	44.0	8	47.5	8	50.0
5.	30 (T.M.)	6	34	7	37	7	41.0	8	47.5	8	51.5	8	56.5
6.	60 (T.M.)	5	33.5	5	35	6	35.5	6	36.5	6	38	6	43.0
7.	90 (T.M.)	5	32.5	--	--	4*	33.5*	4	37.0	5	40	5	41.0
8.	**8 (Gms)	6	33	6	34	6	34	6	35	7	38	7	41.5

*Height and leaves of plants after replanting.

**8 Gms. of N:P:K, 15:15:6 dissolved in 5 Ltrs. and applied to 100 seedlings monthly (Normal Dose)

PLATE-2:- EFFECT OF HIGH CONCENTRATION OF N:P:K FERTILIZER APPLIED TRIMONTHLY AT THE RATE OF 90 GMS/SEEDLINGS.

dose the plants were suffering from salt injury due to high salt concentration (Plate 2). This treatment is not seem to be desirable.

A treatment with 8 gms. of NPK mixture (15:15:6) dissolved in 5 litre and equally applying to 100 seedlings shows very slow growth and leaf production rate. It was slightly higher than the plants in control treatment when compared to monthly and trimonthly application of NPK 12:12:17 mixture, it did not seem to be so effective. However, like control, plants in this treatment did not show general yellowing symptom a usual case of nitrogen deficiency.

In general, it can be seen that application of 20 gms. of dose per pot per month showed best response as compared to control, other monthly and trimonthly fertilizer applications and a normal N:P:K 15:15:6 dose of fertilizer. A lowest trimonthly dose was the next to show better response among other. A comparative growth rate of plants in the control, monthly, trimonthly and normal dose of monthly treatments has been presented in the Plate-III.

4.5.2: EFFECT OF DOSE OF NPK AND TIME OF APPLICATION ON THE DRY MATTER PRODUCTION OF OILPALM SEEDLINGS :

Results of dry matter production as effected by graded dose of NPK and time of application are presented in the Table (18). Dry matter production of shoots increased upto 20 gms. of monthly dose of NPK 12:12:17 mixture whereas there is gradual decrease from third graded monthly dose. The dry matter produced ranged from 4.12 to 27.13 gms. It can be seen that the lowest rate of dry matter production in the Quarterly highest dose of fertilizer

PLATE-3:- EFFECT OF GRADED LEVEL OF N:P:K FERTILIZER AND TIME OF APPLICATION ON THE GROWTH OF SEEDLINGS IN COMPARISON WITH CONTROL.

TABLE-18

EFFECT OF DOSE OF N,P,K AND TIME OF APPLICATION ON THE DRY MATTER PRODUCTION OF OILPALM SEEDLINGS (GMS/POT OF THREE SEEDLINGS)

Treatment	Roots	Shoots	Total (Root + Shoot)
T_0	3.3730	7.65	11.0213
T_1	7.5957	21.96	29.554
T_2	12.7803	27.13	39.9077
T_3	9.9460	21.68	31.6310
T_4	9.8847	17.26	27.141
T_5	3.1567	7.20	10.3557
T_6	1.2343	4.12	5.3513
T_7	3.9563	8.78	12.7367
C.D. (5%)	4.2364**	12.13**	15.1716**

**Significant at 1% level

where plants were not surviving. Dry matter of shoots produced as indicated by the normal dose of N:P:K 15:15:6 mixture is little more than that of control plants. When it is compared with lowest monthly dose, medium monthly and lowest quarterly seems to be too low.

Similar trend has been also observed with the dry matter production of root and total dry matter in accordance with graded dose and time of application. Dry matter of roots ranged from 1.23 to 12.78 gms. and significant (4.2364) at 1% level. It is higher in the medium monthly NPK dose thereafter decreasing constantly. Normal monthly dose as in the case of root gave a dry matter only one gram more than the control. Total dry matter production had also been in the same order as in the case of shoots and roots dry matter. It is ranging from 5.35 to 39.90 gms.

In general, medium monthly NPK fertilizer dose seems to be more effective as per the dry matter production is concerned when compared to the other treatments. Quarterly application of lowest NPK dose also seems to be desirable but relatively poorer than monthly applications.

4.5.3: EFFECT DOSE OF NPK AND TIME OF APPLICATION ON THE NUTRIENT CONTENT OF OILPALM SEEDLINGS :

Effect of graded dose of fertilizer had a greater influence on the nutrient composition of Oilpalm seedlings. There were observed an appreciable as well as undesirable effects of fertilizer on the composition and concentration of other nutrients.

i) NITROGEN :- Application of monthly graded dose of fertilizer increased the concentration of nitrogen in the Oilpalm shoot even upto the third level. There observed a marked increase in the nitrogen content from that of control. Increase in the concentration at the third level of treatment is more than three times of control. But the trend is reversed in the quarterly application of graded doses as the concentration is highest in the lowest dose thereafter decreased constantly. Among the three graded levels of monthly application, the concentration is highest in the third treatment of quarterly application, lowest dose of fertilizer showed highest concentration of nitrogen. Between the normal dose of 15:15:6 NPK nd control difference is only 0.2%. No other treatment had shown so much low concentration which is comparable with control.

Like shoots, concentration of nitrogen in the roots also increased with increasing graded monthly dose of fertilizer upto the third level and also the increase in concentration in the third level is more than 3 times of control plants. The quarterly application did not show the same trend as that of shoots. The highest concentration of nitrogen showed by medium quarterly dose and highest rate of quarterly dose. Monthly graded doses when compared with quarterly, lowest quarterly showed higher concentration of nitrogen than that of monthly application. The results of nitrogen concentration of roots with graded dose of fertilizer varied from 0.6907 to 1.8467% (Table 19).

(ii) PHOSPHOROUS:- Data of phosphorous content of shoots of Oilpalm seedlings as effected by graded levels of fertilizer dose and frequency of application are presented in the Table (19). It is ranged between 0.1485 to 0.5401% and is found to increase

TABLE-19

EFFECT OF DOSE OF N,P,K AND TIME OF APPLICATION ON THE NUTRIENT CONTENT OF OILPALM SEEDLINGS (N,P,K % PER POT OF THREE SEEDLINGS)

Treatments Dose/Pot of 10 kg.soil (Gms)	NITROGEN		PHOSPHOROUS		POTASSIUM	
	Root	Shoot	Root	Shoot	Root	Shoot
T_0 (0)	0.6907	0.8167	0.1190	0.1485	0.5600	0.6467
T_1 (10) M.	0.9260	1.9227	0.1445	0.1976	1.0533	1.9333
T_2 (20) M.	1.3160	2.0160	0.1837	0.2226	1.4067	1.9500
T_3 (30) M.	1.8467	2.9493	0.2275	0.2989	1.4000	2.3000
T_4 (30) T.M.	1.0920	2.0160	0.1422	0.1953	1.3867	2.0833
T_5 (60) T.M.	1.2320	1.9787	0.1723	0.2058	1.0533	1.7000
T_6 (90) T.M.	1.1200	1.5493	0.1657	0.5401	0.9917	1.9833
T_7 Normal M	0.6947	1.0267	0.1122	0.1499	0.5500	0.6500
C.D. (5%)	0.2346**	0.7278**	0.0511**	0.1056**	0.3711**	0.4473**

**Significant at 1% level.

with the graded levels of monthly application. The highest percentage is associated with the third level of monthly application. The increase in prosphorous content is about two times of control plants. It also increased with the increasing dose of fertilizer in the quarterly application. However lowest and medium quarterly doses showed low percentage composition of phosphorous when compared to lowest and medium application but the highest fertilizer dose applied at every three months resulted in the highest phosphorous content than any other treatments. It is about 0.4% higher than control treatment. Among all the treatments normal dose of fertilizer showed quite low phosphorous content which is only about 0.0014% and on part with control.

Root phosphorous content is also found to increase with graded levels of fertilizer dose when plants are fertilized every month. Data of phosphorous contents are ranged from 0.1122 to 0.2275%. The increase in the content is about two times than that of control as in the case of shoot phosphorous. Trimonthly application of fertilizer dose had a decreasing trend of phosphorous content of Oilpalm roots.

(iii) POTASSIUM :- Results of potassium content of shoots of Oilpalm seedlings are presented in the Table (19). Monthly application of graded dose increased the potassium content in the Oilpalm shoot and the highest dose dose recorded about 2% of potassium. However, the quarterly applications lowest rate contained high potassium followed by the treatments with high and medium dose.

The normal dose of 15::15:6 NPK mixture did not increase the potassium level to required extent as it is found to be almost equal to control. None of the treatments resulted in such a low content of potassium in plant shoot. The potassium content of shoots are ranging from 0.6467 to 2.3%. Content being highest in the monthly highest dose of fertilizer applications.

Potassium content of plant roots varied from 0.55 to 1.4067%. Unlike shoots, root potassium content of Oilplam decreased with increasing dose of monthly fertilizer. Among the monthly applications medium dose showed highest content and is about 1.0%. Quarterly application of fertilizer dose also decreased the potassium concentration with increasing level of fertilizer. Among three quarterly, lowest treatment resulted in high concentration. Among three monthly and quarterly treatments, potassium content is lower in medium and highest quarterly. In the normal dose of NPK root potassium concentration is found to be lower than that of control by about 0.01%.

(iv) CALCIUM :- Results of calcium content of Oilpalm shoot varied in accordance with different rate and time of application (Table 20). It is ranging from 0.0166 to 0.1195%. Monthly application of graded dose decreased the calcium content with increasing level of NPK. The content in all the three treatments is lower than that of control and it is more in the treatment with lowest dose. It is also found to increase with rate of fertilizer in the quarterly treatments except at the highest rate where the

TABLE-20

EFFECT OF DOSE OF N,P,K AND TIME OF APPLICATION ON THE NUTRIENT CONTENT OF OILPALM SEEDLINGS (Ca, Mg, Fe PER POT OF THREE SEEDLINGS)

Treatments Dose/Pot of 10 kg.soil (Gms)	CALCIUM % Root	CALCIUM % Shoot	MAGNESIUM % Root	MAGNESIUM % Shoot	IRON (ppm) Root	IRON (ppm) Shoot
T_0(0)	0.0450	0.0805	0.0951	0.1411	4.1	34.4
T_1(10) M.	0.0306	0.0524	0.0876	0.1609	4.6	28.4
T_2(20) M.	0.0258	0.0409	0.0650	0.1069	4.7	26.0
T_3(30)M.	0.0246	0.0166	0.0610	0.0392	5.3	30.4
T_4 (30) T.M.	0.0270	0.0249	0.0878	0.0639	4.7	26.2
T_5(60) T.M.	0.0354	0.0326	0.0805	0.0669	5.0	35.1
T_6(90) T.M.	0.0399	0.0920	0.0831	0.1253	5.5	33.1
T_7Normal M	0.0492	0.1195	0.1323	0.1978	4.1	31.7
C.D.(5%)	0.0130**	0.0664*	0.0213**	--	0.8*	--

*Significant at 5% level

**Significant at 1% level

content increased to about 0.01% to that of control. It has increased about 4 times that of the lowest quarterly and 3 times that in medium dose. Unlike Nitrogen, potassium, phosphorous, calcium content is found to be more in the normal fertilizer treatment. This treatment showed highest content of calcium than the other monthly and quarterly application.

Like shoot, the content of calcium in the roots also decreased with increasing rate of fertilizer in monthly application. The content in three treatments, however is lower than that in control by about 0.01 to 0.02%. It also increased with the increasing dose of quarterly application. The concentration of calcium in the roots is highest in the normal dose of fertilizer treatment followed by control. It is about 0.0042% more than the control in the normal dose.

(v) MAGNESIUM:- The concentration of Magnesium in the shoots of Oilpalm seedling did not show significant variation. It is in the range of 0.0392 to 0.1978%. Its content is highest in the normal dose. In general its concentration decreases with increasing rate of monthly application and increases with the increase in the rate of quarterly fertilizer dose (Table 20).

The root magnesium content is found to be highly significant (0.0213) at 1% level. The concentration of magnesium gradually decreased with the increasing rates of fertilizer at every months. The decrease in the concentration in the highest rate of fertilizer is by about 0.02% than in the lowest rate and about 0.03% to that of control. Trimonthly application of fertilizer dose at the graded levels showed increase in the concentration of magnesium except at the lower rate. Normal dose showed greater increase in the concentration of Magnesium from that of control and other treatments of fertilizer. The increase in the plants with normal dose of fertilizer is by about 0.04% over control.

(vi) IRON:- Shoot content of Iron in Oilpalm seedlings is not found to be significant as seen from the table (20). It showed variation among different treatments. Graded doses of application had significant effect on the root Iron content. It increases with the increasing the rate of fertilizer in monthly and trimonthly frequency. The rate of increase of concentration with graded dose is relatively more in trimonthly application than in monthly application. Control plants and those with normal fertilizer dose recorded almost the same concentration of Iron content in roots. When compared to various treatments, content is lowest in the roots of plants grown in normal dose and without fertilizer.

(vii) COPPER :- Copper content of Oilpalm shoots in accordance with graded dose of fertilizer ranged from 1.7 to 2.3 ppm (Table 21). The Concentration of copper decreases with the graded dose of monthly fertilizer application. The treatment of lowest monthly dose showed more content whereas those with highest monthly dose recorded lowest content than the control plants. It also found to decrease in two of the three quarterly application. Seedlings in the treatment with normal dose also showed high content of copper than in other treatments.

Root copper content of seedlings varied from 26.8 to 76.6 ppm

TABLE-21

EFFECT OF DOSE OF N,P,K AND TIME OF APPLICATION ON THE NUTRIENT CONTENT OF OILPALM SEEDLINGS (Cu, Zn, Mn, ppm PER POT OF THREE SEEDLINGS)

Treatments Dose/Pot of 10 kg.soil (Gms)	COPPER		ZINC		MANGANESE	
	Root	Shoot	Root	Shoot	Root	Shoot
T_0 (0)	26.8	1.7	4.7	2.1	119.0	20.3
T_1 (10) M.	76.6	2.1	6.4	2.4	218.8	56.1
T_2 (20) M.	51.8	1.9	5.5	2.3	315.7	64.9
T_3 (30) M.	41.8	1.7	5.4	2.3	457.4	79.4
T_4 (30) T.M.	33.5	1.9	4.6	2.2	257.0	45.4
T_5 (60) T.M.	31.0	1.4	18.9	1.8	405.4	45.2
T_6 (90) T.M.	53.7	2.3	3.8	2.6	362.7	39.1
T_7 Normal M	39.3	2.3	3.1	2.5	147.3	24.1
C.D. (5%)	17.8**	0.5*	--	--	102.3**	23.3**

*Significant at 5% level.

**Significant at 1% level.

which is significante at (17.8) 1% level. Control plants showed very low content of copper compared to monthly application. The content of copper is highest in the treatment with lowest dose. In the treatments where fertilizer was applied quarterly, content decreased gradually in the lowest and medium dose whereas in highest rate it has increased. Normal dose of fertilizer eventhough increased copper concentration of roots, the increased quantity is significantly low than that of monthly applications.

(viii) ZINC :- Application of NPK in graded dose and with different frequencies did not find any significant effect on the zinc content of roots and shoots of Oilpalm seedlings. Concentration of zinc in shoots is ranged from 1.8 to 2.6 ppm and in roots from 4.6 to 18.9 ppm (Table 21).

(ix) MANGANESE:- Results of manganese content of shoots as varied with the graded dose are presented in the table (21). The treatments resulted in the significant effect on the manganese content of shoots which is significant (23.3) at 1% level. Manganese content increased with the increasing dose of fertilizer where the increase is about 4 times in the third monthly application. Among the three monthly treatments, gradual increase of about 10 ppm is observed. Plants with trimonthly application indicated reverse trend as dose increased there is a decrease in the mangnese content of shoots. All the three trimonthly applications showed low manganese content compared to monthly applications.

Monthly and quarterly application of fertilizer had a significant (102.3) effect on the Manganese content of roots. It increased with rate of fertilizer dose in the monthly treatments gradually by about 100 ppm and the content is in the range of 119 to 457 ppm. However the content gradually increased from lowest to middle level of monthly application which decreased beyond this dose. Among the three trimonthly applications medium dose of fertilizer showed high content than others. Plants with normal fertilizer dose applied in very month though recorded an increase in the content of manganese with respect to control but is much lower compared to monthly and trimonthly applications.

4.5.4: EFFECT OF DOSE OF NPK AND TIME OF APPLICATION ON THE NUTRIENT UPTAKE BY OILPALM SEEDLINGS:

Composition of fertilizer mixture, its concentration and frequency of application to the Oilpalm resulted in the greater effect on the uptake of different nutrients. The uptake differed markedly among various treatments. The difference in uptake of each of the nutrients is described and detailed information is provided in the tables (22 & 23).

(i) NITROGEN :- Results of nitrogen uptake by Oilpalm seedlings in accordance with various treatments are summarised in the Table (22). Uptake of nitrogen by shoots ranged from 61.96 to 558.07 mg. It increased with the increasing graded dose of monthly application and there is about 8 times increase in the uptake to that of control when the plants are supplied with highest dose for every month. But when the plants were treated for every month the effect is reversed as uptake decreased gradually with the increasing rate. When plants with monthly application is compared with those in quarterly application uptake is more pronounced in monthly application. The uptake in the treatment of normal dose is very low when compared to other treatments.

Uptake of nitrogen by roots of Oilpalm ranged from 14.04 to 181.77 mg. It is found to increase with the dose of fertilizer when applied in every month. There is about 9 times increase in the uptake by roots of plants in the treatment receiving highest rate of fertilizer dose. Lowest monthly treatment did not show significant increase as in the case of medium and highest rate. But the application of fertilizer dose for every three months resulted in gradual decrease in the uptake of nitrogen by plant roots. When quarterly treatments compared with monthly, the uptake is found to be in the reverse order. A normal dose of fertilizer, eventhough indicated more uptake than the control but the magnitude is reduced when compared with other treatments.

Composition of total nitrogen content in the Oilpalms ranged from 85 to 748 mg. Graded dose of fertilizer application for every month resulted in the gradual increase of nitrogen uptake highest being in the plants grown in heaviest dose.

TABLE-22

EFFECT OF DOSE OF N,P,K AND TIME OF APPLICATION ON THE NUTRIENT UPTAKE OF OILPALM SEEDLINGS

(N, P, K, mg, PER POT OF THREE SEEDLINGS)

Treatments Dose/Pot of 10 kg.soil (Gms)	NITROGEN			PHOSPHOROUS			POTASSIUM		
	Root	Shoot	Total	Root	Shoot	Total	Root	Shoot	Total
T_0 (0)	23.39	61.96	85.35	3.82	11.20	15.01	19.26	49.13	69.73
T_1 (10) M.	37.21	432.30	496.62	11.13	44.14	55.30	81.34	431.93	513.27
T_2 (20) M.	167.97	517.63	687.60	23.69	61.03	88.41	179.93	532.63	712.53
T_3 (30) M.	181.77	558.07	748.83	23.52	62.36	85.87	142.47	527.00	669.47
T_4 (30) T.M.	108.10	421.17	529.27	14.51	40.94	55.45	139.10	437.87	572.97
T_5 (60) T.M.	39.53	153.47	193.00	5.46	15.08	21.27	35.24	120.95	156.19
T_6 (90) T.M.	14.04	64.41	78.45	2.06	21.28	23.34	11.67	81.98	96.88
T_7 Normal M	27.78	54.66	115.81	4.37	13.34	15.30	21.23	57.62	78.85
C.D. (5%)	56.16**	26.23**	438.03*	10.35**	31.43**	104.26**	67.42**	323.68**	375.77**

*Significant at 5% level
**Significant at 1% level

(ii) PHOSPHOROUS :- Uptake of phosphorous by Oilpalm roots ranged from 2.06 to 23.69 mg. There is marked increase of phosphorous uptake by Oilpalm roots with the increasing dose of fertilizer in the monthly treatments. The amount of increase in the phosphorus uptake by Oilpalm roots in the highest rate of monthly dose is about 8 times more than that of the control plants.

Unlike monthly treatments, phosphorous uptake decreased with increased rate of trimonthly fertilizer application and highest uptake being in the lowest dose. It can be observed that uptake in the treatment with highest rate is lower than the control. Normal dose of fertilizer though increased the quantitative uptake but significantly lower than the other treatments (Table 22).

Shoot uptake of phosphorous also ranged from 11.20 to 62.36 mg. There is a gradual increase in the uptake with the increasing rate of monthly fertilizer dose. It is increased by about 6 times when the monthly highest rate was applied. Among three monthly treatments medium and highest rate of treatments did not show much variation in the uptake whereas lowest rate indicated low uptake than the other two. While trimonthly applications of graded doses did not show increased uptake. Among the three trimonthly treatments medium dose indicated much lower uptake only 4 mg. more than the control plants. Plants with normal fertilizer dose though increased the uptake, it is only about 2 mg., more than the control plants.

Total uptake of phosphorous by Oilpalm plants ranged from 15 to 88 mg., lowest being in the control plants. The results are found to be significant at 1% level. Monthly fertilizer treatments showed greater uptake and it is quite high in the medium and high doses than the lowest dose of fertilizer. There is six fold increase in the uptake of phosphorous in plants having been treated with highest monthly dose. Unlike monthly treatments, trimonthly did not show gradual increase in the uptake. Among the three trimonthly treatments uptake has been found to be greater in the lowest rate of fertilizer dose.

(iii) POTASSIUM:- Root potassium uptake by Oilpalm varied significantly (67.42) which is in the range of 11 to 179 mg. It is seen that (Table 22) the application of fertilizer for every month resulted in extensive uptake of fertilizer potassium. There is four times increase in lowest, nine times increase in medium dose and seven times increase in the highest doses of monthly applications when compared to control. Among the three monthly doses, potassium uptake doubled from lowest to medium whereas highest rate of fertilizer dose did not show the expected increase. While comparing trimonthly treatments with the respective monthlies, it is seen that order is reversed as there is a fall in the uptake of potassium. Normal rate of fertilizer increased uptake to little extent and is about 2 mg., higher than control.

Like root, shoot uptake of potassium increases 8 to 10 times by the application of monthly fertilizer at graded doses. Uptake increased by about 100 mg., from lowest dose to medium but the corresponding increase has not been found from medium to highest level of dose. Trimonthly doses of fertilizer at a graded levels showed a similar trend as in the root uptake. However lowest monthly and trimonthly applications showed almost a comparable magnitude of uptake.

Total uptake of potassium by Oilpalm ranged from 69. to 712 mg., lowest uptake being associated with the control plants. Total uptake of potassium also indicated the same trend as in the case of root and shoot uptake. Monthly application of fertilizer dose at graded levels resulted in the extensive uptake of potassium. The increase in the uptake at the lowest rate is about 8 times than that of control plants. Quarterly application of fertilizer at graded levels showed gradual decline in the total uptake of potassium. The lowest rate of fertilizer dose showed extensive uptake even greater than the lowest monthly application.

(iv) CALCIUM :- Results of calcium uptake by Oilpalm are presented in the Table (23). Data of root calcium uptake ranged from 0.47 to 3.26 mg. Application of fertilizer dose at every month and once in three months affected the rate of uptake of calcium. There is three times increase in the uptake of calcium at the medium dose of monthly fertilizer application. Quarterly treatments indicated a decrease in the rate of calcium uptake with the increasing rate of fertilizer dose. Lowest trimonthly treatment represented uptake rate analogus to the monthly treatment whereas in other two trimonthly dose had uptake rate lower than the control plants. A treatment with normal fertilizer dose showed an increase in rate of calcium uptake by roots than the control plants.

Application of monthly and quarterly fertilizer dose at graded levels had strange effect on the calcium uptake by Oilpalm shoots. Monthly treatments resulted in gradual decrease in the calcium uptake with the increasing rate of fertilizer dose. Uptake of calcium decreased to about 4 times in the shoot of Oilpalms treated with highest monthly dose than in shoots of control plants. Trimonthly treatments also showed a similar decrease in the uptake rate except at highest graded dose where it is slightly higher (12 mg) than the control. Among the three quarterly treatments uptake is lowest in lower dose followed by gradual increase in the medium and highest graded doses.

Data of total calcium taken up by plants ranged from 3.62 to 16.06 mg. There is gradual fall in the uptake with the increasing rates of monthly and trimonthly fertilizer application. Normal dose also increased the total uptake of calcium like control plants. The results did not vary significantly.

(v) MAGNESIUM:- Results of Magnesium uptake by roots of Oilpalm seedlings are presented in the table (23). Uptake is ranging from 1.03 to 8.76 mg with significance (3.41) at 1% level. Monthly application resulted in an increase in the uptake of magnesium than in the control plants. Among the three monthly treatments uptake increases from lowest to medium doses whereas it is reversed in the high level of fertilizer. Quarterly treatments resulted in the gradual decrease in the uptake of magnesium by Oilpalm roots and the highest graded doses showed marked decrease even less than the contrrol plants. The lowest

TABLE-23

EFFECT OF DOSE OF N,P,K AND TIME OF APPLICATION ON THE NUTRIENT UPTAKE OF OILPALM SEEDLINGS (Ca, Mg, Fe) PER POT OF THREE SEEDLINGS

Treatments Dose/Pot of 10 kg.soil (Gms)	CALCIUM (mg) root	CALCIUM (mg) shoot	CALCIUM (mg) Total	MAGNESIUM (mg) root	MAGNESIUM (mg) shoot	MAGNESIUM (mg) Total	IRON (μg) root	IRON (μg) shoot	IRON (μg) Total
T_0 (0)	1.54	80.47	82.01	3.17	28.56	31.61	135.67	3440.00	2785.33
T_1 (10) M.	2.51	52.37	54.84	6.61	85.74	92.84	341.67	2843.33	6349.00
T_2 (20) M.	3.26	40.87	44.13	8.21	25.85	34.06	464.00	2600.00	7471.67
T_3 (30) M.	2.51	16.57	19.08	5.95	10.72	16.67	515.67	3036.66	7159.67
T_4 (30) T.M.	2.68	24.87	26.44	8.76	13.73	22.49	471.33	2616.66	6042.67
T_5 (60) T.M.	1.08	32.57	33.62	2.50	4.83	7.33	161.00	3513.33	2803.67
T_6 (90) T.M.	0.47	92.00	92.47	1.03	5.23	6.26	63.33	3319.0	1433.00
T_7 Normal M	1.90	119.47	121.47	5.28	16.75	22.37	166.67	3173.33	3086.67
C.D. (5%)	1.56*	66.43*	--	3.41**	48.41*	--	207.89**	--	4194.30*

* Significant at 5% level.

** Significant at 1% level.

quarterly treatment showed greater uptake than any other treatments. Normal dose of monthly fertilizer increased the Magnesium uptake to a considerable extent.

Uptake of Magnesium by shoots ranged from 4 to 85 Mg monthly graded doses decreased the rate of uptake of magnesium with the increasing level of fertilizer. A high uptake rate was found only in the lowest graded monthly treatment and other treatments showed uptake lower than the control plants. Quarterly treatments also decreased the uptake. A normal dose of fertilizer did not show the decreasing uptake of magnesium in the shoots.

Total uptake of Magnesium by Oilpalms ranged from 6.26 to 136 mg. Highest total uptake being in the plants treated with normal dose and lowest being in the plants supplied with highest quarterly dose.

(vi) IRON :- The results of root iron uptake are summarised in the Table (23). Uptake of iron ranged from 63 to 515 µg with the significance (207.89) at 1% level. It can be seen that uptake of iron by roots increases with the increase in the dose of fertilizer of monthly treatments. There was an increase in the uptake about 5 times in the treatment of highest graded dose of monthly application. Quarterly application of fertilizer decreased the uptake of iron. Quarterly treatments when compared to monthly had a lower uptake except in the lowest dose of fertilizer. Normal dose of fertilizer though increased the uptake than the control, the increased is not as much as in any of the monthly application.

Shoot uptake of iron did not show any significant effect within the monthly or trimonthly application of graded doses of fertilizer.

(vii) COPPER:- Results of copper uptake by Oilpalms are indicated in the table (24). Root copper uptake is ranging from 920 to 6529 µg. There is a gradual increase in the uptake of copper by roots in the monthly graded doses except at the highest rate where it had a depressing effect. The consequent increase is more than 6 times the uptake by control plants. Among the three monthly treatments medium dose showed highest uptake of copper. The uptake of copper by Oilpalm roots in treatments with quarterly fertilizer doses showed reverse trend as it is decreased with increasing concentration of fertilizer. Normal dose increased the uptake of root copper two times the uptake of copper but lower than that of the rest of treatments.

Shoot uptake of copper showed reverse effect of fertilizer. Monthly application of graded dose of fertilizer decreased the uptake of shoot copper gradually. Uptake of copper ranged from 1400 to 2300 µg. Among the three quarterly treatments uptake decreased gradually from lower to medium dose but it is highest in the third level. Unlike root, the plants with normal dose showed highest uptake than any other treatments.

viii) ZINC:- Uptake of zinc by roots ranged from 47 to 701 µg with the significance (208.84) at 1% level. It can be seen from the Table (24) that the lowest and medium doses of

TABLE-24

EFFECT OF DOSE OF N,P,K AND TIME OF APPLICATION ON THE NUTRIENT UPTAKE OF OILPALM SEEDLINGS
(Cu, Zn, Mn) µg PER POT OF THREE SEEDLINGS

Treatments Dose/Pot of 10 kg. Soil (Gms)	COPPER			ZINC			MANGANESE		
	Root	Shoot	Total	Root	Shoot	Total	Root	Shoot	Total
T_0	920.33	1666.67	2533.67	152.67	2066.67	2312.00	3801.33	1554.67	5356.00
T_1 (10) M.	5858.33	2100.00	7318.67	466.33	2366.67	2984.67	15780.00	28180.00	28678.33
T_2 (20) M.	6529.33	1900.00	7038.00	701.67	2266.67	2920.67	39350.00	17843.33	57193.33
T_3 (30) M.	4129.33	1700.00	5520.33	521.33	2266.67	2706.67	43273.33	17327.67	60600.00
T_4 (30) T.M.	3616.00	1933.33	4021.00	459.33	2166.67	2619.67	26786.67	11314.33	38100.00
T_5 (60) T.M.	949.67	1400.00	2350.33	185.67	1800.00	1817.67	13083.00	3642.33	16723.00
T_6 (90) T.M.	668.00	2266.67	2764.63	47.00	2600.00	2647.00	4383.67	4106.33	6035.00
T_7 Normal M	1518.00	2300.00	3724.67	126.67	2533.33	2659.00	5898.67	2153.67	8052.67
C.D. (5%)	2777.25**	537.02*	2930.88**	208.84**	--	2512.21**	12106.71**	15444.32*	20181.53**

* Significant at 5% level

** Significant at 1% level

monthly treatments increased zinc uptake while highest dose showed decreasing effect. The quantitative increase is about 6 times than that of control. The uptake of zinc among the three monthly applications is highest in the medium followed by highest and lowest graded dose. Trimonthly treatments showed a sharp decrease in the uptake with the increasing concentration of fertilizer.

Shoots of Oilpalms did not show significant effect on the zinc uptake in accordance with different treatments. It can be seen that normal dose of fertilizer increased the uptake of zinc by shoots of Oilpalms.

(ix) MANGANESE :- Results of Manganese uptake by Oilpalm roots ranged from 3801 to 43273 µg with the significance of (12106.71) at 1% level. The uptake of manganese increased extensively with the increasing graded dose of monthly fertilizer. The increase in the uptake is about 10 times greater than the uptake in control. Trimonthly treatments unlike monthlies decreased the uptake of Manganese. The lowest rate of quarterly application showed comparable magnitude to that of monthly application. Normal dose of monthly application increased uptake of Manganese more than the control but less than rest of the treatments.

Trimonthly and monthly application of fertilizer at a graded level decreased the shoot uptake of manganese. The variation in the uptake of Manganese significantly effected by the graded dose of fertilizer. All the three quarterly treatments showed the uptake lower than any of the monthly application. The increase in the uptake in the shoots of plants treated with normal dose was doubled than that of control plants.

.5: EFFECT OF DOSE OF N.P.K. AND TIME OF APPLICATION ON THE SOIL PH AND AVAILABILITY OF N.P.K. CONTENT OF THE END OF STUDIES :-

(i) SOIL pH:- Results of soil pH as obtained at the end of idies are presented in the table (25). Application of fertilizer e and time of application effected the soil pH significantly 34) at 1% level. In the control treatments the soil pH has n increased whereas application of fertilizer at monthly ervals decreased the soil pH. Among the three monthly applications highest dose showed marked decrease in the soil pH lower than other treatments.

Quarterly treatments of graded doses also decreased the soil but comparatively higher than the monthly applications except medium dose. It can be seen that application of normal dose fertilizer did not increase acidity.

(ii) AVAILABLE NITROGEN :- Application of monthly and trimonthly rtilizer dose has no significant effect on the available soil trogen at the end of the studies.

It is ranged from 80 to 125 ppm lowest being in the highest te of monthly application. However it can be seen that in the ntrol treatments eventhough fertilizer was not supplied, availability nitrogen increased appreciably than any of the monthly and quarterly eatments. Availability of nitrogen seems to decrease with increasing aded dose of fertilizer. Normal dose of fertilizer also increased e soil availability of nitrogen. Table (25).

TABLE-25

EFFECT OF DOSE OF N,P,K AND TIME OF APPLICATION ON THE SOIL PH AND AVAILABLE N,P,K CONTENT AT THE END OF THE STUDIES

Treatments Dose/Pot of 10 kg. Soil (Gms)	SOIL PH (1:2.5) Soil:Water	Available Nitrogen (ppm)	Available Phosphorous (ppm)	Available Potassium (ppm)
T_0	5.67	125.00	49.60	61.33
T_1 (10) M.	4.70	97.33	487.21	148.33
T_2 (20) M.	4.69	113.33	640.87	141.67
T_3 (30) M.	4.60	80.33	657.18	200.00
T_4 (30)T.M.	4.82	85.00	506.17	188.33
T_5 (60) T.M.	4.65	96.67	885.36	236.67
T_6 (90) T.M.	4.75	87.67	742.06	278.33
T_7 Normal M.	5.25	101.33	99.86	45.00
C.D. (5%)	0.34**	--	140.24**	72.95**

**Significant at 1% level.

(iii) AVAILABLE PHOSPHOROUS :- Monthly and quarterly treatments of fertilizer effected availability of phosphorous significantly. Availability of phosphorous increased with the increasing dose. The increase in the available phosphorous is about more than 10 times that of control in the monthly treatments. The monthly treatments showed gradual increase in the availability of phosphorous.

Like monthlies, quarterly applications also increased the available phosphorous with the increasing doses of fertilizer. Off the three treatments, medium dose of fertilizer showed more available phosphorous followed by highest dose. Normal dose of fertilizer increased soil available phosphorous by 2 times than that of control.

(iv) AVAILABLE POTASSIUM :- Monthly and quarterly application of fertilizer and time of application effected availability of potassium significantly. It can be seen from Table (25) that availability of potassium increased with increase in the concentration of monthly and trimonthly applications. Available potassium ranged from 45 to 278 ppm. Application of monthly fertilizer increased the soil potassium availability by two times than that of control. Among the trimonthlies highest graded dose showed significant difference in the available potassium than the other two.

Quarterly applications of graded doses constantly increased the availability of potassium. The quantitative increase in the available potassium is higher than the control and monthly application. Unlike available phosphorous and nitrogen, available potassium of normal treatments decreased below the control.

4.6 INFLUENCE OF GRADED DOSE OF NITROGEN ON THE OILPALM SEEDLINGS:-

4.6.1 : EFFECT OF GRADED DOSE OF NITROGEN ON THE DRY MATTER PRODUCTION OF OILPALM SEEDLINGS :-

Results of root, shoot and total dry matter production of Oilpalm as influenced by the graded dose of nitrogen are presented in the Table (26). Graded dose of nitrogen did not show any significant effect on the dry matter production of Oilpalm seedlings. It can be seen from the table that there is a slight increment in the rate of shoot dry matter production with increase in the graded level of fertilizer. However the increase in the dry matter from N_1 to N_2 level did not differ appreciably from each other. Root production of dry matter gradually increased with the increasing nitrogen level. Total Dry matter produced by Oilpalms ranged from 11.5 to 15.4 gms. Total dry matter produced is found to increase with the graded level of nitrogen. It is increased constantly by 2 gms. from N_0 to N_1 and N_1 to N_2 level of nitrogen fertilization.

4.6.2: EFFECT OF GRADED DOSE OF NITROGEN ON THE CONTENT AND UPTAKE OF NITROGEN :-

Content of Nitrogen and its uptake by Oilpalm seedlings with increase in the dose of nitrogen are summarised in the Table (27). Shoot content of nitrogen Of Oilpalm seedlings is ranged from 0.77 to 0.98%. It increased with level of nitrogen applied and the increment is about 0.2% than that of control and the two levels of nitrogen application differed by only 0.01% of nitrogen content. The same trend is observed in the shoot uptake of nitrogen where application of nitrogen in 2 levels increased

TABLE - 26

EFFECT OF GRADE DOSE OF NITROGEN ON THE DRY MATTER PRODUCTION OF OILPALM SEEDLINGS. (Gms)

Treatments	Shoot	Root	Total Dry Weight (Root + Shoot)
N_0	8.2688	3.2857	11.55
N_1	9.6323	3.6518	13.28
N_2	9.8485	5.5955	15.44
C.D. (5%)	--	--	--

TABLE-27

EFFECT OF GRADED DOSE OF NITROGEN ON THE CONTENT AND UPTAKE OF NITROGEN BY OILPALM SEEDLINGS

Treatment	Shoot N%	Total uptake of N by shoot (mg)	Root N%	Total uptake of N by root (mg)	Total N uptake root + shoot (mg)
N_0	0.7700	63.7	0.5927	19.3	83.0
N_1	0.9753	94.6	0.7700	28.2	124.0
N_2	0.9847	96.2	0.8213	44.8	141.1
C.D. (5%)	0.1197**	26.8*	0.0852**	18.4*	42.6*

* Significant at 5% level
** Significant at 1% level

the uptake to appreciable amount than the control. It is increased by about 30 mg to that of the control.

The root content of nitrogen in the Oilpalm seedlings ranged from 0.5927 to 0.8213%. The increase in the root nitrogen content by applying graded dose of nitrogen is about 0.2% to 0.3%. The two levels of nitrogen, N_1 and N_2 differed by 0.1% of nitrogen.

Total uptake of nitrogen by Oilpalm roots was in the range of 19.3 to 44.8 mg. The graded dose of Nitrogen increased uptake of root nitrogen from 19.3 to 28.2 mg in the first level of fertilizer. Whilst the increase in uptake from N_1 to N_2 level was from 28.2 to 44.8 mg.

DISCUSSION

V. DISCUSSION

The results indicated that the adsorption of phosphorous and potassium progressively increased with increasing concentration in all the three soils. The increased adsorption of phosphate ions is probably accompanied by increasing energy of adsorption. However more adsorption was recorded by the red sandy loam soil compared to other two. This is probably due to the presence of R_2O_3 as well as fairly high content of illite by the clay materials. Andrew and Evans (1988) indicated that different organic components present in the red sandy soil influenced the adsorption of phosphate. Although the clay content and organic matter content in the forest soil is more the adsorption of phosphorous and potassium is moderate. The laterite soil suppose to fix high content of phosphate but it is not reflected in the present study.

The isotherm constants "b" & "k" showed almost similar trend as that of adsorption properties of the soils. The adsorption maximum is high for the red sandy loam soil followed by forest and laterite soils for both the elements. This clearly suggests that the presence of high amount of adsorbate in these soil. The bounding energy showed a reverse trend as that of "b" value. As the adsorption maxima increases the bonding energy decreases which further suggest that the adsorption of phosphorous and potassium could be desorbed easily in the red sandy loam soil compared to laterite. The releasing and displacement of the adsorbed phosphorous and potassium would be rather difficult and require stronger force to release in the laterite soils. This has a greater bonding on the nutrient availability to the Oilpalm seedlings. Similar observations were made by Chatterjee and Datta (1951).

The Results of desorption pattern of phosphorous and potassium showed that first three extractions desorbed major portion of the adsorbed nutrient in all the soils. Thereafter desorption tended to almost a constant till 8th extraction. The release of phosphrous was more in the red sandy loam and forest soils when compared to the laterite. "This is related with the percentage of clay content and free iron oxides Nakas (1987).

Greater releasing capacity is also probably due to high adsorption of phosphate by these two soils. On the other hand the desorption of potassium is resolved more in the laterite followed by red sandy loam soils. Initially high desorption of phosphorous in laterite and potassium in forest soil was achieved. After fifth extraction the release rate of potassium was constant for all the three soils. This clearly suggests that the potassium supplying ability of these soils to Oilpalm at a constant rate of 4 to 5 ppm.

The data on the selective distribution of phosphorous and potassium revealed that the dominant fraction of phosphorous has been bound to alluminium followed by iron in all the three soils. When the phosphorous fractionation is made the water soluble phosphorous gets converted into Alluminium phosphorous (Al-p) followed by iron phosphorous (Fe-p) in the acid soils (Balasubramanian and Raj 1969). The saloid bound phosphorous (SB-p) was also high indicating that the fairly high amount of phosphorous are still held loosely in the soil which is readily available to the crop on the other hand major portion of the added potassium was held in the water soluble portion followed by loosely bound potassium. The bound potassium is low showing that these soils do not fix the potassium to a large extent. This is because the absence of 2:1 illite type by the clay minerals in the soils. The dominant clay mineral in these soils is 1:1 kaolinitic type which loosely hold potassium on their exchange site (Khan etal 1982).

The studies of the sand culture on withholding one nutrient at a time showed that withholding nitrogen and phosphorous adversely affected and growth and number of leaf production when compared to the other nutrients. Withholding the potassium, calcium, magnesium and zinc did not markedly affected the productivity of Oilpalm which is comparable to the full nutrient supply.This is also reflected in the dry matter production of shoot and root,with-holding of nitrogen badly depressed the growth of the Oilpalm seedlings followed by phosphorous. The uptake of nitrogen and phosphorous affected by withholding nitrogen and phosphorous while potassium uptake was affected by withholding potassium, phosphorous and nitrogen. The Nitrogen and phosphorous uptake may be attributed to the general relationship of nitrogen and phosphorous since both being constituents of plant protiens, their concentration must remain constant.If concentration of Nitrogen increases or decreases the protein can keep its normal composition only if phosphorous also correspondingly increases or decreases Ollagnier etal (1970). The effect of withholding Nitrogen on potassium is probably due to synergestic effect of Nitrogen on potassium, calcium and magnesium. Other nutrients did not influence the uptake of Nitrogen, phosphorous and potassium by the Oilpalm seedlings. The uptake of calcium was influenced by withholding calcium followed by zinc and nitrogen whereas magnesium uptake was depressed by withholding magnesium, zinc and nitrogen. Almost a similar results are obtained as far as nutrient concentration in different parts of Oilpalm seedlings. This may be due to synergestic effect of Nitrogen on calcium and Magnesium. This indicates that the uptake of certain nutrient has been influenced by certain nutrients in the growth medium. Some of them exert synergestic effect and some would influence antagonistically. It is imporative that a balanced amount of nutrient must be present for the optimum uptake which inturn influences maximum productivity.

The results on the effect of fertilizer dose and time of application on the growth and mineral nutrition of Oilpalm indicated that there was a differential behaviour in the growth of Oilpalm is concerned. The application of 12:12:17 ratio N:P:K at the rate of 20 gms., per pot per month has produced maximum height and leaf production. Beyond this the effect is on negative side. This is probably due to excess of nutrient induced some of toxicity or antagonism in the uptake of secondary and micro-nutrients which are essential for the growth. The control plant showed least growth due to the shortage of various essential nutrients in the soil. On the other hand the trimonthly application of fertilizer did not had significant influence compared to monthly application. Although the trimonthly application required the same quantity of fertilizer as in the case of monthly application, the growth was poor because of high concentration of fertilizer given at one stock. This is probably inhibited the roots to absorb sufficient nutrients required for its growth due to high concentration of nutrient in the soil. The heavy of trimonthly application vertically decreased the growth very much due to same fact explained above. The normal recommendation of fertilizer (Trial 8) showed not much improvement in growth compared to monthly and trimonthly application. This is probably due to insufficient quantity of the nutrients available in the soil for maximum productivity. This is also reflected in the total dry matter production. The total dry matter production was more in middle dose of monthly application followed by other two treatments of monthly application. However the trimonthly application has reduced the dry matter to very low value which is almost comparable to control plants. This might be due to highly concentrated contents of nutrients in the root zone which inhibitated its uptake and metabolism.

The Palode method of fertilizer application did not prove significant over control. This suggests that the present system of fertilizer application to the nursery seedlings of Oilpalm needs changing. That is monthly application of 20 grams of 12:12:17 per seedlings could successfully be used for nursery fertilization of Oilpalm seedlings.

The data on the nutrient concentration in shoots and roots showed that the high dose of fertilizer applied monthly recorded the highest contents of nitrogen, phosphorous and potassium respectively. On the other hand other treatments recorded relatively lower concentration. In the case of Palode method the concentration of Nitrogen Phosphorous and Potassium in times is very much comprable to that of control plants. The content of Magnesium and Calcium in the times showed that the T_1 treatment recorded high concentration and lowest being control followed by Palode method. This is due to the fact that the high potassium content in the medium inhibited the uptake of magnesium and calcium considerably, thereby reducing its concentration in the times. Almost a similar type of results have been obtained for Micronutrents contents by the Oilpalm seedlings.

The uptake of major, secondary and micronutrients by the Oilpalm seedlings indicated that the total uptake was high in T_3 treatment followed by T_2. The root content of treatments showed considerable low quantity due to the fact that the nutrient concentration in the soil was very high which inhibited in their uptake (T_4, T_5, T_6). However low uptake was recorded in the seedlings treated with Palode method. This might be due to the low content of the nutrient in the soil. This treatment is almost comparable with that of control. A similar pattern of data have been recorded for secondary and micronutrients also.

The data on the soil analysis indicated that soil pH progressively decreased as the concentration of fertilizer increased, specially true for treatments No. T_1 to T_6. This is due the high quantity of fertilizer added which results in the acid residue in the soil. However control soil and soils recovered from Palodue treatment showed high pH of the soil. The available soil nitrogen at the end of experiment did not show much variation between the treatments.

Totally to say the residual effect of applied nitrogen is much less than that of phosphorous and potassium. Phosphorous and potassium both showed considerable buildup in the soils treated with graded dose of fertilizer. The application of graded dose of fertilizer within monthly or quarterly reflected high Total content showing the profuse residual effect. From this, it is imparative that the management of nitrogen in the Oilpalm nursery soil is the most important component while potassium and phosphorous does not require much of attention.

The effect of graded level of nitrogen is well pronounced as far as dry matter and biomass production is concerned. The Total biomass increased with increasing level of nitrogen, similarly upto N_2 level. Almost a similar pattern was recorded by the shoot and root weights. The nitrogen content in seedlings is progressively increased from 0.77% to 0.98% probably due to high available nitrogen in the nitrogen treated pots. This effect is also seen in the nitrogen content of root. The total uptake of nitrogen also increased with increasing level of nitrogen application. This clearly suggests that the response of Oilpalm to nitrogen fertilization is positive upto the level tried in the present study. Therefore for proper management of Oilpalm nursery could be achieved with judicious application of nitrogen fertilizer.

SUMMARY AND CONCLUSION

vi. SUMMARY AND CONCLUSION

The studies carried out both in the soil and seedlings of Oilpalm leads to the following conclusions.

(1) High adsorption of phosphorous and potassium was noticed in red sandy loam soil rather than laterite and forest soils.

(2) As the adsorption maxima increases the bounding strength of the ions decreases.

(3) Major portion of the adsorbed phosphorous and potassium could be desorbed easily within 2 to 3 extractions.

(4) The selective distribution of phosphorous and potassium in the soil indicated that the phosphorous is bound to alluminium followed calcium chloride extractable form.

(5) The productivity of Oilpalm seedlings have been affected by withholding the nitrogen, phosphorous and potassium as the case may be.

(6) Secondary and micronutrients content and uptake has not been influenced by the withholding of major nutrients in the soil.

(7) The studies of dose and time of fertilizer application to Oilpalm seedlings indicated that 20 gms of 12:12:17 ratio of NPK at monthly interval followed by 40 gms treatment.

(8) High dose fertilizer application at quarterly interval in fact deteriorated the growth and productivity of Oilpalm seedlings.

(9) There was a more response to the nitrogen application.

(10) The phosphorous and potassium appeared to be built up in the soil suggesting such high dose of phosphorous and potassium might not necessary for Oilpalm seedling culture.

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