

STUDY ON NUTRITIONAL UPTAKE BY COCONUT PALM (Cocos nucifera L.)

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MASTER OF SCIENCE IN AGRICULTURE
(HORTICULTURE)

BY
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Dated, the 13th July, 1987.

C E R T I F I C A T E

Certified that the thesis entitled " STUDIES
ON NUTRITIONAL UPTAKE BY COCONUT PALM " submitted in
partial fulfilment of the requirements for the award
of DEGREE OF MASTER OF SCIENCE IN AGRICULTURE
(HORTICULTURE) of the Orissa University of Agriculture &
Technology, Bhubaneswar is a faithful record of
bonafide research work carried out by Shri Narayan Nath
under my guidance and supervision. No part of the
thesis has been submitted for any other degree or
diplom or published in any other form.

It is further certified that such help or
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CHAPTER I

INTRODUCTION

INTRODUCTION

The coconut (Cocos nucifera L.) is the most useful of the Tropical palms. It occupies an unique position among the pameological fruits as well as plantation crops in the world. Every part of this monocot palm like fruit, copra, testa, oil, fibre, fronds and trunks is being utilised by mankind in various ways for some of the economic purpose. Large number of Industries employed labour on production of coir fibre and coir products. It gives yield all through out the year, almost at monthly interval upto 80 years. On account of its usefulness, it has been rightly called in Sanskrit " KALPA VRIKSHA " or " TREE OF HEAVEN " , because the tree provides all necessities of human life.

In Puran, it is said that coconut has brought to India from NAGALOKA, the blissful region beneath the sea, by an illustrious king for special worship.

India is the third longest coconut producing country in the world. It occupies about 1.2 million hectares spread over mostly entire coastal belt. Orissa comes to fifth position in relation to crop distribution in India.

The Nutrient applied to soil is carried through xylem and translocated to every part of the tree. The rate of Nutrient uptake by plant specially of leaves depend on type of soil. Nutrient level also indicates the growth pattern and other physiological behaviours of the plant. Application of different fertiliser doses affects the Nutrition uptake by leaves. So the Nutritional uptake studies gain more importance in recommending the optimum fertiliser doses to different soils. The Nutrition uptake is also influenced by soil condition, environment and genotypes.

Considering the above facts in view, an experiment has been laid out by the All India Co-ordinated Coconut Improvement Project (I.C.A.R.) under the Orissa University of Agriculture & Technology, Bhubaneswar at Konark to determine the optimal requirement of N, P and K for sandy belt of Orissa on the basis of growth and yield of coconut palm but not on the basis of uptake of nutrients N, P and K by leaf analysis. The study on this aspect is very important.

Therefore the present study was undertaken with the following objectives.

1. To study the uptake of Nutrients (N, P and K) by the coconut palms.
2. To ascertain the status of the nutrients in the soil and in the leaf at different dates.
3. To study the effect of different treatments on the growth of the plant (girth, height and leaf number).
4. To find out the effect of different treatments on the fruit bearing.

CHAPTER II

REVIEW OF LITERATURE

REVIEW OF LITERATURE

The relevant literature on different aspects of present study on " NUTRITIONAL UPTAKE BY COCONUT PALM " is reviewed as under:

1. FOLIAR ANALYSIS AS A GUIDE TO MANURING IN COCONUT.

Fremont and Lamthe (1968) find out the principal causes and methods of correcting mineral deficiencies in coconut palm on a basis of the results of twenty years research by the International Research and Horticultural Organisations in different parts of the world. The value of Foliar diagnosis in this field was stressed and the critical levels adopted are listed for leaf contents of Nitrogen, Phosphorus, Potassium, calcium and Magnesium.

Wahid, Devi and Haridasan (1977) have reviewed and discussed on annual nutrient removal by coconut palm including the Nutritious status of various parts of a productive coconut palm. They gave a critical review on phosphatic Fertilization and percentage of Phosphorus in leaves of tall, semi tall and dwarf palms and leaf status of mineral Nutrition in relation to Fertilization.

Santiago (1978) reported on the importance of Foliar analysis in coconut palm in respect to manuring.

Magat (1979) reported on the use of leaf analysis in conducting Fertiliser trials in coconut. He made ten fertiliser trials on coastal and inland areas of Davao and Misamis Oriental provinces of Philippines. Positive response was recorded which was closely related to improvement of leaf Nitrogen and Chlorine contents (not in Phosphorus, Potash, Calcium and Magnesium levels suggesting that the palm had an adequate supply of these Nutrients). The results confirmed the value of leaf analysis in diagnosing the fertiliser need of the local tall. Using the critical levels of leaf 14:1:84 Nitrogen, 0.12% Phosphorus, 0.8% Potassium, 0.3% Calcium and 0.2% Magnesium.

2. NUTRIENT CONTENT OF COCONUT LEAVES IN RELATION TO GROWTH VIGOUR.

Santiago (1978) reported on the influence of soil types and fertility variation on growth of coconut seedlings of cultivar Marinduque green Dwarf. Differential treatment, effect on seedling vigour on leaf nitrogen, phosphorus, potassium chlorine and magnesium content were not much. Leaf potassium content was correlated with seedling girth height and number of leaves and leaf chlorine content was negatively correlated with seedling girth and height.

3. NUTRIENT CONTENT AND PRODUCTIVITY.

Indira Ratty et al (1968) showed that there was general increase in the Foliar contents of N, P, and K with increase in yield but calcium and magnesium did not show that trend.

Konapathy (1971) reported that leaf Nutrient levels were not connected with yields but nutrient levels differed between progenies.

Loganathan et al (1981) reported that yield was positively correlated with leaf nitrogen and chlorine and negatively correlated with leaf magnesium, critical concentration of potassium and chlorine in the 14th leaf were 1.3 and 0.26% respectively.

4. NUTRITIONAL UPTAKE BY COCONUT LEAVES.

Prevot and Bachy (1962) have studied on Nutritional uptake of coconut palms under various soil management. Foliar analysis was made for nitrogen, phosphorus, potassium, calcium and magnesium of leaves 1, 6, 11, 16, 21 and 26 collected from palms of same age but of difference in vegetative development.

Prevot and Allaghier (1963) have reported the critical levels of nitrogen, phosphorus, potassium, calcium and magnesium for oil palms and coconuts.

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Prevot and Allaghier (1963) have reported the critical levels of nitrogen, phosphorus, potassium, calcium and magnesium for oil palms and coconuts.

Indirakutty et al (1986) reported that Foliar nutrient content was decreasing in order of nitrogen, potassium, phosphorus, calcium and magnesium in coconut palms in general.

Schut (1975) reported the critical levels of nitrogen, phosphorus, potash, calcium and magnesium in the 9th leaf of two dwarf coconut palm varieties (Suriham and Malayan Dwarf) at different locations and times (from 1966 to 1970).

Schut (1975) found the possible source of variation in nutrient content in coconut leaves due to the choice of leaf number for sampling, time of sampling, ground water level and genetic combination.

Wahid et al (1977) reported on phosphate fertilisation in which they indicated the phosphorus content of the healthy adult palm and the phosphorus percentages in the leaves of the tall, semi-tall and dwarf palms in relation to phosphorus and phosphorus potassium interaction.

Singh and Velayuthan (1979) reported on the nutrient indexing of coconut leaves. The data showed the levels of nutrients on the maximum, minimum and average basis of nitrogen, phosphorus, potassium, calcium, magnesium and sulphure content in the leaf samples collected from ten localities of Lakshadweep Island.

Magat (1979) found out the critical levels of uptake by the 14th leaf of coconut palm in Phillipines which were 1.8% nitrogen, 0.12% nitrogen phosphorus, 0.8% potassium, 0.3% calcium, 0.2% magnesium, 0.5% chlorine and 0.1% sulphate.

Loganthan et al (1981) found out the critical concentration of potassium and chlorine in the 14th leaf to be 1.3 and 0.26% respectively.

Loganthan et al (1982) determined the phosphorus concentration in the 14th leaf of the coconut palm at 35 sites in Sri Lanka as 0.120%. In Sri Lanka phosphorus status of unfertilized soils at 58 sites of major coconut growing areas was at extremely lower level.

Mahid et al (1981) have tabulated data on yield, soil chemical characteristics and nutrient concentration (Nitrogen, Phosphorus, Potassium, Calcium, Magnesium etc.) in the leaves of ten coconut varieties and hybrid receiving uniform nitrogen, phosphorus and potassium.

Ouvrier, M. (1982) carried out trials with the coconut hybrid 99-121 (Malayan yellow Dwarf x West African Tall). The major mineral elements (N, P, K, Ca, Mg, Na, Cl and B) were determined for the different bunch components (Stalk, Spikelets, husk, shell and albumen) from flower to maturity. The total amount of each element increased considerably between bunches of

rank 14 to 18. The most important elements were K, Cl and N. The rise in certain elements (N, P and S) in the developing albumen was partially compensated for by their reduction in the husk. Calculating fertiliser requirements on the basis of the uncut crop with simple restriction of nutrients exported, was not effective because any fertiliser applied has no effect on bunches above rank 18, which accounted for 65% of the uncut crops. Leaf analysis however is recommended.

Loganathan, P., Dayaratan P.M., Shanmugathan R.T. (1982) reported the P status of unfertilised soils at 58 sites in the major coconut growing regions was in most cases extremely low. P concentrations in the 14th leaf of coconuts were determined at 35 sites, these concentrations (0.074-0.11%) were below the critical concentration (0.120%).

Whid P.A., Raman K., Ramlan N.V., Venugopal V.K. (1982) have tabulated data on the yield soil chemical characteristics in the soil basins and nutrient concentrations (N, P, K, Na, Ca, Mg., S., Cu and Mn.) in the levels of 10 coconut CVs and hybrids receiving uniform NPK fertilisation. The pattern of variation in nutrient levels did not differ markedly in the different CVs and hybrids. Generally leaf N decline with the onset of the

monsoon and increased following fertiliser application in September. Leaf K level increased until December and decreased thereafter, whereas Ca and Mg increased after December. Leaf P increased slightly and S and Fe decreased during the rainy season. The Cu and Mn levels were little affected by the seasons. Mn fell to its lowest level in September and increased thereafter. The best time for Foliar diagnosis under Keral conditions was December.

Loganathan P., Balakrishnan Murty T.S. (1982) have presented data from an 11 year trial on the response of coconuts to N (as sulphate of Ammonia at 0-4.40 Kg/palm annually) P (as Super phosphate 27.5% P_2O_5 at 0-3.32 Kg/Palm annually) and K (as muriate of potash at 0-1.92 Kg/Palm annually in various combinations. The optimum annual application rates/palm were 1.1 Kg. sulphate of ammonia, 0 or 0.93 Kg Super Phosphate and 1.8 Kg muriate of potash, which gave an average annual yield of 12 Kg copra/palm. Leaf K and CL contents were increased by Muriate of Potash but leaf Ca and Mg were reduced. Sulphate of Ammonia decreased leaf CL and Super Phosphate raised leaf P and CL and negatively correlated with leaf Mg. critical concentrations of K and CL in the 14th leaf were 1.3 and 0.26% respectively.

Ouvrier M. (1925) have studied on coconut palm planted in 1970 on sandy soil poor in nutrients. KCL manuring increased the production of albumen in the nut when K fertilisation was increased, K and CL levels in the husk rose. There was a good correlation between husk and leaf 14 contents. Shell and albumen K and CL contents were relatively constant whatever the KCL rate applied. Leaving husks in the field is recommended to return K and CL to the soil. Mg manuring generally only increased tissue Mg contents. The need to base manuring on fertiliser trials and leaf analysis is stressed.

Ollagnier M., Mahyuni M. (1985) have reviewed the results obtained in several soils and climates. N Nutrition is generally satisfactory except in soils low in organic matter. The optimum N leaf level is 2.2% in leaf 14 in west Africa P deficiency occurs in soil of low P content and its correction is very economic. The optimum P content for leaf 14 is 0.12% K and CL nutrition are closely linked. CL deficiency is common in plantations more than 20-25 from the sea. Both elements increase the nuts/tree and copra/nut (upto 40% in Indonesia). Increasing in yield due to K + CL fertilisation are always economic.

because of the diversity of ecological condition encountered, the optimum leaf levels proposed (K 1.4% + CL 0.6-0.7%) require confirmation. Since CL deficiency has frequently to be corrected. It is suggested that fertilisation programmes to correct it should also correct possible K and Mg deficiencies by applying KCL and Kiesarite (Mg soli H_2O) which have shown a positive interactive effect in the Ivory coast.

5. LEAF NUTRIENT LEVEL INFLUENCED BY DIFFERENT FACTORS.

Shawky et al (1975) reported that in date palm young leaves contained more nitrogen and/or potassium than old leaves. Contents of dry matter, nitrogen and potash was greater in pinna than rachis, but phosphorus level was similar in both.

6. CHOICE OF LEAF NUMBER AND POSITION.

Prevot and Bachy (1962) carried out foliar analysis for Nitrogen, Phosphorus, Potash, Calcium, Magnesium and Sodium on leaves number 1, 6, 11, 16, 21 and 26 (1 being the most recently untold) from palms of same age but differing in vegetative development. They concluded that the 6th leaf showed consistently highest Nitrogen content with regards to phosphorus and potash, it decreased from leaf 1 to 26, whereas calcium

and magnesium increased. The more vigorous the palm, higher the values for Nitrogen and phosphorus, potassium calcium and magnesium were not affected by vigour plant vigour and leaf position interacted with regard to Foliar calcium, magnesium and sodium. The recommendation for routine Foliar diagnosis was the 4th leaf for palms upto four years old, 9th leaf from 5-7 years old and 14th leaf for older palms.

7. HEALTHY AND DISEASED PLANTS .

Sankar Subramany et al (1952) conducted Foliar analysis of healthy and diseased plants, suffering from rot diseases. There was accumulation of Nitrogen, Phosphorus and potash in the leaves of diseased plants. Further data are required before it can be determined whether this is due to impaired physiological processes or inadequate translocations.

8. EFFECT OF ENVIRONMENT .

Cecil and Pillai (1973) gave a note on the mineral losses from coconut leaves by Foliar leaching by rainfall. Annual losses of Nutrients by leaching from the leaves of a hectare of 170 coconut palms, caused by an annual rainfall of 2500 mm were computed as 85 Kg potash, 74 Kg Nitrogen, 32 Kg sodium, 25 Kg. calcium, 8.7 Kg magnesium and 2.9 Kg. Phosphorus.

Duvrier and Ochy (1980) found that there was little seasonal change in mineral uptake excepting those of trace elements.

Mahid et al (1981) reported the pattern of variation in Nutrient levels which did not differ markedly on the different cultivars and hybrids. Generally leaf nitrogen declines with the onset of the monsoon and increased following fertiliser application in September leaf potash level increased upto December and decreased thereafter, whereas calcium and magnesium increased after December. Leaf phosphorus increased slightly and sulphur and iron decreased during the rainy season. However copper and manganese levels were little effected by the seasons. Sodium was reported to be falling to its lower level in September and increased thereafter. The best time for Foliar diagnosis under Keral condition was December.

9. EFFECT OF SOIL TYPES.

Indira Kutty and Pandalai (1969) studied on the Foliar Nutrient content of tall coconut palms of different yield capacity growing in four soil types viz. Litteral sand, red loam, sandy loam and laterite

gravel. Leaf samples were collected for analysis towards the end of the summer. The nitrogen and phosphorus contents were maximum in samples collected from palms growing on red loam. The potash and calcium contents were maximum with potash growing in sandy loam and the magnesium content was highest with palms growing on littoral sandy soils.

Santiago (1978) reported on the influence of soil types on Nutritional uptake of coconut seedling (Vs Marinduque Green Dwarf) were grown in polythene bags containing clay loam, silty clay loam or sand fertilised with Nitrogen, Phosphorus, Potash, Calcium, sulphure and chlorine at three levels. Differential effect on leaf nitrogen, phosphorus, potash chlorine and magnesium content were slight but leaf calcium content was the highest with the plants growing on clay loam and silty clay loam receiving a low fertiliser level.

10. METHODS OF FOLIAR ANALYSIS IN COCONUT.

Provot and Bachy (1962) studied on the Foliar diagnosis in coconut and effect of leaf position on Nutritional uptake study. The recommendation was to use the 4th leaf of four years old palms, 9th leaf of 5-7 years old and 14th leaf of older palms.

**11. EFFECT OF FERTILISER APPLICATION
ON NUTRITIONAL UPTAKE OF COCONUT PALM.**

Ramanandan and Pillai (1974) reported on the effect of continuous cultivation and manuring on the leaf nutrient composition at three permanent observational plots.

(A) In First plot with no cultivation and no manuring. (B) In second with regular cultivation but no manuring (C) The third with regular cultivation and manuring, have been maintained at the central plantation crop Research Institute since 1919. Analysis of leaf samples collected during both March and July showed that the leaves of the palms in treatments (C) contained significantly higher amount of Nitrogen (1.90% dry matter in summer and 1.92% in rainy season) and potash (0.40 and 1.09% respectively).

Davi and Velayutham (1977) studied on the leaf Nutrient concentration following fertiliser application.

Monitoring Nutrient concentration in the 14th leaf immediately after N.P.K. application to the soil. It was found that maximum concentration was obtained on the 5th day after the application for Nitrogen and Phosphorus and on the 2nd day for potash. The increase in Nitrogen, Phosphorus, Potash concentration in unopened leaves were 31-36%, 14-25% and 27-60%

respectively. Similar increases in the 14th leaf were 19.32%, 29.67% and 32.51% respectively. Nitrogen and phosphate values were similar to the critical levels fixed by Fremont whereas calcium was lower and potassium was much higher in the oldest green leaves.

12. EFFECT OF FERTILISER APPLICATION ON GROWTH AND FRUIT BEARING.

Ouvrier M. Ochs R. (1980) studied on the removal of N, P, K, Ca, Mg, Na, Cl, S in harvested bunches was measured for 10 hybrid coconut palms, Port-Bout 121 (yellow Dwarf x West African Tall) growing in a very sandy soil. K and Cl contents were particularly high in all parts of the bunch except the copra which however was rich in N and P. There was little seasonal change in mineral uptake except in trace elements. In this soil, removed K had been adequately replaced by applied fertilisers but removed N had not. Equations relating the removal of the 8 nutrients to copra yields are given.

Singh K.D., Velayutham M. (1980) have described the methods and results of leaf and soil analysis. Data are tabulated on the maximum, minimum and average N, P, K, Na, Ca, Mg and Iron contents in leaf samples taken at 10 localities. The results indicated that 44% of the

palm on the ISLANDS were severally affected by K deficiency and that 50% of the palms would respond to N fertilisation.

Magat S.S., Maravilla J.M., Padrones G.D. (1981) studied on 3 year trials with mature bearing palms of the coconut CV local Tali Laguna the palms received different rates and combinations of N, CL and S fertilisers. The highest increased in Nut (32-34/palm) and copra yield (10-11 Kg/Palm) over the control (53.6 nuts/palm and 9 kg/palm) were obtained from palms receiving 1.8 Kg ammonium sulphate + 2 Kg HCL + 4 Kg Dolomite or 1.8 Kg Ammonium sulphate + 2 Kg Na CL/palm annually.

Tenorio Z., Rocha Filto J.V., Dec., Gomes I.F.P., Sarruge J.R. (1981) have studied on 4-years trials at 3 localities with 15 year old coconuts the tree received 0.4 Kg N, 0.18 Kg P_2O_5 , 1.2 Kg K_2O + 20 Kg F.Y.M./tree. The yield at the 3 localities which ranged from 631 to 794 coconuts/ha in the first year was increased to 1195-2283 coconuts/ha in the second year yield data for all years are tabulated.

Louis I.N., Krishnaswamy V., Venkateswaran A.N., Vijayan K.P. (1982) have carried out long term trials (1961-1977) with the coconut CV east coast tall spaced at 6.1 x 6.1 m, 7.6 x 7.6 m or 9.1 x 9.1 m $N.P_2O_5$ and K_2O were applied at 45-340: 45-227% 90-454 gm/palm per year (single dose or 90-680: 90-454: 180-908% gm/palm per year (double dose). Data are tabulated on the effect of treatments on the root system, trunk girth, trunk height, number of leaves. Flowering, fruit set and nut yield. Mean yield for the years 1973-1977 was highest (9078 nuts/ha) on the closest spaced plots receiving double N.P.K. rates.

Magat S.S., Maravilla J.N., Padrones G.D. (1984) reported the combined applications of N, CL and S resulted in a significant annual increase of 32-34 nuts/palm over the control. They similarly caused the increase on weight of copra as early as two years from initial fertiliser application. Copra per nut increased by 27.34% and copra yield per palm increased by 10.11 kg. The study also revealed that leaf CL and S were both strongly and positively correlated with nut production and copra yields. While only leaf CL and Ca were highly

significantly correlated with copra per nut. The application of (a) 8 Kg ammonium sulphate (21-0-0) + 2 Kg sodium chloride or (b) 1.8 Kg ammonium sulphate + 2 Kg potassium chloride (0-0-60) per tree/year is suggested.

13. FERTILISER REQUIREMENT OF COCONUT PALM.

Tenorioz et al (1979) reported on the effect of application of minerals and organic fertilisers on the productivity of tall coconut. For 15 years old palm, 0.4 Kg Nitrogen, 0.18 Kg phosphate, 1.2 Kg Potash + 20 Kg of F.YM per tree gave the highest yield.

Manicot, Ollagnier and Ochy (1979) reported as the mineral Nutrition and Fertilisation of coconut around the world. They described the deficiency symptoms due to lack of potash, calcium, magnesium, sodium and chlorine. The results of numerous national experiments of a number of countries were also given.

Sri Lanka coconut Research Institute gave some salient features on manuring of adult coconut palms in 1977. Each elements of nitrogen, phosphate, potash and magnesium was applied separately which showed

differential yields, but the best results were obtained by applying NPK with magnesium. The effects of using $(\text{NH}_4)_2\text{SO}_4$ and/or urea on different soils were reported. Techniques, economics, method and times of fertiliser application were also discussed.

Ramakrishnan and Pillai (1980) studied the role of Mg in coconut nutrition. Application of Mg to coconut palms growing on sandy soil increased trunk girth, total number of leaves, palm height, flowering percentage and cumulative nut yield (1976-78) from 453 in control to 667 nuts/palm.

Dunmore (1957) mentions that phosphoric acid promotes the absorption of potash by pine apple plants.

Sicaris and Young (1946) found that the absorption of nitrogen by the roots of pine apple is greater with a large supply of potassium than with a low potassium content of the nutrient solution.

Almadan and Santiago (1980) found that a spacing of 80 x 80 cm resulted in greater seedling girth at seven months after transplanting, higher number of split leaves and increased growth vigour. Application of nitrogen potash at 30:30, 60: 50 or 90:86 g per seedling also had beneficial effects on the growth of palms.

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CHAPTER III

MATERIALS AND METHODS

MATERIAL AND METHODS

3.1 Experimental site.

The investigation reported in the thesis is carried out at the All India Co-ordinated Coconut Improvement Project, Konark (OUAT) of the Orissa University of Agriculture & Technology, Bhubaneswar. Konark is situated near the sea-shore of Bay of Bengal, approximately at four Km distance from the Sun Temple in the district of Puri (Orissa).

3.2 Soil .

The soil of the Experimental Plot is completely sandy in nature having very low organic matter and water holding capacity. The pits were 1/3 filled up with soil and organic manure before transplanting of coconut seedlings. The rest portion of the pit was filled up in the subsequent years. The physical and chemical composition of the soil was determined by mechanical and chemical analysis, collected from the surface soil and sub-soils, following the approved soil sample collection technique. The data re presented in the Table Kb.1.

TABLE NO. I

PHYSICAL AND CHEMICAL COMPOSITION OF THE SOIL

Sl. No.	Soil characteristic.	Number of soil sample collection.		
I	2	3	4	5
1.	Depth from which sample was taken.	30 cm	60 cm	90 cm
2.	Mechanical composition.			
	Sand	89.4%	89.6%	92.6%
	Silt	4.3%	3.6%	0.8%
	Clay	7.3%	6.6%	6.6%
3.	Texture	Sandy	Sandy	Sandy
4.	P. H.	6.20	6.50	6.50
5.	Available			
	N	112-S ppm	100 ppm	80 ppm
	P	3.5 ppm	3.2 ppm	2.3 ppm
	K	55 ppm	47.5 ppm	42.5 ppm
6.	Organic carbon.	0.45%	0.4%	0.32%

3.3 History of the plot.

The All India Co-ordinated Coconut Improvement Project (I.C.A.R.) laid out an N, P, K trial on coconut at Konark with a view to know the significance of fertiliser combinations to obtain the best yield under Orissa Agroclimatic condition. The coconut seedlings of variety Sakhiyopal Local Tall were planted on 16.9.75. The application of fertilisers was taken up one year after planting. The present study on nutritional uptake by coconut palm is taken up with the existing palms of the fertiliser trial during the period from December, 1986 to May, 1987. The usual practice of a fertiliser application for the trial is to apply the fertiliser in two split doses during the year i.e. $1/3$ of the dose in June and rest $2/3$ in the month of January. Neither any intercropping nor covering cropping is practiced. No organic manure are applied in this trial except the chemical fertilisers. Irrigation is given at interval of fifteen days during summer right from March.

3.4 Details of experiment.

(a) Design and Layout.

The design adopted for the Experiment was 3^3 confounded factorial design. In addition to the 27 treatments under trial, nine extra treatments were

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included namely - $N_0 P_0 K_0 = 3$, $N, P, K + Ca + Mg = 3$

$N_3 P_3 K_3 + Ca + Mg = 3$.

(b) Layout.

(Particulars regarding the layout
of the Experiment).

Number of Blocks = 3

Number of treatments = $27 + 3 + 6 = 36$

(Additional 3 treatments in each Block)

Number of Plots or treatment per block = $9 + 3 = 12$
(Extra 3 plots/Block)

Total number of plots = 36

Number of Plants per plot = 6 palms/plot
(Each having same treatment)

Gross plot size = 75 ft. x 50 ft.

Spacing = 25 ft. x 25 ft.

Total area of the experimental field including
border rows = 4 acres.

FOUR BORDER ROWS

BLOCK III

BLOCK II

BLOCK I

FIVE BORDER ROWS

$N_3 P_2 K_3$ 36	$N_0 P_0 K_0$ 30	$N_1 P_2 K_2$ 24	$N_3 P_1 K_2$ 18	$N_3 P_1 K_3$ 12	$N_2 P_3 K_3$ 6
$N_1 P_2 K_1$ 35	$N_1 P_1 K_2$ 29	$N_3 P_3 K_3 + \text{Camp}$ 33	$N_2 P_2 K_3$ 17	$N_1 P_2 K_3$ 11	$N_3 P_3 K_3 + \text{Camp}$ 5
$N_1 P_3 K_3$ 34	$N_3 P_3 K_2$ 28	$N_2 P_1 K_1$ 22	$N_3 P_2 K_1$ 16	$N_1 P_1 K_1$ 10	$N_1 P_1 K_1 + \text{Camp}$ 4
$N_3 P_3 K_3 + \text{Camp}$ 33	$N_2 P_3 K_1$ 27	$N_0 P_0 K_0$ 21	$N_3 P_3 K_3$ 15	$N_0 P_0 K_0$ 9	$N_2 P_2 K_1$ 3
$N_2 P_2 K_2$ 32	$N_1 P_1 K_1 + \text{Camp}$ 26	$N_2 P_3 K_2$ 20	$N_1 P_1 K_3$ 14	$N_3 P_2 K_2$ 18	$N_1 P_3 K_2$ 2
$N_3 P_1 K_1$ 31	$N_2 P_1 K_3$ 25	$N_1 P_3 K_1$ 19	$N_1 P_1 K_1 + \text{Camp}$ 13	$N_2 P_1 K_2$ 7	$N_3 P_3 K_1$ 1

TOW BORDER ROWS

ONE BORDER ROWS

3³ FACTORIAL EXPERIMENT (CONFOUNDING)

PLOT No 1-36

No OF BLOCKS = 3

No OF TREATMENTS = 27 + 3 (CONTROLE) + 6 (Camp) = 36

No OF PLOTS PER BLOCK = 12

No OF PLAMS PER PLOT = 6

TABLE NO.2

Randomised distribution of treatments in different
Blocks.

Plot No.	<u>Block No. I</u>			<u>Block No. II</u>			<u>Block No. III</u>		
	N	P	K	N	P	K	N	P	K
1	3	3	1	1	1	1+Camg	2	1	3
2	1	3	1	1	1	3	1	1	1+Camg
3	2	2	1	3	3	3	2	3	1
4	1	1	1+Camg	3	2	1	3	3	2
5	3	3	3+Camg	2	2	3	1	1	2
6	2	3	3	3	1	2	0	0	0
7	2	1	2	1	3	1	3	1	1
8	3	2	2	2	3	2	2	2	2
9	0	0	0	0	0	0	3	3	3+Camg
10	1	1	1	2	1	1	1	3	3
11	1	2	3	3	3	3+Camg	1	2	1
12	3	1	3	1	2	2	3	2	3

3.5 Forms of manures and fertilisers used.

Each plots except 0 levels were provided with N, P, K at different doses basing on treatment as mentioned in Table No.3 in the Form of Urea, single super phosphate and muriate of potash Ca 0 and Mg 0 were applied alongwith different doses of N, P, K as required in the experiment.

The Nutrient contents of these fertilisers
were given in Table-3.

TABLE NO.3

NUTRIENT CONTENT OF FERTILISERS

Name of manures and fertilisers.		Nutrient content in percentage.
1. Urea	Nitrogen	46%
2. Single super phosphate	$P_2 O_5$	16%
3. Muriate of potash	$K_2 O$	60%
4. Ca O	Ca	55.5%
5. Mg O	Mg	42.85%

27 of different NPK combination

3 of Zero level ($N_0 P_0 K_0$)

3 of treatment - $N_1 P_1 K_1$ + Ca Mg

3 of treatment - $N_2 P_2 K_2$ + Ca Mg

Total 36 treatments.

TABLE NO.4

LEVELS OF DIFFERENT TREATMENT USED

<u>(a) Level of Nitrogen.</u>	<u>Level of Phosphate (b)</u>	<u>Level of Potash (c)</u>
N_0 Control 0 gm N/Plant	P_0 = Control 0 gm P_2O_5 /Plant	K_0 = Control 0 gm K_2O /Plant
N_1 = 500 gm N/Plant	P_1 = 250 gm P_2O_5 /Plant	K_1 = 750 gm K_2O /Plant
N_2 = 1000 gm N/Plant	P_2 = 500 gm P_2O_5 /Plant	K_2 = 1250 gm K_2O /Plant
N_3 = 1500 gm N/Plant	P_3 = 750 gm P_2O_5 /Plant	K_3 = 1750 gm K_2O /Plant

Additional treatments

150 gm Ca O/Plant

300 Mg O/Plant

2/3rd dose was applied to the plant in a shallow trench method around the base of the palm at a radius of 2 metres from the trunk in second week of January 1987. 1/3rd dose was applied in the month of June, 1986.

3.6 Schedule of application of fertilisers.

The All India Co-ordinated Coconut Improvement Project has fixed schedule of application fertilisers in two split doses i.e. (a) 1/3rd dose was applied in June, 1986 (b) 2/3 dose was applied in second week of January, 1987. The experiment observations on Nutritional uptake by coconut palm is therefore confined to the second dose (2/3rd dose) of fertiliser application only (Table-7).

TABLE NO.5

Nutritional Schedule (General)

Sl. No. Type of manure and fertilisers.	Dose in grams of Nutrient/ Plant.	Quantity of fertiliser applied/Plant.
1. Urea	500 gm N 1000 gm N 1500 gm N	1 Kg 657 gm Urea 2 Kg 175 gm -do- 3 Kg 260 gm -do-
2. Single super phosphate.	250 gm P ₂ O ₅ 500 gm P ₂ O ₅ 750 gm P ₂ O ₅	1 Kg 562 gm SSP 2 Kg 125 gm -do- 4 Kg 685 gm -do-
3. Muriate of Potash.	750 gm K ₂ O 1250 gm K ₂ O 1750 gm K ₂ O	1 Kg 250 gm 2 Kg 083 gm -do- 2 Kg 916 gm -do-
4. CaO	150 g CaO	
5. MgO	300 g MgO	

The quantities of nutrients applied during
the year are detailed below.

TABLE NO.6

(a) June application of nutrients.

Sl. No.	Levels of Nitrogen in gms of N/Plant.	Levels of P_2O_5 in gm of P_2O_5 per plant.	Levels of K_2O in gm of K_2O per plant.
1.	$N_0 = 0$	$P_0 = 0$	$K_0 = 0$
2.	$N_1 = 166$	$P_1 = 83$	$K_1 = 250$
3.	$N_2 = 332$	$P_2 = 166$	$K_2 = 416$
4.	$N_3 = 500$	$P_3 = 250$	$K_3 = 583$

Ca 0 = 50 gm/plant

Mg 0 = 100 gm/plant.

TABLE NO.7

(b) January application of nutrients.

Sl. No.	Levels of Nitrogen in gms of N/plant.	Level of P_2O_5 gm of P_2O_5 per plant.	Level of K_2O in gm of K_2O per plant.
1.	$N_0 = 0$	$P_0 = 0$	$K_0 = 0$
2.	$N_1 = 334$	$P_1 = 167$	$K_1 = 500$
3.	$N_2 = 668$	$P_2 = 334$	$K_2 = 934$
4.	$N_3 = 1000$	$P_3 = 500$	$K_3 = 1167$

Ca 0 = 100 gm/plant

Mg 0 = 200 gm/plant.

Date of fertiliser application 10.1.87.

TABLE NO. 2

FERTILISER SCHEDULE FOR JANUARY 1987

Sl. No.	Nutrient applied	Fertiliser applied
No.	per plant in gm.	per plant in gm.

1.	(N) N_1 334	726 gm Urea
	N_2 668	1 Kg 452 gm Urea
	N_3 1000	2 Kg 173 gm -do-
2.	(P_2O_5) P_1 167	1 Kg 043 gm S/P
	P_2 334	2 Kg 087 gm -do-
	P_3 500	3 Kg 125 gm -do-
3.	(K_2O) K_1 500	833 gm MOP
	K_2 834	1 Kg 390 gm -do-
	K_3 1167	1 Kg 945 gm -do-
4.	CaO - 100 gms	
5.	Mg O - 200 gms.	

3.7 Sample collection.

In each plot, six plants are maintained out of which one was selected as observation plant. So totally 36 palms were selected out of 216 palms in three blocks. Leaf samples were collected from 36 labeled palms for the laboratory estimations. Soil samples at different depth (30 cm, 60 cm = 90 cm)



Sakhigopal Local Tall

were collected at a distance of 1.5 metre from the base of the palm. Growth character like height of plant, collar growth and number of leaves and also number of nuts in palm were taken. First leaf and soil sample were taken before application of fertiliser in December to know the availability of nutrients (N. P. K.) status. Then leaf soil samples were taken twice after application of fertilisers to know the rate of nutrient uptake by the coconut palm.

<u>Sample Number.</u>	<u>Date of collection.</u>	<u>Interval</u>
A	11.12.86 to 17.12.86	One month before fertiliser application.
B	12.2.87 to 18.2.87	One month after fertiliser application.
C	9.4.87 to 15.4.87	Two months after first sample collection.

(b) Experimental informations.

Variety = Sakhigopal Local Tall

Date of planting = 16.9.1975

Stage of plant = Very few plants are in flowering and Fruit set phase at the time of first sample collection.

(c) Sampling Technique.

Some of the selected palms in the experiment had less than 14 leaves and minimum of 9 leaves. So to maintain equality the ninth leaf of the Palm was selected for leaf analysis as against 14th leaf as suggested by Provet et al (1962) (counting No.1 the most recent unfolded leaf). Two pinnae were selected from each side of the main rachis or from the middle position of the leaf. From each leaflet or pinnae, the middle portion (central 4" or 10 cm) was selected including rachis and taken for chemical analysis.

(d) Sampling Technique (Soil).

The soil samples were taken from 3 spots (equal distance) at a distance of 1.5 metre from the Base of the Palm. Soils of 30 cm depth from 3 spots were collected by soil Augur, dried, mixed through only 250 gm soil was taken in polythene bag properly levelled for analysis. Like wise soil sample of 60 cm and 90 cm was collected separately. Soil samples were collected 3 times (a) six months after first split of fertiliser application (b) one month after

second sligt application of fertiliser (c) three months after fertiliser application.

(e) Growth observations .

(i) Height

Plant height refers to the height of the plant from the ground level to the Jip of the upper most leaf of the tree and accordingly the height of the palm was recorded in metres.

(ii) Girth

The Girth of the palm was measured one foot above the ground level in metres of the selected sample palms.

(iii) Number of leaves.

Number of functioning leaves were recorded before application of fertilisers. The same observations were also taken thrice after application of fertilisers.

(iv) Fruit bearing

Observations were taken on fruit bearing characters such fruit set and fruit drops before and after application of fertilisers of the selected palms.

3.8 Leaf analysis procedure.

The collected leave samples were cut into small pieces along with the rachis by a sharp cutture. Then the leave samples were kept in the oven (in paper trays) for minimum 72 hours to dry them properly. Completely oven dried samples were grinded by an electrical grinder using 40 mesh sieve. These dried and ground leaf samples were kept separately with proper levelling in paper packets.

(A) Estimation of Nitrogen (Kjeldahl method).

(1) Required Reagents.

(a) Concentrated sulphuric acid (SP.Gr.1.840).

(b) Digestion mixture II Grind separately 10 parts of A.G. potassium sulphate and one part of A.R. Cupric sulphate to a fine powder in a porcelain mortar and pestle. Mix these two powder chemicals thoroughly on a clean butter paper and keep in a clean and dry wide mouth bottle.

(c) Mixed Indicator - To 0.5 gm of bromocresol green and 10 ml of 0.1 N sodium hydroxide and made upto 500 ml with distilled water. To 0.75 gm of methyl red, add 7.5 ml of 0.1 N sodium hydroxide and

made the volume upto 250 ml with distilled water.
Mix 150 ml of the bromo cresol green solutions with
50 ml of methyl red solution and made upto 400 ml
with ethanol. Store in a brown stoppered bottle.

(d) Standard 0.02 N H_2SO_4 .

(d) Boric Acid solution.

Dissolve 10 mg reagent grade boric acid in
about 200 ml of boiling water and made upto 500 ml
in a volumetric flask. To this add 50 ml mixed
indicator as mentioned above and store in a coloured
win chester bottle.

(f) Sodium hydroxide 50% (NaOH).

Add slowly with stirring one Kg of sodium
hydroxide flakes to 2000 ml of distilled water in a
porcelain pot and allow to cool. Then filter through
glass wool and store in a winchester bottle.

(g) Salicylated sulphuric acid.

Prepare by adding 10 gm of (R.G.) salicylic
acid to 500 ml of concentrated sulphuric acid (Sp.gr.
1.840) and stir till the solid dissolve.

Procedure.

(a) Digestion

Weight accurately 0.1 gm of the dried and ground plant samples (Leaf) or 0.25 gm of green materials into a 30 ml clean and dry pyrex made Kjeldahl flask. Add to it a quarter tea spoonful of digestion mixture (Reagent 2) and 3.4 ml of solicylated sulphuric acid followed by the addition of a lead of sodium thiesulphate. Slowly heat the flask till the frothing ceases and then heat strongly till the contents in the flask become clean and bluish green, continue heating for another 15 minutes to ensure complete digestion. Then cool and dilute with 15 ml of distilled water. Swirl and allow to stand till the contents are cold.

(b) Distillations.

Transfer the whole digestion with two or three washings into the vacuumantle of the micro Kjeldahl distillation apparatus. Add 10 to 15 ml of 50% sodium hydroxide solution (Reagent F) and steam distill the ammonia for 3^{to}5 minutes in to 20 ml of boric acid solution taken in a 100 ml conical flask.

(c) Titration .

Titrate the resulting ammonia against standard 0.02 N (H_2SO_4) sulphuric acid solution to a pink end point.

(d) Standard 0.02 N H_2SO_4

10 ml of NH_4SO_4 was made upto the mark of a 500 ml volumetric flask by distilled water.

Calculation .

$$1 \text{ ml of } 0.02 \text{ } \text{NH}_4\text{SO}_4 = 0.00028 \text{ gm N.}$$

$$\text{Percentage of N} = \frac{\text{Grams of Nitrogen} \times 100}{0.1 \text{ mg}}$$

$$\text{Gm of N} = \text{Reading} \times \text{Factor} = \frac{4.5 \times 0.00028 \times 100}{0.1}$$

UPTAKE OF NITROGEN

Leaf samples were collected at three different dates to know the uptake of Nitrogen for all the treatments under trial. The leaf samples were chemically analysed following the procedure described in the previous chapter and the analysis report has been presented in Table No.9.

TABLE NO.9

Effect of N,P,K, Ca,Mg application on uptake of Nitrogen

..

Sl. No.	Treatments.	Uptake of Nitrogen in percentage		
		One month before 1/3 dose ferti-liser applica-tion.	One month after 2/3 dose ferti-liser applica-tion.	Two months after 1st sample collection.
1.	N ₁ P ₁ K ₁	1.400	1.428	0.868
2.	N ₁ P ₁ K ₁	1.148	1.176	1.008
3.	N ₁ P ₁ K ₂	1.148	1.652	1.120
4.	N ₁ P ₁ K ₃	1.372	1.652	1.036
5.	N ₁ P ₂ K ₂	1.456	1.652	1.372
6.	N ₁ P ₂ K ₃	1.288	1.344	1.064
7.	N ₁ P ₃ K ₁	1.204	1.372	1.316
8.	N ₁ P ₃ K ₂	1.288	1.400	1.120
9.	N ₁ P ₃ K ₃	1.652	1.904	1.143
10.	N ₂ P ₁ K ₁	1.232	1.288	0.980
11.	N ₂ P ₁ K ₂	1.252	1.764	0.840
12.	N ₂ P ₁ K ₃	1.232	1.344	1.143
13.	N ₂ P ₂ K ₁	1.428	1.792	1.260
14.	N ₂ P ₂ K ₂	1.120	1.372	1.120
15.	N ₂ P ₂ K ₃	1.316	1.400	0.980
16.	N ₂ P ₃ K ₁	1.372	1.400	1.204
17.	N ₂ P ₃ K ₂	1.204	1.232	1.008
18.	N ₂ P ₃ K ₃	1.288	1.484	1.289
19.	N ₃ P ₁ K ₁	1.400	1.600	1.232
20.	N ₃ P ₁ K ₂	1.400	1.456	1.232
21.	N ₃ P ₁ K ₃	1.008	1.148	0.868
22.	N ₃ P ₂ K ₁	1.149	1.680	1.148
23.	N ₃ P ₂ K ₂	1.108	1.316	1.344
24.	N ₃ P ₂ K ₃	1.344	1.372	1.148
25.	N ₃ P ₃ K ₁	1.232	1.596	1.176
26.	N ₃ P ₃ K ₂	1.372	1.400	1.456
27.	N ₃ P ₃ K ₃	1.372	1.400	1.176
<u>Control</u>				
28.	N ₀ P ₀ K ₀ (Block-I)	1.120	1.092	0.568
29.	N ₀ P ₀ K ₀ (Block II)	1.036	0.924	0.700
30.	N ₀ P ₀ K ₀ (Block III)	1.008	0.952	0.728
31.	N ₀ P ₀ K ₀ CaMg (Block I)	1.512	1.540	1.120
32.	N ₀ P ₀ K ₀ CaMg (B. I)	1.008	1.260	0.840
33.	N ₀ P ₀ K ₀ CaMg (B. III)	1.232	1.428	1.232
34.	N ₀ P ₀ K ₀ CaMg (B. I)	1.876	1.932	1.423
35.	N ₀ P ₀ K ₀ CaMg (B. II)	1.232	1.372	1.120
36.	N ₀ P ₀ K ₀ CaMg (B. III)	1.560	1.596	1.372

Wet digestion of the plant material
for the estimation of P and K.

Procedure

(a) Predigestion .

Weigh accurately 1 gm of the dried and ground plant material into 100 ml clean and dry conical flask (made of pyrex glass) add to it 20 ml of AR Nitric Acid and leave over night.

(b) Digestion.

Next day add 3 ml of perchloric acid and mix by gentle swirling glass leads may be added to check bumping heat the contents slowly. After the initial reaction is complete (which is indicated by disappearance of the copious brown fumes the heat is to be increased, continue heat till white fumes appear. This occurs when all the HNO_3 has evaporated and the oxidation with perchloric acid completed. Then cool and treated as described below.

(c) Filter and Dilution.

After digestion is completed, cool the contents, wash the sides of the flask with about 25-30 distills water, wash and filter into 100 ml volumetric flask. Wash the filter paper several times

with warm distilled water into the flask make the volume upto the mark. This solution can be designated as stock solution and should be kept for the estimation of P and K.

Estimation of Phosphorus.

(Amino Naphthal sulphuric acid method).

Reagents

(a) Sulphomolybdic Acid Solution.

Dissolve 25 ml of AR ammonium molybdate in 150 ml of distilled water heated to about 60 C and cool. To 150 ml of distilled water add 136 ml of concentrated sulphuric acid AR (Sp.gr 1.840) and cool mix both the solutions, cool and make upto 500 ml with distilled water and store in a reagent stoppered bottle.

(b) Amino naphthal sulphuric acid solution.

Mix thoroughly in dry condition 2.5 gm 1 amino, 2 naphthal-4 sulphuric acid, 5 gm sodium sulphate (Na_2SO_4) and 146.25 gm sodium metabisulphate ($\text{Na}_2\text{S}_2\text{O}_5$) grind the mixture to a fine powder in a porcelain mortar and pestal and store in a tightly stoppered brown bottle. Dissolve 8.0 gm of the

mixture powder in 50 ml warm distilled water and allow the solution to stand over night store. It is in a glass stoppered bottle. The solution can be kept only for 2-3 weeks.

(c) Standard phosphorus solution.

Dissolve exactly 0.2132 gm of AR Ammonium phosphate $(\text{NH}_4)_2 \text{H}_2\text{P O}_4$ may be taken in place of $(\text{NH}_4)_2 \text{HPO}_4$. This solution contains 50 mg of P per litre.

Dilute the standard stock solution to lines and develop colour in aliquots of 2, 4, 6, 8, 10, 12, 14, 16 and 20 ppm of this diluted solution according to the procedure detailed below.

Procedure

Take 5 ml out of 100 ml of the diluted plants digest in a 100 ml volumetric flask. To this add 5 ml of sulphomolybdic acid solution. Shake and dilute to about 80 with distilled water. Then develop colour by adding 5 ml aminonaphthol sulphuric acid solution. Make the contents 100 ml by distilled water and shake gently. Take reading the blue colour in a photo electric colorimeter using 660 read filter after 10 minutes with the blank adjusting

the blank to zero. The blank is taken taking 5 ml of distilled water in place of the aliquot. Read the Mg of 'P' in the sample from the reading and standard curve.

Calculation

From the reading in the colorimeter the percent transmittance (or) optical density was noted. A standard curve was drawn against the known concentration of phosphorus. The sample reading were determined in ppm from the standard graph.

$$\text{Percentage of P} = \frac{\text{ppm of P} \times 100 \times 100}{5 \times 10 \times \text{Wt of sample in gm.}}$$

Uptake of phosphorus.

At three different dates, leaf samples were collected to know the uptake of phosphorus for all treatments. The samples were analysed and the percentage of phosphorus have been presented in Table No. 10.

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STANDARD GRAPH FOR PHOS WTRUS

(1 and 2nd sample)

<u>ppm of P.</u>	<u>Colorimeter reading</u> <u>(Percentage of transmittance).</u>	<u>Absorbance.</u>
0	100	0
1	86	65.5
2	74	130.8
4	57	244.1
6	45	346.5

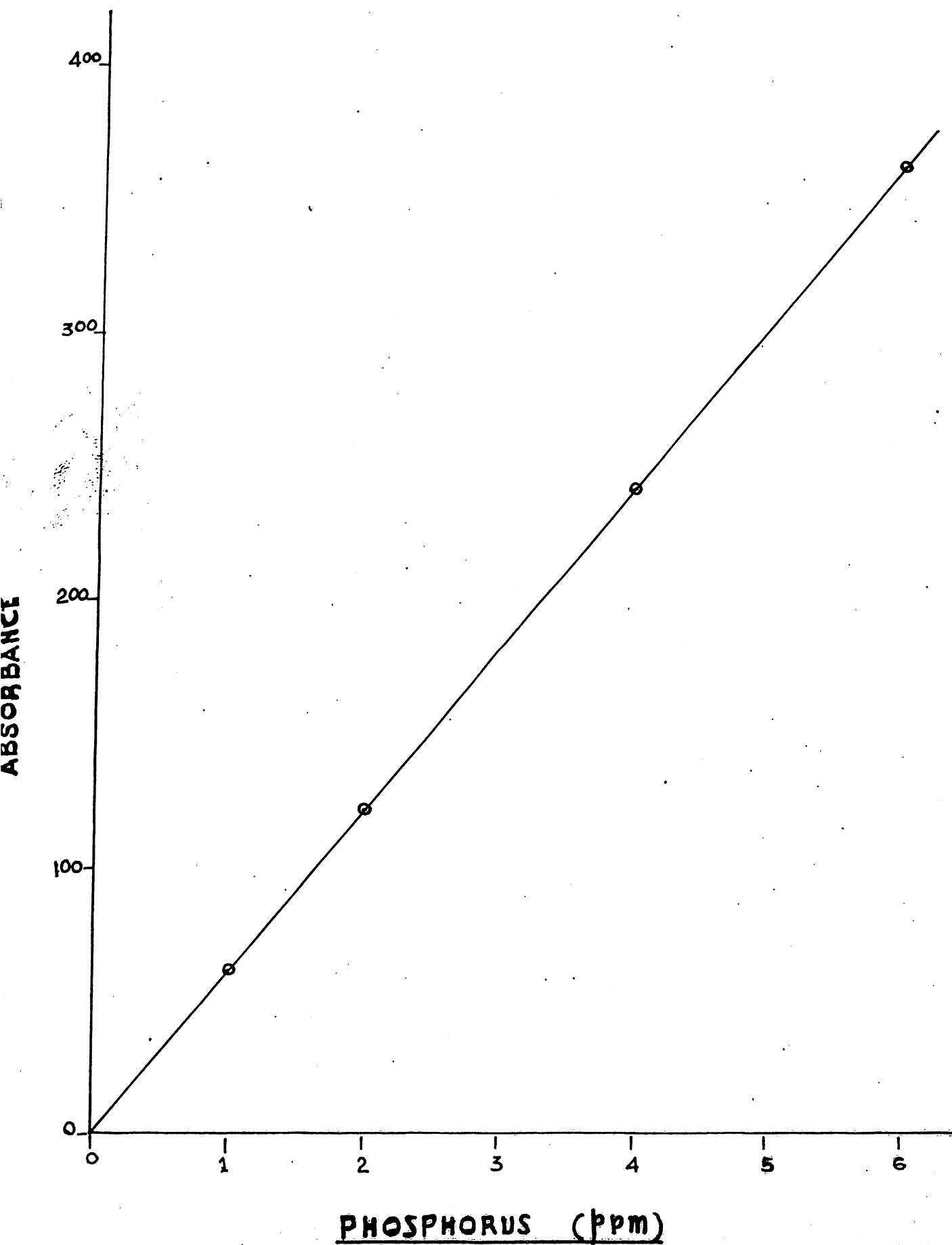
STANDARD G

(3rd sample)

<u>ppm of P.</u>	<u>TS</u>	<u>Absorbance</u>
0	100	0
2	92	36.2
4	84	75.7
8	71	148.7
12	60	221.9
16	50	301.0
20	42	376.7

FIG. - .2

PHOSPHORUS STANDARD GRAPH (A)



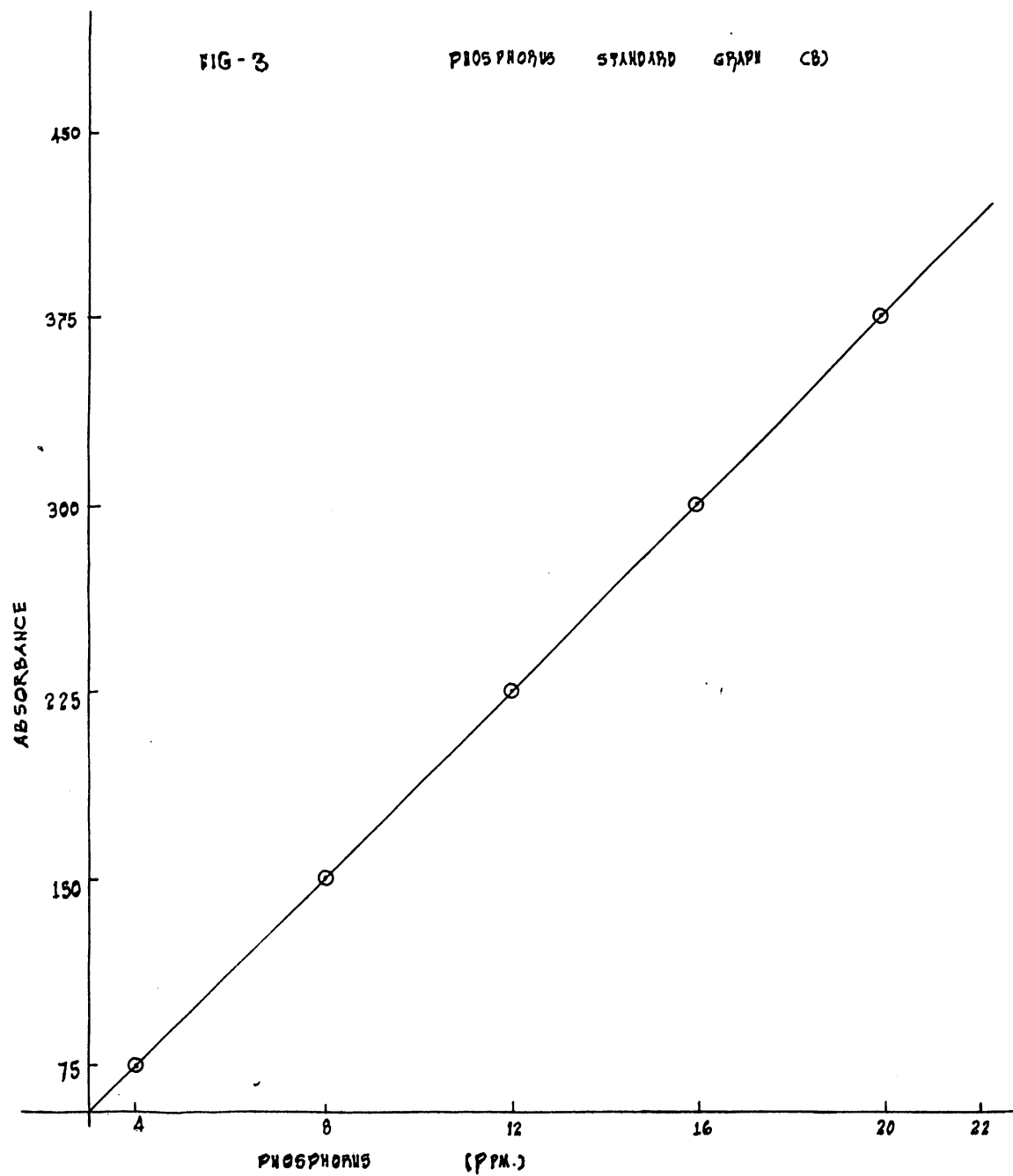


TABLE NO.10

Effect of N,P,K,Ca,Mg application on uptake of Phosphorus.

Sl. No. Treatments.	Uptake of phosphorus in percentage.		
	1st date.	2nd date.	3rd date.
1. N ₁ P ₁ K ₁	0.11	0.12	0.95
2. N ₁ P ₂ K ₁	0.11	0.12	0.21
3. N ₁ P ₃ K ₁	0.12	0.14	0.46
4. N ₁ P ₄ K ₁	0.16	0.17	0.26
5. N ₁ P ₅ K ₁	0.16	0.18	0.33
6. N ₁ P ₆ K ₁	0.13	0.90	1.03
7. N ₁ P ₇ K ₁	0.12	0.17	0.38
8. N ₁ P ₈ K ₁	0.12	0.15	0.96
9. N ₁ P ₉ K ₁	0.15	0.16	0.20
10. N ₁ P ₁₀ K ₁	0.14	0.15	0.26
11. N ₁ P ₁₁ K ₁	0.11	0.12	1.03
12. N ₁ P ₁₂ K ₁	0.13	0.14	0.25
13. N ₁ P ₁₃ K ₁	0.12	0.14	1.08
14. N ₁ P ₁₄ K ₁	0.15	0.17	0.22
15. N ₁ P ₁₅ K ₁	0.14	0.14	0.39
16. N ₁ P ₁₆ K ₁	0.14	0.16	0.32
17. N ₁ P ₁₇ K ₁	0.12	0.14	0.26
18. N ₁ P ₁₈ K ₁	0.14	0.15	1.12
19. N ₁ P ₁₉ K ₁	0.13	0.14	0.21
20. N ₁ P ₂₀ K ₁	0.16	0.16	0.27
21. N ₁ P ₂₁ K ₁	0.11	0.12	0.59
22. N ₁ P ₂₂ K ₁	0.15	0.15	0.41
23. N ₁ P ₂₃ K ₁	0.14	0.15	1.00
24. N ₁ P ₂₄ K ₁	0.12	0.14	0.23
25. N ₁ P ₂₅ K ₁	0.12	0.13	1.08
26. N ₁ P ₂₆ K ₁	0.15	0.16	0.27
27. N ₁ P ₂₇ K ₁	0.14	0.14	0.41
28. N ₁ P ₂₈ K ₁ (Block-I)	0.10	0.11	0.68
29. N ₁ P ₂₉ K ₁ (Block-II)	0.12	0.13	0.67
30. N ₁ P ₃₀ K ₁ (Block-III)	0.12	0.13	0.67
31. N ₁ P ₃₁ K ₁ (Block-I)	0.12	0.14	0.90
32. N ₁ P ₃₂ K ₁ (Block-II)	0.10	0.15	0.85
33. N ₁ P ₃₃ K ₁ (Block-III)	0.11	0.14	0.27
34. N ₁ P ₃₄ K ₁ (Block-I)	0.16	0.19	1.08
35. N ₁ P ₃₅ K ₁ (Block-II)	0.14	0.16	0.26
36. N ₁ P ₃₆ K ₁ (Block-III)	0.17	0.21	0.24

(C) Estimation of potassium
(By Flame Photometer).

Reagents.

Standard K solution and preparation of

(a) Standard curve

Prepare a solution of pure KCl in distilled water which will contain 1000 Mg K in one litre. Dilute this 10 times with distilled water. From this take 2, 4, 6, 8, 10, 12, 14, 16, 18 and 20 ml of liqure in 100 ml volumetric flask and make the volume to the mark. Shake and take the reading in the Flame Photometer K filter.

(b) Procedure for the samples.

Take 5 ml of the liquid from the diluted 100 ml of the stock solution in a 100 ml volumetric flask. Make up the volume with the distilled water.

(c) Procedure for the Reading.

Potassium Filter was fitted to the instrument. The gas pressure was fixed at 7 PSI Red Filter was used having 768 blue wave length. The burner was igrated. The Galvanometer was gently

made into the working position. Distilled water was kept near the end of the wire to adjust the zero and 100 was set in the highest concentration, (10 ppm K in this case). After standardisation, the reading for different known samples were taken and the standard curve was prepared. From the sample reading, computed on the standard graph. The value in ppm of the unknown samples were obtained as given below :

Calculation of percentage of K =

$$\frac{\text{ppm of K} \times 100 \times 100}{5 \times 10 \times \text{Wt of the sample in gms.}}$$

Uptake of Potash

The leaf samples were collected at three different dates to know the uptake of potash in all treatments. The samples were analysed and the uptake of potash was obtained by flame photo meter reading. The percentage of potash have been presented in Table No.11.

STANDARD GRAPH FOR K

<u>ppm for K</u>	<u>Photometer reading</u>
0	0
1	20
2	40
3	60
4	80
5	100

FIG. 4. POTASSIUM STANDARD GRAPH.

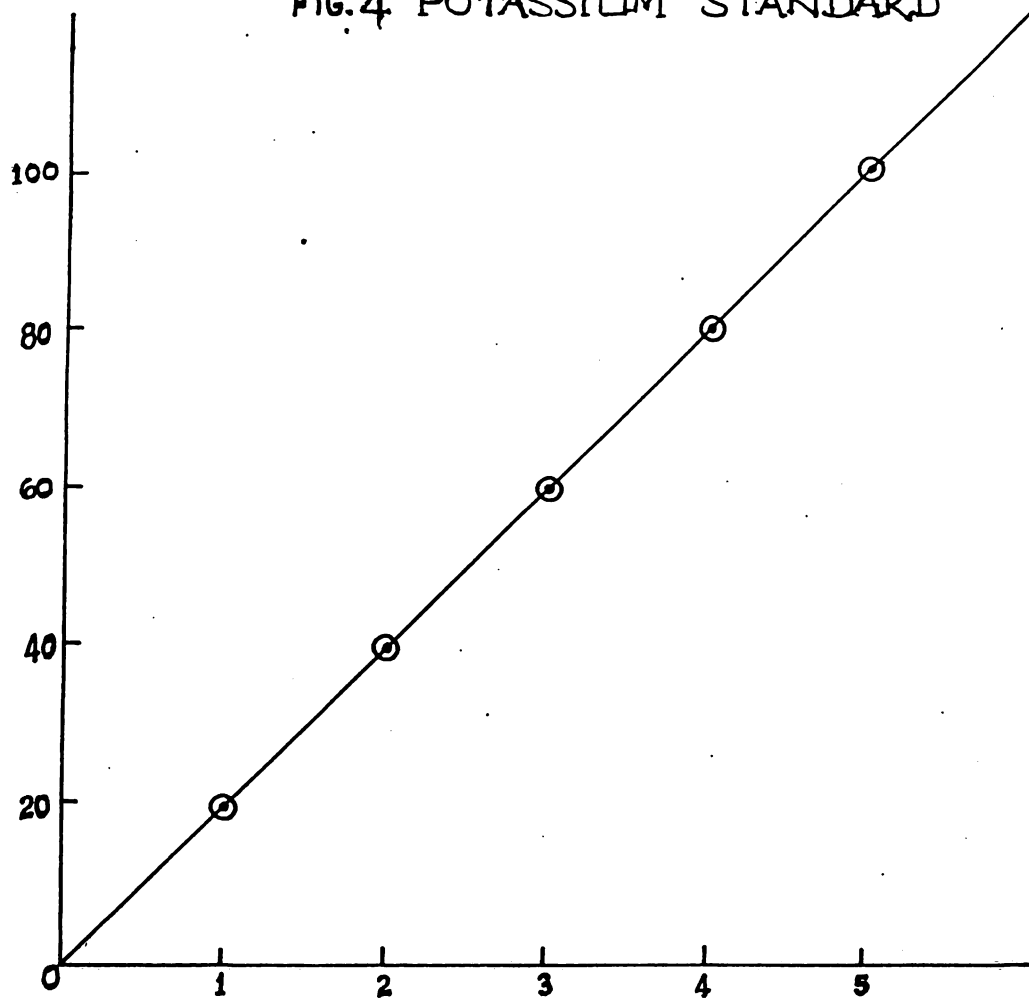


TABLE NO.11

Effect of N,P,K,Ca,Mg application on uptake of Potassium.

Sl. No.	Treatments.	Uptake of potassium in percentage		
		1st date.	2nd date	3rd date.
1.	N ₁ P ₁ K ₁	13.35	14.25	5.75
2.	N ₁ P ₁ K ₂	10.25	13.00	6.25
3.	N ₁ P ₁ K ₃	9.75	19.75	12.50
4.	N ₁ P ₂ K ₁	15.00	16.00	7.25
5.	N ₁ P ₂ K ₂	12.00	15.25	6.75
6.	N ₁ P ₂ K ₃	10.50	18.50	11.25
7.	N ₁ P ₃ K ₁	17.50	18.00	9.20
8.	N ₁ P ₃ K ₂	17.00	20.25	8.00
9.	N ₁ P ₃ K ₃	16.35	19.00	10.25
10.	N ₂ P ₁ K ₁	18.75	19.00	8.50
11.	N ₂ P ₁ K ₂	15.25	16.75	6.00
12.	N ₂ P ₁ K ₃	12.75	14.50	9.00
13.	N ₂ P ₂ K ₁	12.25	13.25	7.10
14.	N ₂ P ₂ K ₂	7.50	17.75	9.25
15.	N ₂ P ₂ K ₃	19.25	19.75	12.50
16.	N ₂ P ₃ K ₁	12.25	16.50	7.50
17.	N ₂ P ₃ K ₂	12.25	17.50	6.75
18.	N ₂ P ₃ K ₃	12.25	17.75	12.00
19.	N ₃ P ₁ K ₁	14.00	15.00	5.50
20.	N ₃ P ₁ K ₂	14.25	17.25	5.50
21.	N ₃ P ₁ K ₃	10.75	12.75	10.50
22.	N ₃ P ₂ K ₁	10.25	11.50	4.25
23.	N ₃ P ₂ K ₂	12.25	17.25	12.70
24.	N ₃ P ₂ K ₃	13.25	13.35	12.25
25.	N ₃ P ₃ K ₁	14.00	16.00	6.00
26.	N ₃ P ₃ K ₂	17.50	18.00	7.50
27.	N ₃ P ₃ K ₃	17.50	19.50	11.00
28.	N ₀ P ₀ K ₀ (Block-I)	7.25	6.50	2.00
29.	N ₀ P ₀ K ₀ (Block-II)	6.50	1.50	0.52
30.	N ₀ P ₀ K ₀ (Block-III)	8.75	8.25	3.25
31.	N ₀ P ₀ K ₀ +CaMg (Block-I)	10.50	20.25	8.00
32.	N ₀ P ₀ K ₀ +CaMg (Bl.-II)	11.00	15.25	4.50
33.	N ₀ P ₀ K ₀ +CaMg (Bl. III)	10.25	14.32	8.50
34.	N ₀ P ₀ K ₀ +CaMg (Bl. I)	14.25	19.00	9.50
35.	N ₀ P ₀ K ₀ +CaMg (Bl. II)	17.75	17.75	7.00
36.	N ₀ P ₀ K ₀ +CaMg (Bl. III)	12.25	15.75	7.25

3.8(B) Soil analysis.

The following methods were adopted for analysis of the soil samples and determination of soil texture.

(1) Determination of soil texture.

Mechanical analysis of soil consists of the determination of the percentage of sand, silt and clay present in a soil. Diameter of the particles are given below:

Gravels	Above 2mm dia
Coarse sand	2.0-0.2 mm dia
Fine sand	0.2-0.02 mm dia
silt	0.02-0.002 mm dia
Clay	0.002 mm dia

This hydrometer method gives approximate values for silt and clay. It should not be used for saline, alkali, calcareous and organic soils.

Procedure (Pinner 1950)

1. Transfer 50 g of soil to a 500 ml beaker.
2. Add about 200 ml of distilled water and 15 ml of 0.5N sodium oxalate solution.

3. Stir in a glass rod for 5 minutes and in a mechanical shirrer for 20 minutes.
 4. Transfer the content without loss into a 1 liter tall measuring cylinder and make the volume to 1 liter by distilled water.
 5. Close the mouth of the cylinder by a rubber pad or by the palm of your hand and shake the content end to end for one minute.
 6. Keep the cylinder on the table and immediately note the time of commencement of sedimentation.
 7. Take hydrometer reading just after 5 minutes and note the temperature of the suspension.
 8. Shake the content of the cylinder again as before. Keep it on the table, note the time and take hydrometer reading just after 5 hours. Take the temperature reading by a thermometer.
- N.B. (1) To take hydrometer reading, carefully introduce the hydrometer into the suspension 20-30 seconds before the predetermined time and note the reading at the exact time. If frothing at the surface

of the suspension, makes it difficult to read the hydrometer scale, add one or two drops of amyl or capryl alcohol to break the froth.

(2) If the temperature of the suspension differs markedly from 19.4 C, correct the hydrometer reading by adding 0.3 units for every degree above 19.4 C or subtracting the same amount for each degree below 19.4 C.

(3) The hydrometer reads the density of the suspension in g/lit.

Calculation

Percentage of silt + clay = First corrected reading $\times$ 2

Percentage of clay = 2nd corrected reading $\times$ 2

Percentage of sand = 100 (% of silt + clay)

Percentage of silt = (% silt + clay) - (% clay).

Accordingly find out the percentage of sand, silt and clay in the sample and determine the textural class of the soil by putting these values in the Triangular Co-ordinate.

(2) Determination of soil PH
(Backman's P.H. Metro).

Apparatus

Glass electrode , P.H.metro, 50 ml.

Polythene Beakers, glass rods.

Reagents

(a) Standard buffer solution PH 4.

Dissolve one PH 4 buffer Tablet or
1.021 gm potassium hydrogen phthalate (dried at
110°C) in distilled water and dilute to 100 cc.

(b) Standard buffer solution PH 9.2.

Dissolve one PH 9.2 buffer tablet or
0.301 gm sodium tetraborate ($\text{Na}_2\text{B}_4\text{O}_7 \cdot 10 \text{H}_2\text{O}$) in
distilled water and dilute to 100 cc.

Use freshly boiled and cooled distilled
water store the buffer solution into polythene bottles.
Discard the solutions when any mould formation is
observed.

Procedure for measurement.

1. Take 10 gm of soil in a 50 ml polythene beaker.
2. Add to it 20 ml distilled water.
3. Stir with a glass rod for one minute. Stir
intermittently and wait for half an hour.

4. Check the PH metre with standard buffer solution.
5. Stir the soil suspension immediately before measuring the PH by PH meter and measure the PH.
6. Wash the electrodes properly before and after each measurement.

Note - Preserve the soil suspension for measuring electrical conductivity.

(3) Determination of organic carbon
(Walkely and Black's Rapid titration method).

Apparatus - 500 ml conical flask

Reagents - Standard 1 N $K_2Cr_2O_7$

Dissolve 49.04 gm $K_2Cr_2O_7$ in distilled water and dilute to 1 liter.

Ferrous ammonium sulphate solution 0.5 N

Dissolve. 196.1 gm $Fe (NH_4)_2 (SO_4)_2 \cdot 6 H_2O$ in 800 ml water containing 20 ml conc H_2SO_4 and dilute to 1 litre.

Diphenyl amine indicator solution. Dissolve 0.5 gm reagent in 20 ml water and 100 ml conc. H_2SO_4 .

Cons H_3PO_4 (85%)

Solid NaF

Procedure.

1. In a dry 500 ml conical flask take 2 gm of soil (crushed and sieved through 60 mesh sieve). Take less soil if it contain more than 1% oc.

/ 59 /

2. Add 10 ml of standard 1 $\text{NK}_2\text{Cr}_2\text{O}_7$ and mix.
3. Add 20 ml of conc H_2SO_4 mix the contents by gentle swirling for one minute. Allow to start for 30 minutes.
4. Add about 200 ml water, 10 ml conc H_3PO_4 or about 0.2 gm NaF and mix.
5. Add about 20-30 drops diphenyl amine indicator and mix ensure the solution in deep violet.
6. Titrate against ferrous amm. sulphate solution to a parrot green colour.

Blank - Run a blank titration following all the above sheets without taking soil

Percentage of organic carbon in soil =

$$10 \left(1 - \frac{S}{B} \right) \times 0.0039 \times \frac{100}{N}$$

where = B = ML of FAS for blank

S = Wt of soil taken

Percentage of organic matter =

$$\% \text{ of O.C} \times \frac{100}{56}$$

TABLE NO. 12

Effect of N, P, K, Ca, Mg application on availability
of organic carbon in soil

Sl. No.	Treatments.	1st date			2nd date			3rd date		
		1°	2°	3°	1°	2°	3°	1°	2°	3°
1.	N ₁	L	L	L	L	L	L	L	L	L
2.	N ₂	L	L	L	L	L	L	L	L	L
3.	N ₃	L	L	L	L	L	L	L	L	L
4.	N ₄	L	L	L	L	L	L	L	L	L
5.	N ₅	L	L	L	M	L	L	L	L	L
6.	N ₆	L	L	L	M	L	L	L	L	L
7.	N ₇	L	L	L	L	L	L	L	L	L
8.	N ₈	L	L	L	L	L	L	L	L	L
9.	N ₉	L	L	L	M	L	L	L	L	L
10.	N ₁₀	L	L	L	L	L	L	L	L	L
11.	N ₁₁	L	L	L	L	L	L	L	L	L
12.	N ₁₂	L	L	L	L	L	L	L	L	L
13.	N ₁₃	L	L	L	L	L	L	L	L	L
14.	N ₁₄	M	L	L	M	L	L	L	L	L
15.	N ₁₅	L	L	L	M	L	L	L	L	L
16.	N ₁₆	L	L	L	M	L	L	L	L	L
17.	N ₁₇	L	L	L	L	L	L	L	L	L
18.	N ₁₈	L	L	L	L	L	L	L	L	L
19.	N ₁₉	L	L	L	L	L	L	L	L	L
20.	N ₂₀	L	L	L	L	L	L	L	L	L
21.	N ₂₁	L	L	L	L	L	L	L	L	L
22.	N ₂₂	L	L	L	L	L	L	L	L	L
23.	N ₂₃	L	L	L	L	L	L	L	L	L
24.	N ₂₄	L	L	L	M	L	L	L	L	L
25.	N ₂₅	L	L	L	L	L	L	L	L	L
26.	N ₂₆	L	L	L	L	L	L	L	L	L
27.	N ₂₇	M	L	L	M	L	L	L	L	L
28.	N ₂₈	L	L	L	L	L	L	L	L	L
29.	N ₂₉	L	L	L	L	L	L	L	L	L
30.	N ₃₀	L	L	L	L	L	L	L	L	L
31.	N ₃₁	L	L	L	M	L	L	L	L	L
32.	N ₃₂	L	L	L	L	L	L	L	L	L
33.	N ₃₃	L	L	L	L	M	L	L	L	L
34.	N ₃₄	M	L	L	L	L	L	L	L	L
35.	N ₃₅	L	L	L	L	L	L	L	L	L
36.	N ₃₆	L	L	L	M	L	L	L	L	L

AVAILABLE PHOSPHORUS BY OLSEN'S METHOD

(Suitable for Neutral to alkaline soils. Also for soils where wet land paddy to be grown).

Apparatus

1. 100 ml conical flask.
2. 25 ml volumetric flask
3. Shaking machine.

Reagents.

1. Extracting solution = 0.5 N NaHCO_3 solution PH 8.5.

Dissolve 420 NaHCO_3 in water and dilute to about 990 ml. Adjust the PH to 8.5 by adding dil NaOH . Finally make up the volume to 1 liter. Preferable this should be stored in such a way that contact with CO_2 should be avoided as far as possible.

2. Activated characcoal - Darco-C Carbon should be leached with extracting solution then washed with water and finally dried.

3. Chloromolybdic acid reagent.

Dissolve 15 gm ammonium molybdate in 400 ml of warm water. Cool to room temperature. Add this solution to 410 ml of 10 N HCl slowly with constant stirring cool to room temperature and finally dilute to 1 litre.

4. Stannous chloride stock solution.

Dissolve 10 gm of stannous chloride (Analar) in 25 ml of cone HCl, warming if necessary. Add a piece of metabisulfite. Store in ambered coloured bottle away from light in a cool place.

5. Stannous chloride working solution.

Dilute 0.5 ml of stock solution to 66 ml by water every time before use.

6. Standard P solution (stock 50 ppm).

Potassium dihydrogen phosphate (KH_2PO_4) is dried at 40 °C and 0.2195 gm is dissolved in about 400 ml of distilled water in one litre flask. Then 25 ml of 7N H_2SO_4 is added and the solution is made to one litre.

7. Secondary standard P solution.

Dilute 10 cc of the stock 50 ppm solution to 100 ml with water, which will give a 500 µg solution.

Procedure.

1. Extraction - Take 2 gm of soil in 100 ml conical flask and add 40 ml of extracting solution.

2. Add about 1 gm of activated charcoal.

3. Shake for 30 minutes by a mechanical shaker.
4. Filter to another container using dry filter paper.

Discard first few ml of filtrate and collect the rest.

Estimation - Development of colour.

Sample (1) Take 5 ml of the filtrate in a 25 ml volumetric flask.

2. Add 5 ml chloromolybdic acid reagent. Gently swirl several times so that all the Co_2 escapes out.
3. Add water so that the total volume is about 20 ml.
4. Add 1 ml of the dilute stannous chloride solution mix immediately.
5. Make the volume to make with water and mix the contents.

Standard.

Take 0, 1, 2, 3, 4, 5 cc of dilute 5 ppm standard P solution (equivalent to 0, 0.2, 0.4, 0.6, 0.8 and 1.0 ppm P in the final solution) in six 25 ml volumetric flask and add 5 ml of extracting solution to each flask. Follow steps 2.5 as in case of sample and develop the colour.

Taking reading in colourmeter-

Take the colourmetre reading after 10 minutes of adding stannous chloride but before 20 minutes at 660 m (Red Filter) adjusting blank (0 ppm P) to zero (100% transmittance).

Calculation

Plot the standard curve taking P concentration final solution and the corresponding colourmeter reading.

Findout the P concentration in the final solution of sample from the standard curve.

ppm of P in soil =

$$\text{ppm from standard curve} \times \frac{25}{5} \times \frac{40}{2}$$

P in Kg/ha = ppm P in soil x 2.

Sl. No.	Treatments.	<u>1st date</u>			<u>2nd date</u>			<u>3rd date</u>		
		1'	2'	3'	1'	2'	3'	1'	2'	3'
1.	N ₁ P ₁ K ₁	M	M	M	M	M	M	M	L	L
2.	N ₁ P ₁ K ₂	L	M	M	M	M	M	M	M	L
3.	N ₁ P ₁ K ₃	M	M	M	M	M	M	M	M	M
4.	N ₁ P ₁ K ₁	M	M	M	M	M	M	M	M	M
5.	H ₁ P ₂ K ₁	M	M	M	M	M	M	M	M	M
6.	N ₁ P ₂ K ₂	M	M	M	M	M	M	M	M	M
7.	N ₁ P ₂ K ₃	M	M	M	M	M	M	M	M	M
8.	N ₁ P ₂ K ₂	M	M	M	M	M	M	M	M	M
9.	N ₁ P ₂ K ₃	M	M	M	M	M	M	M	M	M
10.	N ₁ P ₂ K ₁	M	M	M	M	M	M	M	M	M
11.	N ₂ P ₁ K ₂	M	L	L	M	M	M	M	M	M
12.	N ₂ P ₁ K ₃	L	M	M	M	M	M	M	M	L
13.	N ₂ P ₁ K ₁	M	M	M	M	M	M	M	M	L
14.	N ₂ P ₂ K ₂	M	M	M	M	M	M	M	M	M
15.	N ₂ P ₂ K ₃	M	M	M	M	M	M	M	M	M
16.	N ₂ P ₂ K ₁	L	M	M	M	M	M	M	M	M
17.	N ₂ P ₃ K ₂	M	M	M	M	M	M	M	M	L
18.	N ₂ P ₃ K ₃	M	M	M	M	M	M	M	M	L
19.	N ₂ P ₃ K ₁	M	M	M	M	M	M	M	L	L
20.	N ₃ P ₁ K ₂	M	M	M	M	M	L	M	L	L
21.	N ₃ P ₁ K ₃	M	M	M	M	M	M	M	L	L
22.	N ₃ P ₁ K ₁	M	M	M	M	M	M	M	M	M
23.	N ₃ P ₂ K ₂	M	M	M	M	M	M	M	M	L
24.	N ₃ P ₂ K ₃	M	M	M	M	M	M	M	M	M
25.	N ₃ P ₃ K ₁	M	M	M	M	M	M	M	M	M
26.	N ₃ P ₃ K ₂	M	M	M	M	M	M	M	M	L
27.	N ₃ P ₃ K ₃	M	M	M	M	M	M	M	M	L
28.	N ₃ P ₃ K ₁	L	L	L	L	L	L	L	L	L
29.	N ₃ P ₃ K ₂	L	L	L	L	L	L	L	L	L
30.	N ₃ P ₃ K ₃	L	L	L	L	L	L	L	L	L
31.	N ₃ P ₃ K ₁	+CaMg			L	H	M	M	L	L
32.	N ₃ P ₃ K ₂	+CaMg			M	H	M	M	M	L
33.	N ₃ P ₃ K ₃	+CaMg			M	H	M	M	M	L
34.	N ₃ P ₃ K ₁	+CaMg			M	H	M	M	M	M
35.	N ₃ P ₃ K ₂	+CaMg			M	H	M	M	M	M
36.	N ₃ P ₃ K ₃	+CaMg			M	H	M	M	M	M

Available potash by Morgan's reagent method.
(Sodium acetate extraction)

Apparatus : (1) 20 ml hard glass test tubes.
(2) 50 ml conical flask.
(3) Hypodermic needle and syringe.
(4) Colourimeter.

Reagents:

(1) Extracting solution: Dissolve 100 gm of pure sodium acetate in water, add 30 ml of glacial acetic acid and dilute to one litre.

(2) Sodium: Cobaltinitrite solution:
Dissolve 5 gms of cobalt nitrate and 30 gms of sodium nitrate in water containing 2.5 ml of glacial acetic acid and dilute to 100 ml. Allow the solution to stand for 24 hours in an unstoppered bottle and then filter. Preserve the solution in brown bottle in a cool dark place.

(3) Alcohol mixture: Mix equal volume of methyl alcohol and isopropyl alcohol and store in glass bottle.

(4) Potassium working standard : Take 0.5, 1.0, 1.5, 2.0 and 2.5 ml of the stock 1000 ppm K solution in five 50 ml volumetric flasks and dilute to mark with extracting solution and mix. This gives solutions with 10, 20, 30, 40 and 50 ppm K.
Procedure : Extraction.

(1) Take 5 gm of soil in a dry 50 ml conical flask and add 25 ml. extracting solution.

(2) Shake for 5 minutes and then filter to another container using dry filter paper. Rinse the container with first portion of the filtrate and reject that portion, collect the rest.

All the reagents, filtrate and K standards are cooled to 15.5 - 19°C.

(1) Take 2 ml of the alcoholic mixture in a cool dry 20 ml test tube.

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(2) Add 6 drops of sodium cobaltinitrite solution and shake until clear. (If not clear add few drops of water and shake. But add same amount of water to sample and all standards).

(3) Add 2 ml of the filtrate (Soil extract) to that mixture by means of a syringe speedily and shake for 1 minute to get uniform turbidity.

Blank and standard should be prepared in the same manner taking 2 ml of extracting solution or K standard solution instead of filtrate.

Standard curve: Measure the turbidity in a spectrophotometer at 660 m light (Red filter) adjusting the blank to 100% transmittance. Plot a standard curve taking the corresponding reading at each K concentration of standards.

$$\text{ppm K in soil} = \text{ppm from standard curve} \times \frac{25}{5}$$

$$\text{Available K in Kg/ha} = \text{ppm K} \times 2.$$

TABLE NO.14

Effect of N, P, K, Ca, Mg application on availability
of Potassium in soil

Sl. No.	Treatments	1st date			2nd date			3rd date		
		1'	2'	3'	1'	2'	3'	1'	2'	3'
1.	N ₁ P ₁ K ₁	L	L	L	M	L	L	L	L	L
2.	N ₂ P ₂ K ₂	L	L	M	L	M	M	L	L	L
3.	N ₃ P ₃ K ₃	L	L	L	L	M	M	L	L	L
4.	N ₄ P ₄ K ₄	L	L	M	M	M	M	L	L	L
5.	N ₅ P ₅ K ₅	L	L	L	M	L	L	L	L	L
6.	N ₆ P ₆ K ₆	L	L	L	M	M	M	L	L	L
7.	N ₇ P ₇ K ₇	L	L	M	M	M	M	L	M	M
8.	N ₈ P ₈ K ₈	L	L	L	M	M	L	L	L	L
9.	N ₉ P ₉ K ₉	L	L	M	M	M	M	L	L	M
10.	N ₁₀ P ₁₀ K ₁₀	L	L	L	M	M	M	L	L	L
11.	N ₁₁ P ₁₁ K ₁₁	L	L	L	L	M	M	L	L	L
12.	N ₁₂ P ₁₂ K ₁₂	L	L	M	M	M	M	L	L	L
13.	N ₁₃ P ₁₃ K ₁₃	L	L	L	M	M	L	L	L	L
14.	N ₁₄ P ₁₄ K ₁₄	L	L	M	M	M	L	L	M	L
15.	N ₁₅ P ₁₅ K ₁₅	L	L	L	M	M	M	L	L	L
16.	N ₁₆ P ₁₆ K ₁₆	L	L	L	M	M	L	L	L	L
17.	N ₁₇ P ₁₇ K ₁₇	L	M	L	L	M	L	L	L	L
18.	N ₁₈ P ₁₈ K ₁₈	L	L	L	L	M	L	L	L	L
19.	N ₁₉ P ₁₉ K ₁₉	L	L	L	M	M	L	L	M	L
20.	N ₂₀ P ₂₀ K ₂₀	L	L	L	L	M	M	L	L	L
21.	N ₂₁ P ₂₁ K ₂₁	L	L	L	L	M	L	L	L	L
22.	N ₂₂ P ₂₂ K ₂₂	L	L	L	M	M	M	M	M	M
23.	N ₂₃ P ₂₃ K ₂₃	L	L	L	M	M	L	L	L	L
24.	N ₂₄ P ₂₄ K ₂₄	L	L	M	M	M	M	L	L	L
25.	N ₂₅ P ₂₅ K ₂₅	L	L	L	M	M	L	L	L	L
26.	N ₂₆ P ₂₆ K ₂₆	L	L	M	M	M	L	L	L	L
27.	N ₂₇ P ₂₇ K ₂₇	L	L	L	M	M	L	L	L	L
28.	N ₂₈ P ₂₈ K ₂₈ (Bl. I)	L	L	L	L	L	L	L	L	L
29.	N ₂₉ P ₂₉ K ₂₉ (Bl. II)	L	L	L	L	L	L	L	L	L
30.	N ₃₀ P ₃₀ K ₃₀ (Bl. III)	L	L	L	L	L	L	L	L	L
31.	N ₃₁ P ₃₁ K ₃₁ +CaMg (I)	L	L	L	L	M	M	L	L	L
32.	N ₃₂ P ₃₂ K ₃₂ +CaMg (II)	L	L	L	L	M	M	L	M	L
33.	N ₃₃ P ₃₃ K ₃₃ +CaMg (III)	L	L	L	L	M	M	L	L	L
34.	N ₃₄ P ₃₄ K ₃₄ +CaMg (I)	L	L	L	L	M	M	L	L	L
35.	N ₃₅ P ₃₅ K ₃₅ +CaMg (II)	L	L	M	M	M	M	L	L	L
36.	N ₃₆ P ₃₆ K ₃₆ +CaMg (III)	L	L	M	M	M	M	L	L	L

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The soil samples were analysed in the State soil testing Laboratory, Sahidnagar, Bhubaneswar, Orissa. The soil analysis data has been presented basing on their report.

1. Rating based on organic carbon content.

Less than 0.5% low

0.5 to 0.75% medium

More than 0.75% high.

2. Rating of based on available phosphorus.

Less than 4 Kg/ha. Very low

4.9 Kg/ha low

9-22 Kg/ha Medium

22-35 Kg/ha High

More than 35 Kg/ha. Very high.

3. Ammonium acetate/morgatis extract tabel K (Potassium rating).

Less than 118 Kg/ha Low

118-280 Kg/ha Medium

More than 280 Kg/ha High.

3.9 Statistical analysis.

The experiment was conducted in a 3^3 confounding factorial design. The analysis of treatment was divided in two parts.

(1) The confounded effect were not calculated as only one replication was taken in three Blocks.

(2) The additional treatment were analysed just like randomised Block design and the additional treatments were compared.

In case of first part, the effect of N, P, K and NP, NK and PK were compared with error sum of square. The effect of different treatments are presented in Table (a), NP, (b) NK (c) PK and (d) extra treatments are presented in different Tables.

The S.E. (m) and C.D. for different treatments and their interaction were calculated.

$$3^3 = 27 + 9 \text{ Extra in one replication.}$$

So total 36 treatments.

$$CF = \left(\frac{\text{Total}}{27} \right)^2$$

$$\text{Total S.S.} = N_1 P_1 K_1^2 + \dots + N_3 P_3 K_3^2 - CF$$

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$$\text{S.S. due to N} = \frac{N_1^2 + N_2^2 + N_3^2}{3 \times 3} - CF$$

$$\text{S.S. due to P} = \frac{P_1^2 + P_2^2 + P_3^2}{9} - CF$$

$$\text{S. S. due to K} = \frac{K_1^2 + K_2^2 + K_3^2}{9} - CF$$

$$\text{S.S. due to NP} = \frac{N_1 P_1^2 + \quad + N_3 P_3^2}{3} - CF - N_{ss} - P_{ss}$$

$$\text{S.S. due to NK} = \frac{N_1 K_1^2 + \quad + N_3 K_3^2}{3} - CF - N_{22} - K_{ss}$$

$$\text{S.S. due to PK} = \frac{P_1 K_1^2 + \quad + P_3 K_3^2}{3} - CF - P_{ss} + K_{ss}$$

S.S. due to Blocks (Blocks not containing additional treatments i.e.

$$N_0 P_0 K_0 + N_1 P_1 K_1 + \text{CmG and } N_3 P_3 K_3 + \text{CmG}$$

$$= \frac{N_1^2 + N_2^2 + N_3^2}{9} - CF$$

Error = By subtracting from total i.e.

$$\text{Total S.S. Block}_{ss} = N_{ss} - P_{ss} - K_{ss} - NP_{ss} - NK_{ss} - PK_{ss}$$

$$\text{S.E. (m) for N, P or K} = \sqrt{\frac{\text{Error}}{9}}$$

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Analysis for extra treatments

$$C.F. = \left(\frac{\text{Total}}{9} \right)^2$$

$$(\text{Block}) \text{ SS} = R_1^2 + R_2^2 + R_3^2 - CF$$

$$(\text{Treatment}) \text{ SS} = \frac{T_1^2 + T_2^2 + T_3^2}{3} - CF$$

$$\text{Error} = t_1 r_1^2 + t_2 r_2^2 + t_3 r_3^2 - CF - B_{ss} - T_{ss}$$

$$S.E. (m) = \sqrt{\frac{\text{Error}}{3}}$$

$$CD = \frac{\sqrt{\text{error}}}{3} \times \sqrt{2} \times t \text{ value of error d.f.}$$

CHAPTER IV

EXPERIMENTAL FINDINGS

EXPERIMENTAL FINDINGS

During the period of present investigation entitled " NUTRITIONAL UPTAKE BY COCONUT PALM " observations recorded on the uptake of NPK and its effect on plant characters like height, girth of plant, number of leaves and fruit bearing have been described in this chapter. The data on the Nutritional uptake and growth observations are subjected to statistical analysis. The summarised results have been presented in tabular form and also illustrated graphically whenever required. The analysis of variance table for different characters have been presented in the Appendix.

1. NUTRITIONAL UPTAKE STUDIES.

1.1 Uptake of Nitrogen

The data on uptake of Nitrogen by the 9th leaf after fertilisation were analysed and the mean data have been presented in the Table No.15 and illustrated in the Figure-5 and Figure-6.

Analysis of variance (Appendix-I) indicated that there was no significant effect of various treatments on the uptake of Nitrogen as determined six months after first dose of fertiliser application (first date). However a significant effect was observed at one month (second date) and three months after second dose of fertiliser application (third date) in (Appendix-II) at 5 percent level. On the second date of observation, highest uptake of Nitrogen (2.734) was recorded in case of N_3 applied in combination with calcium and magnesium (Table-2) (Figure-5 and 6). The uptake of Nitrogen was minimum (0.989) in case of control. Nitrogen uptake as affected by N_3 with calcium and magnesium was significantly higher than N_3 without calcium and magnesium as well as other Nitrogen application without calcium and magnesium. N_2 was found to be significantly superior to N_3 and N_1 which were at par. Similar trend was observed but at reduced rate in the third date of observation, except that the uptake of Nitrogen in N_3 with combination of calcium and magnesium.

TABLE NO.15

Uptake of Nitrogen in percentage as affected by
different dose of Nitrogen

Sl. No. Treatments.	Uptake of Nitrogen in percentage.			Average
	1st date.	2nd date	3rd date.	
1. N ₁	1.328	1.508	1.213	1.349
2. N ₂	1.160	1.795	1.452	1.469
3. N ₃	1.264	1.449	1.197	1.303
4. N ₀ P ₀ K ₀	1.054	0.989	0.672	0.905
5. N ₁ P ₁ K ₁ +CaMg	1.290	1.409	1.064	1.241
6. N ₃ P ₃ K ₃ + CaMg	1.558	2.734	1.306	1.866
Average	1.269	1.647	1.150	1.355

C.D. at 5% = 0.089 second date

0.078 third date

1st date - Date of observation six months after
1st split of fertiliser application
(12.12.66).

2nd date - One month after second split application
of fertilisers (12.2.67).

3rd date - Three months after second split application
of fertiliser (12.4.67).

4th date - Four months after second split application
of fertiliser (12.5.67) on growth.

FIG-5 UP TAKE OF NITROGEN

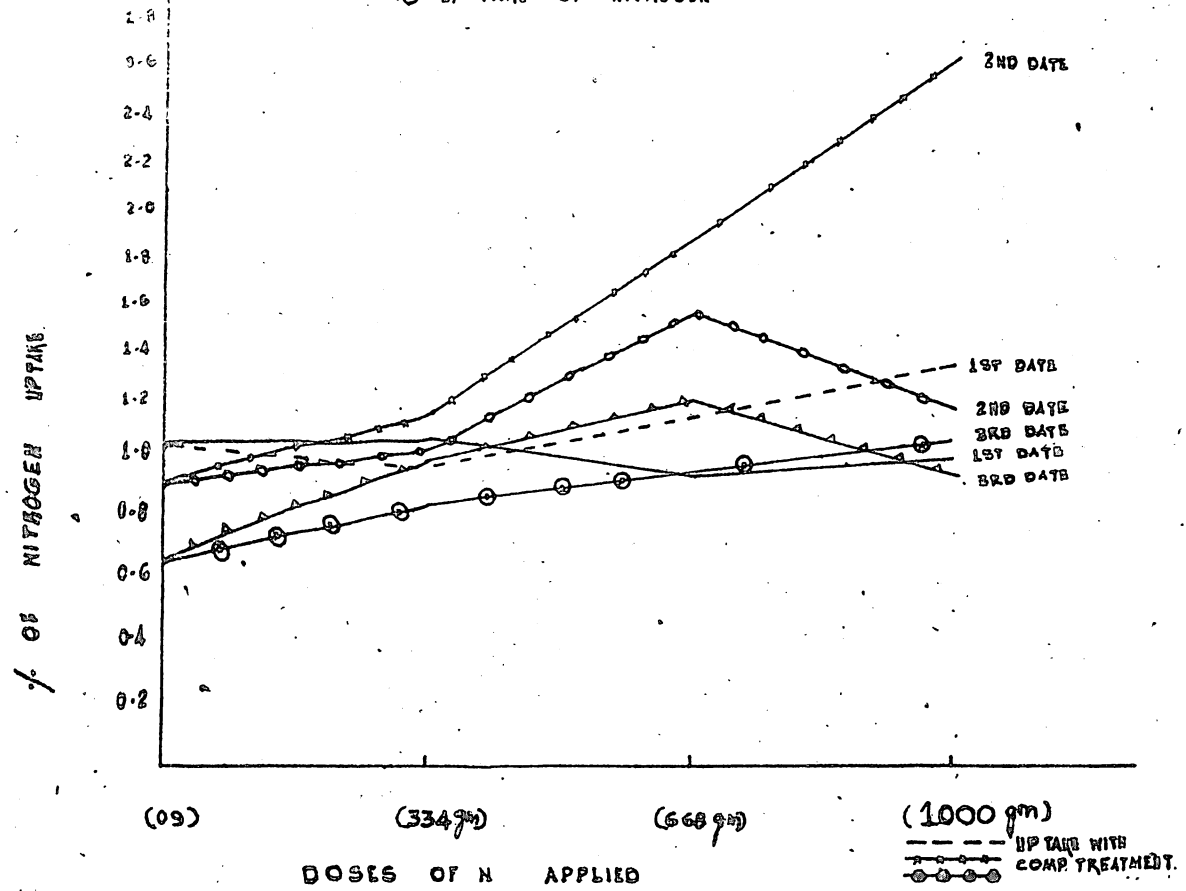
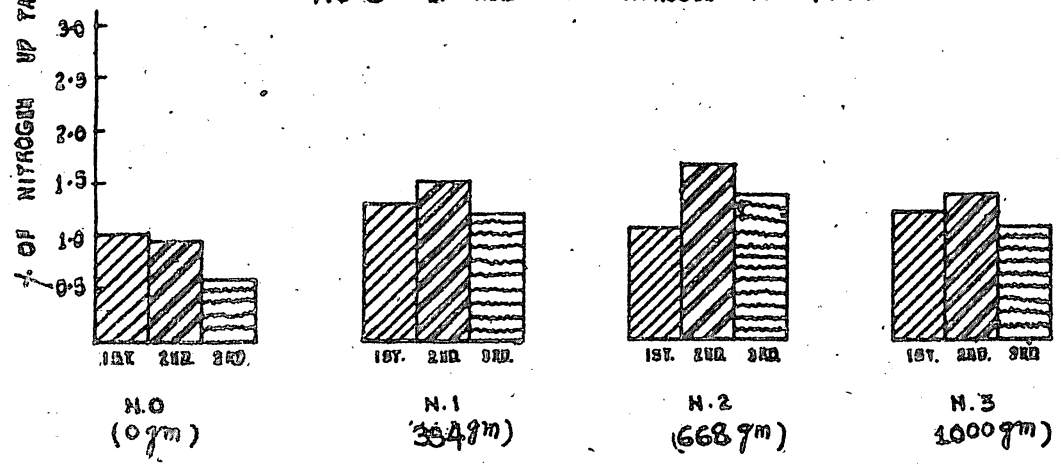


FIG-6 UP TAKE OF NITROGEN IN PERCENTAGE





M₂ P₂ R₂



M₂ P₂ R₂

1.2 Uptake of Phosphorus.

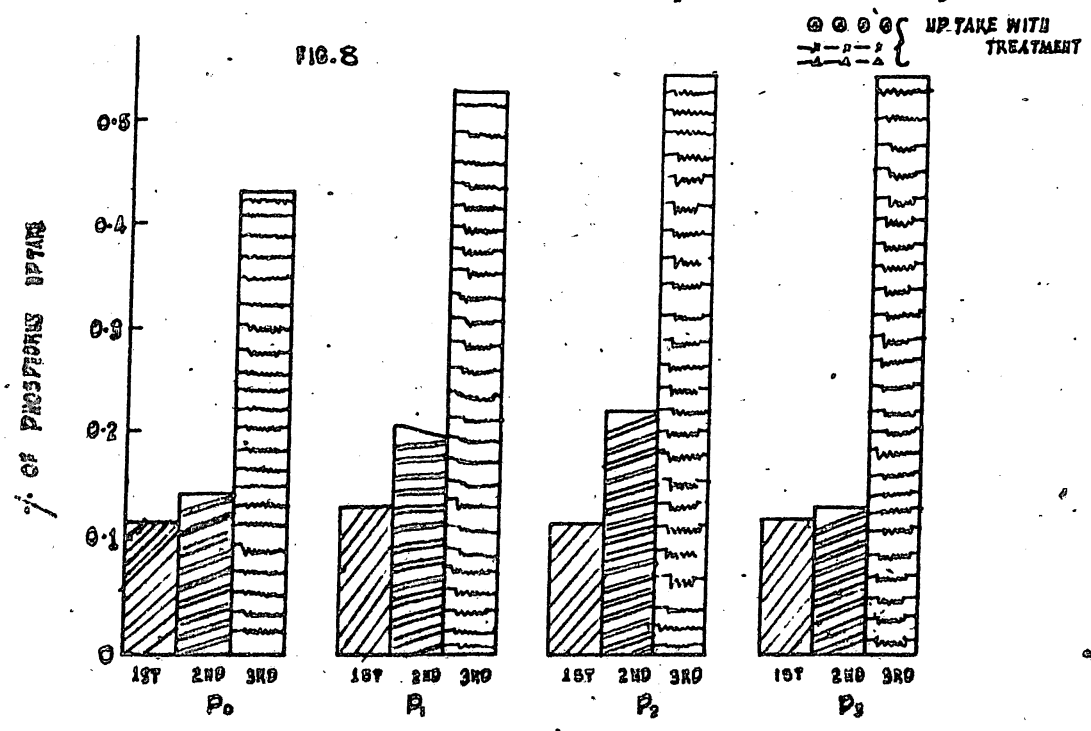
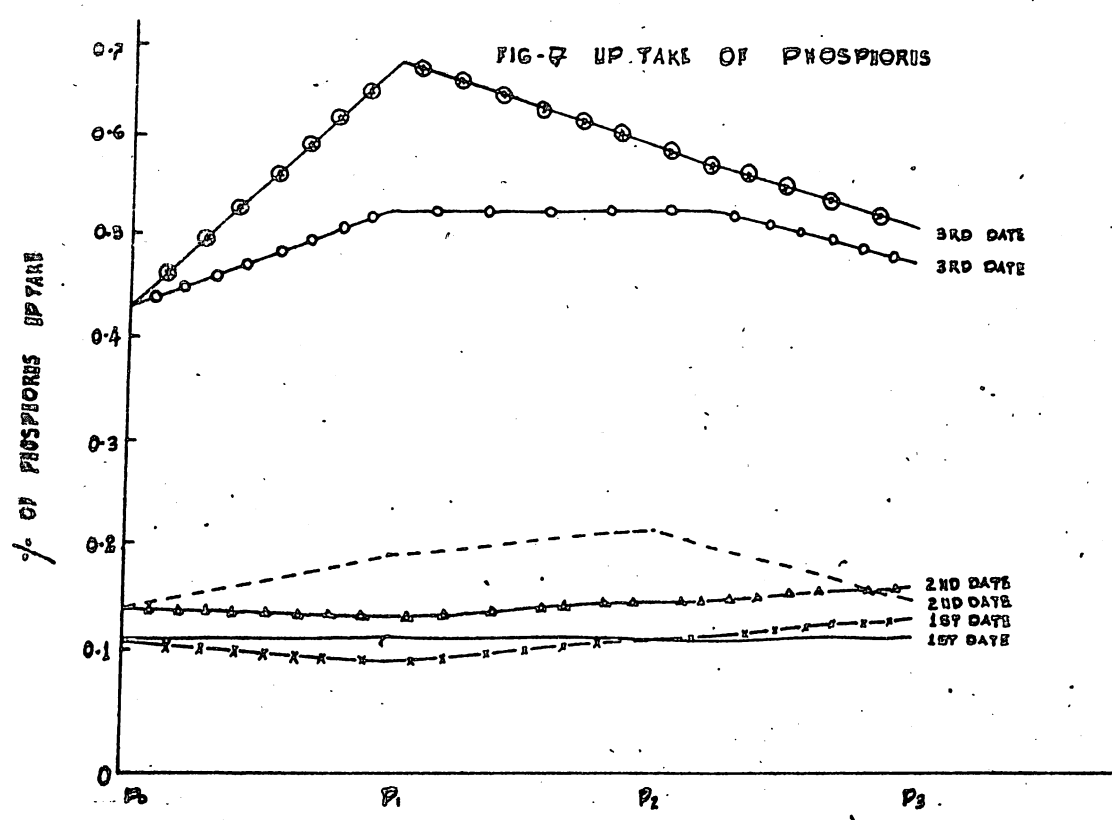
The effect of different doses of phosphorus on the phosphorus content in the leaf was found to be non-significant in the first date of observation (Appendix-I) but it was significant on second and third date of observations (Appendix-II & III). In the second date of observation i.e. one month after second split application of fertilizers highest uptake of P was recorded with P_2 (0.284) followed by P_1 (0.204) and P_3 (0.186) shown in Table No.16 and Figure No.7, 8. The uptake of P was reduced in P_3 alone and P_3 in combination with calcium and magnesium significant when compared with P_2 alone. The uptake of P was increased in all levels of P in comparison to control (0.123). P_3 in combination with calcium and magnesium (0.186) improved over P_3 alone (0.143). The uptake of phosphorus improved considerable in third date of observation in comparison to second date of observation (Table-22). The increase range of P uptake in second date of observation was from 0.123 in control to 0.284 in P_2 while the same was from 0.430 to 0.673 in third date of observation. The highest phosphorus

content of leaf was recorded in P_1 in combination with calcium and magnesium (0.673) followed by P_2 (0.547). P_1 (0.531) and P_3 in combination with calcium and magnesium (0.526). Application of P fertiliser in combination with calcium and magnesium was found to be better than application of P fertiliser lone. The most interesting findings is that the lowest dose of P_2 O_5 in combination with calcium and magnesium recorded highest uptake of P in comparison to all higher doses of P.

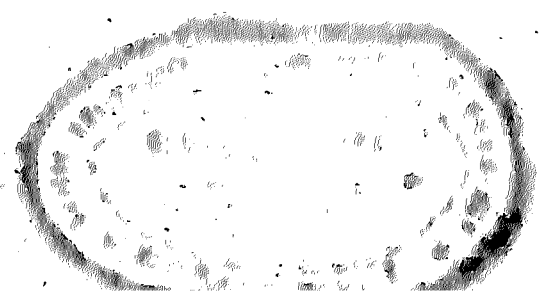
TABLE NO.16

Uptake of phosphorus in percentage as
affected by different dose of
phosphorus.

Sl.	Uptake of phosphorus in				
No. Treatments.	percentage			Average.	
	1st date.	2nd date	3rd date.		
1. P_1	0.131	0.204	0.532	0.288	
2. P_2	0.131	0.284	0.547	0.320	
3. P_3	0.132	0.143	0.496	0.257	
4. $N_0 P_0 K_0$	0.113	0.123	0.430	0.222	
5. $N_1 P_1 K_1 +CaMg$	0.110	0.141	0.673	0.308	
6. $N_3 P_3 K_3 +CaMg$	0.156	0.186	0.526	0.289	
Average	0.128	0.180	0.523	0.280	
C.D. at 5% = 0.080 second date					
0.120 third date.					



Th.1631



1.3 Uptake of Potash

Uptake of Potassium by coconut palm was observed at 3 different dates i.e. first, second and third. The analysis of variance Table (Appendix-I) indicated that the effect of application of different doses of potash was non-significant in the first date of observation while it was found to be significant in the second and third date of observation (Appendix-II and III). The potash content in leaf as observed in the second date was minimum with control (K_0) and it was increased significantly with increase of levels of K dose. Maximum K content was recorded in combination with calcium and magnesium (23.633) followed by K_3 alone (19.433) K_2 (17.038) and K_1 (15.500) (Table No.17) and in (Figure No.9 & 10). Application of potash fertiliser in combination with calcium and magnesium was found to be far better than application of K fertiliser alone.

As compared to second date of observations the uptake of potash was reduced considerably in third date of observation (Table No.23). Similar trend was also observed in the third date of

observation with regard to uptake of potash as affected by different levels of K. But application of K fertiliser in combination with calcium and magnesium at K_3 level did not show any improvement over K_3 alone.

TABLE NO.17

Uptake of potassium in percentage as affected
by different date of potash.

Sl. No.	Treatments.	Uptake of potash in percentage.			Average.
		Ist date.	2nd date	3rd date.	
1.	K_1	13.611	15.500	6.780	11.963
2.	K_2	13.816	17.038	7.633	12.829
3.	K_3	16.538	18.483	11.402	15.423
4.	$N_0 P_0 K_0$	7.50	5.416	1.923	4.946
5.	$N_1 P_1 K_1 + CaMg$	13.25	16.805	7.0	12.351
6.	$N P K + CaMg$	14.75	23.833	7.916	15.499
Average		13.244	16.179	7.083	12.168

C.D. at 5% = 1.397 first date

1.309 second date.

FIG.-9

UPTAKE OF POTASSIUM

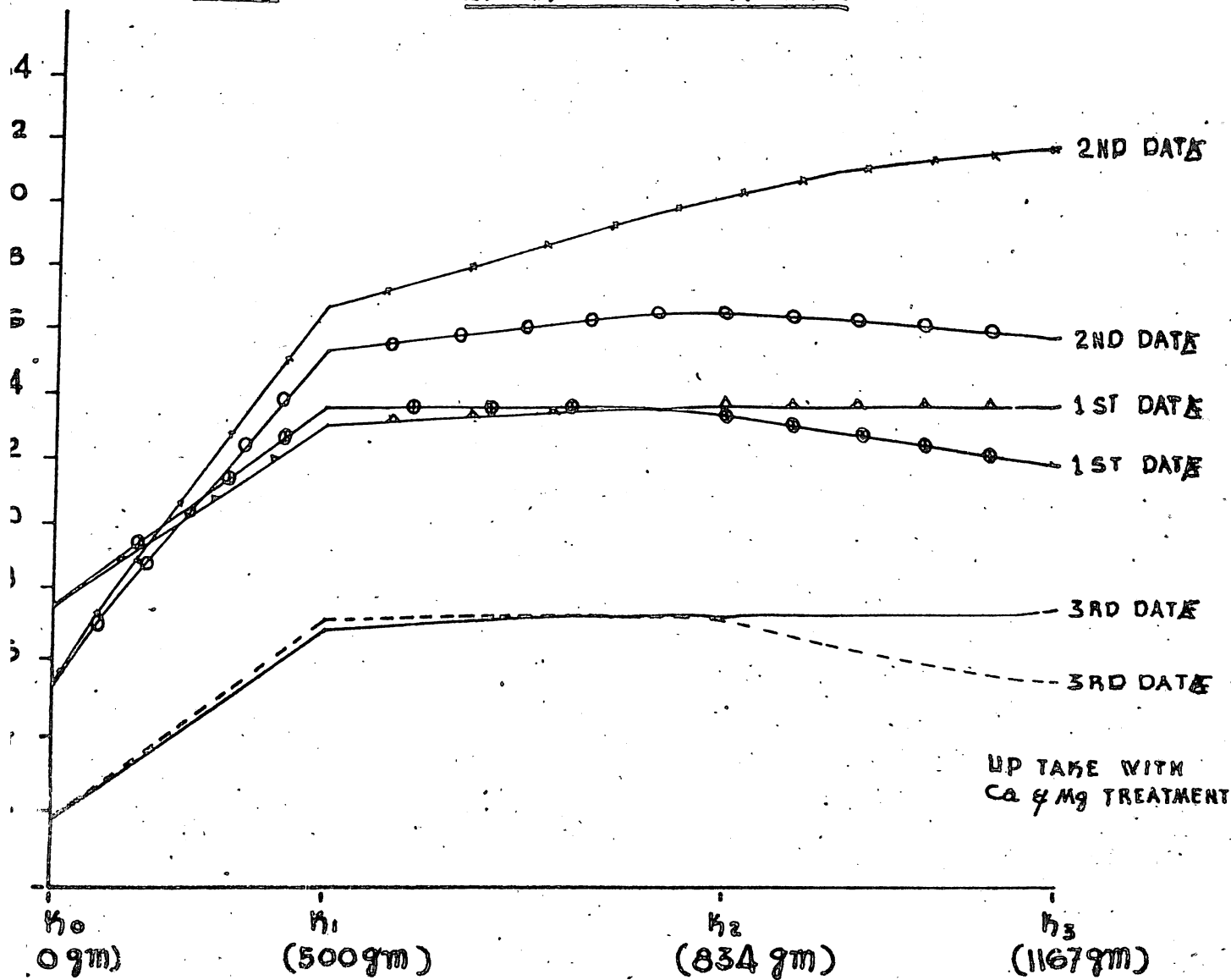
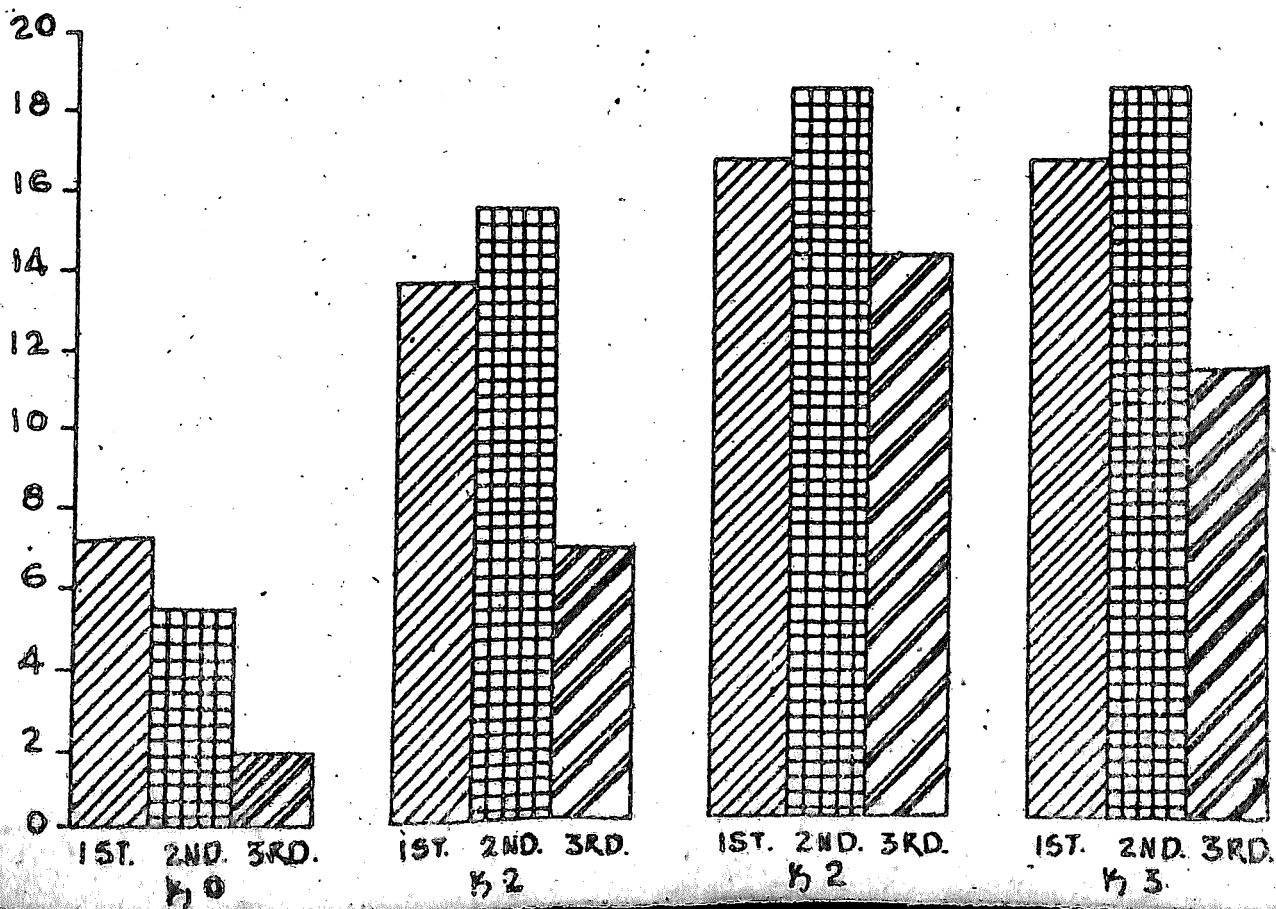


FIG.-10

UPTAKE OF POTASSIUM IN PERCENTAGE



1.4 Effect of of second order.

Effect of seconds order of interaction between $N \times P$, $N \times K$ and $P \times K$ on the uptake of Nitrogen was found to be nonsignificant on the all three dates of observation as indicated by the analysis of variance Table (Appendix-I, II & III).

The effect of interaction $N \times K$ on the uptake of Nitrogen was shown to be significant in second and third date of observations (Appendix-II & III).

Nitrogen content in leaf was maximum with $N_3 K_1$ (1.652) followed by $N_1 K_3$ (1.633) and $N_2 K_1$ (1.493) in second date of observation (Table No.18). $N_3 K_1$ and $N_1 K_3$ were at par and significantly superior to rest of the treatments. This was recorded in the second date of observation. However in the third date of observation $N_1 K_2$ recorded maximum uptake of Nitrogen (1.666) and was significantly superior to all the rest interaction treatments. It was followed by $N_3 K_2$ (1.344) and $N_3 K_1$ (1.185) in (Table No.19).

The rate of uptake of Nitrogen as influenced by interaction between N and K was all most similar in both dates of observation.

Effect of second order of interaction
on the uptake of N, P and K.

TABLE NO.18

Effect of interaction N x K on uptake of Nitrogen
in percentage (second date).

	K ₁	K ₂	K ₃
N ₁	1.484	1.409	1.633
N ₂	1.493	1.456	1.409
N ₃	1.652	1.390	1.306

TABLE NO.19

Effect of interaction N x K on uptake of
Nitrogen in percentage (third date).

	K ₁	K ₂	K ₃
N ₁	1.073	1.666	1.110
N ₂	1.143	0.989	1.138
N ₃	1.185	1.344	1.064

(3) Effect of interaction N x P, N x K and P x K on uptake of phosphorus.

There was no significant effect of N x P, N x K and P x K on the uptake of P in the first and second dates of observation (Appendix No. II) and III). However the interaction between P x K was found to be significant but not N x P and N x K in the third date of observation (Appendix III). Maximum uptake of P was recorded with $P_3 \times K_1$ (0.59) followed by $P_2 K_1$ (0.58) and $P_3 K_3$ (0.57).

TABLE NO. 20

Effect of interaction P x K on uptake of Phosphorus in percentage (third date)

	K_1	K_2	K_3
P_1	0.47	0.50	0.43
P_2	0.58	0.51	0.55
P_3	0.59	0.49	0.57

Effect of interaction $N \times P$, $N \times K$ and $P \times K$ was found to be nonsignificant in first date of observation (Appendix-I). Effect of $N \times P$, $P \times K$ was also found to be nonsignificant on second and third date of observation. Effect of interaction $N \times K$ was found to be significant on second and third date of observation (Appendix-II, III).

It was observed that in the second date of observation highest potash content in leave (19.83) was recorded in N_1K_3 followed by N_3K_2 (17.50), N_2K_2 (17.33) and N_2K_3 (17.33). Minimum potash content was observed in N_3K_1 (14.16). N_1K_3 was found to be significantly superior to all treatment on the uptake of potash (Table No.21).

However in the third date of observation the effect of $N \times K$ was found to be different. Though N_1K_3 resulted in having highest potash content in leave (11.33) but it was not significantly superior to other treatment unlike on second date of observation N_1K_3 , N_2K_3 and N_3K_3 were at par. Minimum potash uptake was observed in N_3K_1 (5.25) (Table No.22).

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TABLE NO.21

Effect of interaction N x K on the uptake of
Potash in percentage (2nd date)

	K ₁	K ₂	K ₃
N ₁	15.75	16.16	19.83
N ₂	16.25	17.33	17.33
N ₃	14.16	17.50	15.20

C.D. at 5% = 1.397.

TABLE NO.22

Effect of interaction N x K on the uptake of
Potash in percentage (third date).

	K ₁	K ₂	K ₃
N ₁	7.40	7.00	11.33
N ₂	7.70	7.33	11.16
N ₃	5.25	8.56	11.25

C.D. at 5% = 1.309

1.5 Effect of N, P, K and their
interaction on the growth.

(A) Plant height

TABLE NO.23

Effect of nutrient application on plant
height.

Sl. No.				Treatments.				Height in metres.			
1.	N ₁	P ₁	K ₁					6.50			
2.	N ₁	P ₁	K ₂					6.90			
3.	N ₁	P ₁	K ₃					7.50			
4.	N ₁	P ₂	K ₁					7.25			
5.	N ₁	P ₂	K ₂					7.00			
6.	N ₁	P ₂	K ₃					7.85			
7.	N ₁	P ₃	K ₁					7.85			
8.	N ₁	P ₃	K ₂					8.10			
9.	N ₁	P ₃	K ₃					7.30			
10.	N ₂	P ₁	K ₁					6.50			
11.	N ₂	P ₁	K ₂					5.00			
12.	N ₂	P ₁	K ₃					5.20			
13.	N ₂	P ₂	K ₁					8.30			
14.	N ₂	P ₂	K ₂					8.10			
15.	N ₂	P ₂	K ₃					6.10			
16.	N ₂	P ₃	K ₁					8.70			
17.	N ₂	P ₃	K ₂						6.65		
18.	N ₂	P ₃	K ₃					7.25			
19.	N ₃	P ₁	K ₁					7.90			
20.	N ₃	P ₁	K ₂					6.90			
21.	N ₃	P ₁	K ₃					6.60			
22.	N ₃	P ₂	K ₁					8.20			
23.	N ₃	P ₂	K ₂					7.90			
24.	N ₃	P ₃	K ₁					7.40			
25.	N ₃	P ₃	K ₂					6.90			
26.	N ₃	P ₃	K ₃					8.20			
27.	N ₃	P ₃	K ₃					8.20			
28.	N ₀	P ₀	K ₀					4.23			
29.	N ₁	P ₁	K ₁				+ CaMg	7.40			
30.	N ₃	P ₃	K ₃				+ CaMg	9.46			

Analysis of variance (Appendix-VII) indicated that phosphorus exhibited a significant effect on the plant height. Neither Nitrogen nor potash nor interaction

TABLE NO.24

Effect of phosphorus on plant height.

Sl. No.	Treatments.	Plant height in metres.
1.	P ₁	6.55
2.	P ₂	6.56
3.	P ₃	7.73

C.D. at 5% = 0.915

TABLE NO.25

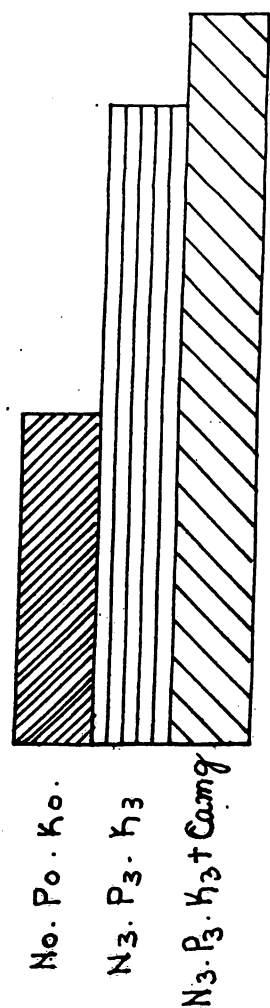
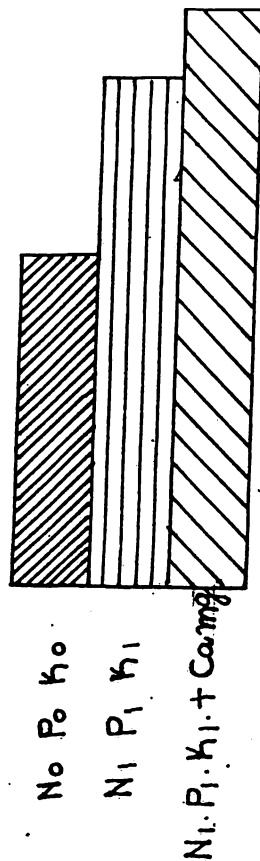
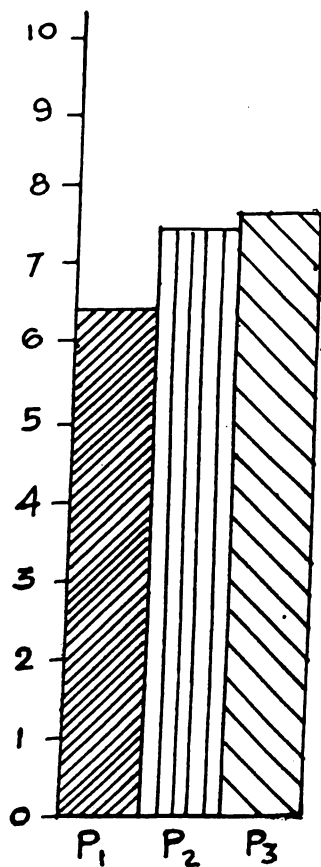
Effect of additional treatment on plant height (metres).

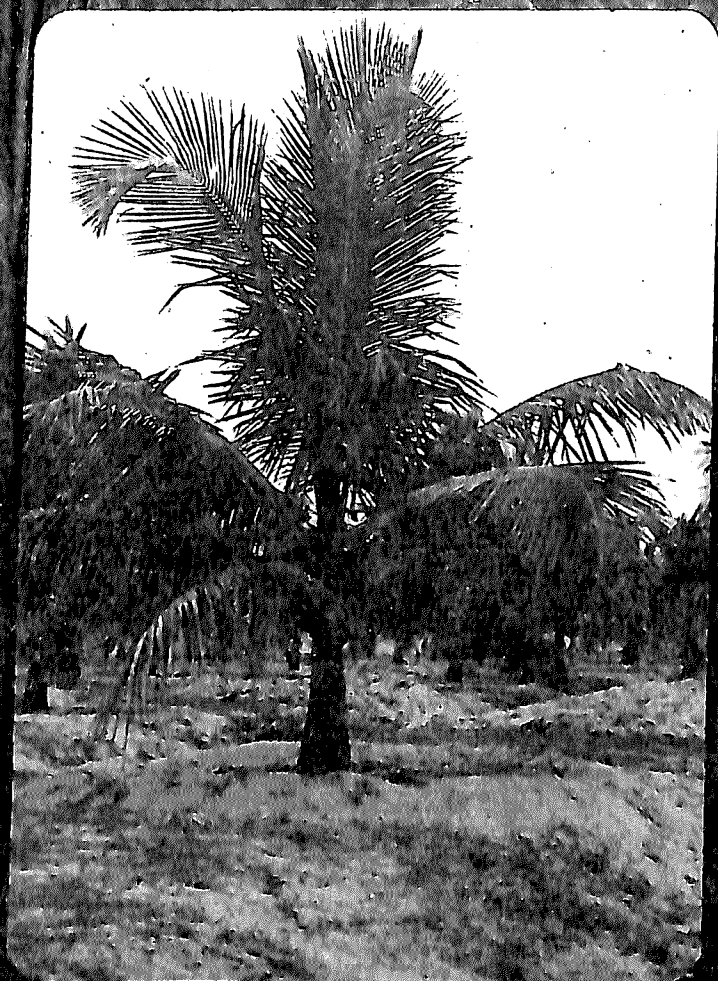
Sl. No.	Treatments.	Plant height in metres.
1.	N ₀ P ₀ K ₀	4.23
2.	N ₁ P ₁ K ₁ + CaMg	7.40
3.	N ₃ P ₃ K ₃ + CaMg	9.46
4.	N ₁ P ₁ K ₁	6.50
5.	N ₃ P ₃ K ₃	8.20

C.D. at 5% = 0.915

FIG.-11
EFFECT OF P
ON PLANT HEIGHTS.

EFFECT OF ADDITIONAL
TREATMENT ON PLANT HEIGHT (METERS)





N₁P₁K₁



N₁P₁K₁ + 500g

TABLE NO. 26

Effect of Nutrient application on Girth
of the Palm

-----			-----		
Sl. No. Treatments.			Girth in metres.		
-----			-----		
1.	N	P			0.92
2.	N	P			1.03
3.	N	P			1.04
4.	N	P			1.02
5.	N	P			0.96
6.	N	P			1.22
7.	N	P			0.88
8.	N	P			1.10
9.	N	P			1.08
10.	N	P			1.20
11.	N	P			0.80
12.	N	P			0.60
13.	N	P			1.10
14.	N	P			1.10
15.	N	P			1.21
16.	N	P			1.33
17.	N	P			0.91
18.	N	P			1.20
19.	N	P			0.91
20.	N	P			0.80
21.	N	P			0.75
22.	N	P			1.20
23.	N	P			1.10
24.	N	P			1.05
25.	N	P			0.90
26.	N	P			1.33
27.	N	P			1.22
28.	N	P			0.65
29.	N	P	+ Careg.		1.02
30.	N	P	+ Careg.		1.22

(B) Girth

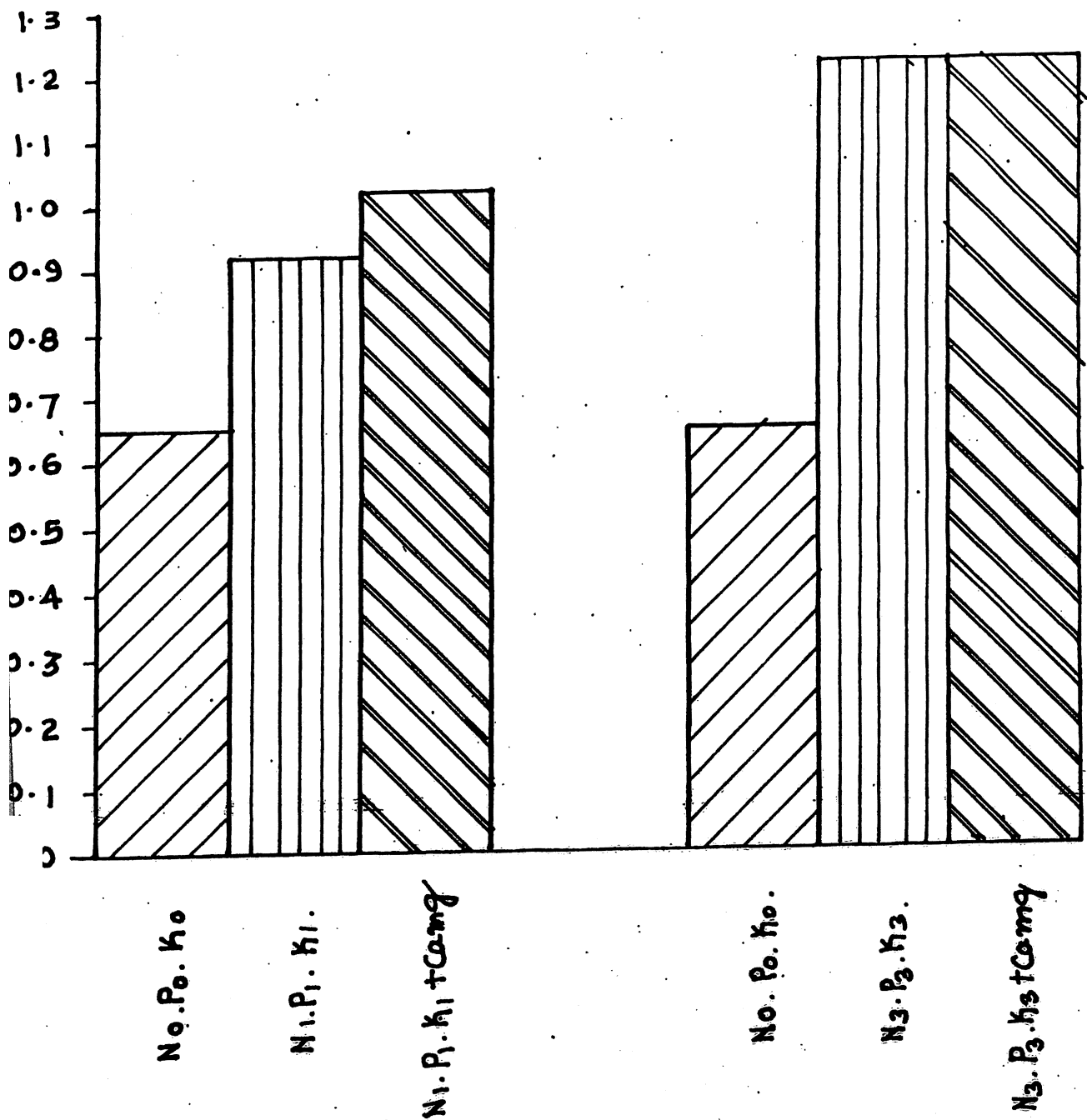
There was no significant effect of Nitrogen, Phosphorus, Potash and interaction on the girth of the coconut palm. Analysis variance Table (Appendix-VIII). However additional treatment produce significant effect on the girth of the palm (Appendix-VIII). There was no significant difference between $N_1 P_1 K_1 + \text{CaMg}$ and $N_3 P_3 K_3 + \text{CaMg}$. Both treatments were significantly superior to $N_0 P_0 K_0$ (Table No.27).

TABLE NO.27
Effect of additional treatment
on girth.

Sl. No. Treatment.		Plant girth in metres.
1.	$N_0 P_0 K_0$	0.65
2.	$N_1 P_1 K_1 + \text{CaMg}$	1.02
3.	$N_3 P_3 K_3 + \text{CaMg}$	1.22
4.	$N_1 P_1 K_1$	0.92
5.	$N_3 P_3 K_3$	1.22

C.D. at 5% = 0.393

FIG.- 12.
EFFECT OF ADDITIONAL TREATMENT ON GIRTH



(C) Number of leaves per plant.

TABLE NO. 28

Effect of nutrient application on number of leaves.

Sl. No. Treatments.				Number of leaves.
1.	N ₁	P ₁	K ₁	18.0
2.	N ₁	P ₁	K ₂	18.0
3.	N ₁	P ₁	K ₃	18.0
4.	N ₁	P ₂	K ₁	22.0
5.	N ₁	P ₂	K ₂	22.0
6.	N ₁	P ₂	K ₃	26.0
7.	N ₁	P ₃	K ₁	21.0
8.	N ₁	P ₃	K ₂	20.0
9.	N ₁	P ₃	K ₃	23.0
10.	N ₂	P ₁	K ₁	24.00
11.	N ₂	P ₁	K ₂	12.0
12.	N ₂	P ₁	K ₃	18.0
13.	N ₂	P ₂	K ₁	24.0
14.	N ₂	P ₂	K ₂	30.0
15.	N ₂	P ₂	K ₃	18.0
16.	N ₂	P ₃	K ₁	27.0
17.	N ₂	P ₃	K ₂	17.0
18.	N ₂	P ₃	K ₃	17.0
19.	N ₃	P ₁	K ₁	19.0
20.	N ₃	P ₁	K ₂	17.0
21.	N ₃	P ₁	K ₃	13.0
22.	N ₃	P ₂	K ₁	17.0
23.	N ₃	P ₂	K ₂	20.0
24.	N ₃	P ₂	K ₃	18.0
25.	N ₃	P ₃	K ₁	17.0
26.	N ₃	P ₃	K ₂	22.0
27.	N ₃	P ₃	K ₃	23.0
28.	N ₀	P ₀	K ₀	14.3
29.	N ₀	P ₀	K ₀ + CaMg	17.6
30.	N ₀	P ₀	K ₀ + CaMg	24.0

Phosphorus had a significant effect on the leaf number of coconut Palm. But neither Nitrogen nor potash nor interaction of $N \times P$, $N \times K$, $P \times K$ produce any significant effect on this character (Appendix-VII).

Analysis variance Table (Appendix-VIII) indicated that additional treatments had significant effect on number of leaves.

The effect of P_2 (20.3) P_3 (19.7) on the leaf number was at par. But significantly higher than P_1 (16.3).

With regard to additional treatment, the highest leaf number was recorded in $N_3 P_3 K_3 + \text{Calc}$ and was significantly more than $N_0 P_0 K_0$ (10.6). But the difference between $N_1 P_1 K_1 + \text{Calc}$ and $N_3 P_3 K_3 + \text{Calc}$ were not significant.

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TABLE NO.29

Effects of phosphorus on number
of leaves.

Sl. No. Treatments.	Number of leaves.
1. P_1	18.0
2. P_2	21.8
3. P_3	21.0

C.D. at 5% = 3.875

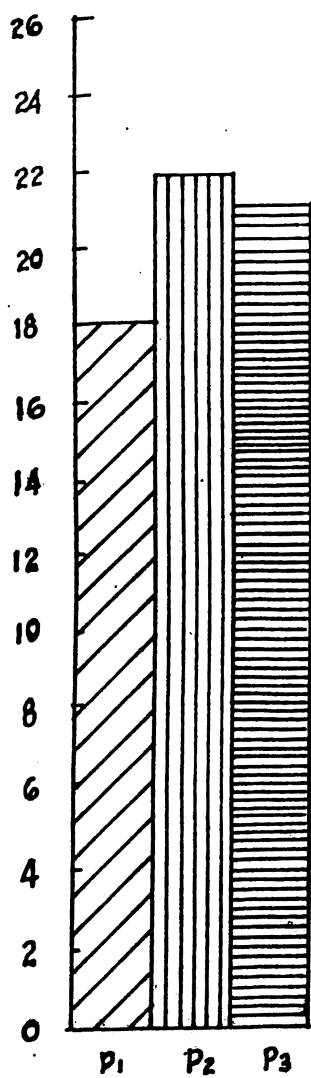
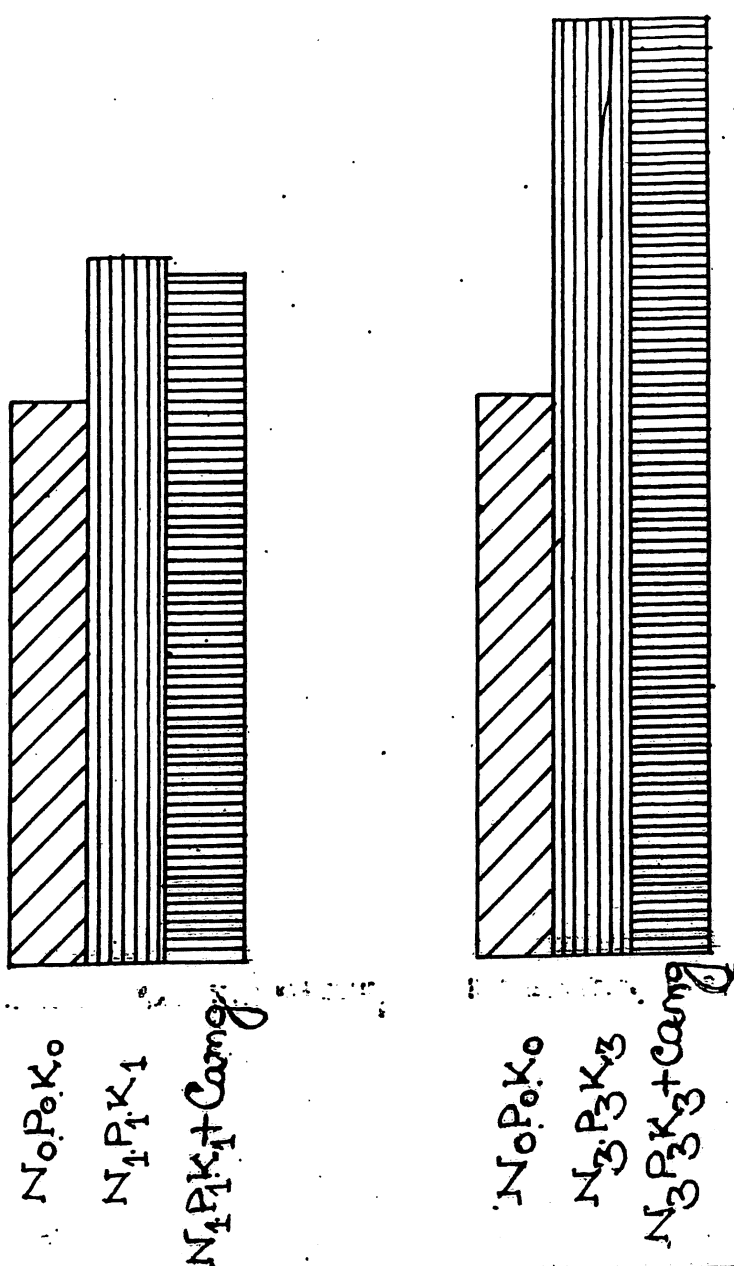
TABLE NO.30

Effect of additional treatments on
number of leaves.

Sl. No. Treatments.	Number of leaves.
1. $N_0 P_0 K_0$	14.3
2. $N_1 P_1 K_1 + \text{CaMg}$	17.6
3. $N_3 P_3 K_3 + \text{CaMg}$	24.0
4. $N_1 P_1 K_1$	18.0
5. $N_3 P_3 K_3$	24.0

C.D. at 5% = 6.852.

FIG-13

EFFECT OF P ON
NUMBERS OF LEAVESEFFECT OF ADDITIONAL TREATMENTS
ON NUMBERS OF LEAVES

1.6 Fruit bearing.

Observations were taken on the fruit bearing characters such as number of plants fruited, fruit set, fruit drop and fruit retention as affected by different treatment of Nutrient application. It was observed that only 16% of the experimental plants started fruiting so far. Therefore no definite inference could be drawn up.

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CHAPTER V

DISCUSSION

RESULTS AND DISCUSSION

In the proceeding chapter, the uptake of nitrogen, phosphorus, potassium at different dates and the nutritional effect on growth of coconut palms grown in the sea shore sand dunes of Konark have been discussed to explain the variation attributed to the effect of different treatments and understand the relationship among them basing on the finding reports presented in the previous chapter.

Uptake of Nitrogen.

Nitrogen is an important constituent of the plant cells, chlorophyll, proteins and their precursors in the plant. A sufficient supply of nitrogen is therefore preliminary condition necessary for the whole vital process pursuing a normal course in the plant. In the coconut palm nitrogen promote early growth and development of the plant. The specific function of the nutrient is to produce more female flowers in coconut palm.

As expected analysis of variance (Appendix-I) indicated that there was no significant effect of various treatment namely N, P, K and their interactions on the uptake of nitrogen on the first date of observation is six months after first dose of fertiliser application. This is because nutrients applied earlier were utilized by the plant. On the second date of observation highest uptake of nitrogen (2.734%) was recorded in case of N_3 applied in combination with calcium and magnesium compared to N_1 , N_2 and N_3 applied without calcium and magnesium (Table-21). Calcium and magnesium create optimum nutritive condition on the soil particularly in sandy and acidic soil. Application of nitrogen of the rate of 1000 gm/palm (N_3) without application of calcium and magnesium recorded only 1.44% N which is much below the optimum nitrogen content in the coconut palm (2.2%) as reported by Ollagnier et al (1985). It clearly shows that application of calcium and magnesium alongwith nitrogen improves uptake of nitrogen on the coconut palm. The uptake of nitrogen

increases with increase of nitrogen doses upto N_2 level and thereafter it is reduced. This finding is in the conformity with the finding of Devi and Valayuthum (1977). As expected uptake of nitrogen was reduced on the subsequent date (third date).

Uptake of phosphorus.

Phosphorus is present in the plant not only in various organic compounds such as nucleic acid, phyllin, phospholipids and as constituent of the enzymes but also in the inorganic form actively participates in the metabolism of the plant. In the construction and decomposition of the carbohydrates, phosphoric acid is the key in all the reactions through which the plant obtains energy for its vital processes. The first product of the photosynthetic assimilation of C_{O_2} is glycerophosphoric acid which is detected in short time as five seconds after the absorption of C_{O_2} . By rearrangements within the molecule and the union of two molecules of glycerophosphoric acid, phosphorylated sugars are formed which in turn

enable starch to be formed. In the reverse direction, the decomposition of starch to sugar and sugar to C_{602} in respiration and fermentation is only possible by the action of phosphoric acid. The phosphoric acid is thus essential for the metabolism of the plant. Besides, phosphoric acid has been found to increase girth at the collar, number of leaves and rate of leaf production in seedling, developes root system and facilitate the uptake and utilisation of nitrogen by the palm.

The effect of different doses of phosphorus on the phosphorus content on the leaf was found to be nonsignificant on the first date of observations (Appendix-I) and it was significant in second and third date of observation (Appendix-II & III). Since first observation was taken six months after application of fertilisers, there is no significant effect of different doses of phosphorus. The uptake of P was increased with increase of P dose upto P_2

level beyond which the uptake of P was reduced in P_3 (Table-22). The application of P in combination of calcium and magnesium improve the uptake of phosphorus. Similar finding is also reported by Thompson (1984). In the subsequent observation (third date) it was observed that the increase range of P uptake was from (0.430) to (0.673) as effected by different treatment of P which was much higher than in the second date of observation (0.123) to (0.284). The low uptake of phosphorus in the second date of observation was due to slow release of available phosphorus in the soil. The P content of leaf in the second date of observation is much higher even in the control (0.430) than optimum level of P content in the leaf (0.12%) as reported by Ollagnier *et al* (1985). This indicates that the coconu palm requires very low dose of phosphorus. It is also interesting to note that the lowest dose of P in combination with calcium and magnesium recorded highest content (0.673).

Uptake of potassium.

Potassium, too, is just as indispensable as nitrogen and phosphorus. However while the two elements already consider as integrating constituent of numerous compounds, this does not apply to potassium. It occurs in the plant only in the inorganic form, either free in the cell sap or also in combination with protein substances. Potassium is to be found everywhere in the plant where large physiological work is in the progress, thus particularly in the leaf and in the various zones of growth in the plant. Sugar and starch formation, the formation of organic acid, the formation of harden tissues, in addition to the reduction of nitrates and consequently the synthesis of protein are largely depended on the plant having sufficient supplies of potassium. Also the transportation of the elaborate assimilates from the leaves to the organ of storage and to the organ of consumption is only ensured by the plant being sufficiently supplied with potassium.

by the plant is the greater the more generously the substrate is supplied with potassium. The increase in uptake of potash by the application of calcium and magnesium is due to the fact that calcium and magnesium promote uptake of potassium (Thomson 1984).

The K content in leaf was reduced considerably in the third date of observation (Table No.23). This may be due to low content of K in soil (Table-14). Optimum K content in leaf as reported by Ollagnier et al (1985) is 1.4%. The K content of coconut palm in the present experiment was recorded as much more than optimum K content ranging from 1.923 in the control to 23.833% in $H_3 P_3 K_3 + Ca + Mg$.

The ash of fully developed coconut palm contain 15% potash. So potash is a nutrient factor intimately associated with the healthy and optimum growth and productivity of the coconut palm.

The results of the present experiment indicated that the effect of application of different dose of potash was found to be nonsignificant on the first date of observation, while it was found to be significant in the second and third date of observation (Appendix-I, II & III). The potash content in the leaf as observed in the second date was minimum with control (5.416) and it was increased significantly with increase of K dose with maximum K content at K_3 level (18.493). It was still increased when applied in combination with calcium and magnesium (23.833) (Table Ib.23). The potash content on this date is much more than the optimum level of potassium as reported by Ollagrier M. et al (1985). High uptake of potassium with the increasing doses of potassium may be explained that the absorption of potassium

by the plant is the greater the more generously the substrate is supplied with potassium. The increase in uptake of potash by the application of calcium and magnesium is due to the fact that calcium and magnesium promote uptake of potassium (Thompson 1984).

The K content in leaf was reduced considerably in the third date of observation (Table No. 23). This may be due to low content of K in soil (Table-14). Optimum K content in leaf as reported by Ollagnier et al (1985) is 1.4%. The K content of coconut palm in the present experiment was recorded as much more than optimum K content ranging from 1.923 in the control to 23.833% in $N_3 P_3 K_3 + Ca + Mg$.

CHAPTER VI

SUMMARY AND CONCLUSION

SUMMARY AND CONCLUSION

Effect of interaction N x P, N x K and P x K on the uptake of Nitrogen.

The results of the present experiment indicated that there was a significant effect of interaction N x K on the uptake of Nitrogen but there was no significant effect of interaction N x P and P x K on the uptake of this element (Appendix-II and III). In the second and third date of observation, Nitrogen content in the leaf was maximum with $N_3 K_1$ (1.652) i.e. with high dose of N applied with low dose of K. When the dose of nitrogen increased with high dose of potash the uptake of nitrogen was reduced i.e. from 1.633 in $N_1 K_3$ to (1.306 in $K_3 N_3$ (Table-18 and 19) whereas the uptake of nitrogen was increased with increased doses of nitrogen applied with low dose of potash. This shows that high dose of potash depresses the uptake of nitrogen. Similar results were reported by Thompson (1984).

Effect of interaction N x P, N x K
and P x K on uptake of Phosphorus.

There was no significant effect of N x P, N x K and P x K on the uptake of P in the first and second date of observation. However the interaction P x K was found to be significant on the third date of observation but interaction N x P, N x K were not significant. Maximum uptake of P was recorded in P_3K_1 (0.59) followed by P_3K_2 (0.56) and P_3K_3 (0.57). This clearly shows that high dose of phosphorus when applied with low dose of potash the uptake of P was increased and decreased when applied with high dose of potash. This finding was in corroboration with Provot and Bachy (1962).

Effect of interaction N x P, N x K
and P x K on uptake of Potash.

The results of the experiment indicated that interaction of N x K only showed significant effect on the uptake of potash in the second and third date of observation. Highest potash content in leaf was observed with N_1K_3 and minimum potash content was recorded with N_3K_1 . This shows that the uptake of potash was increased with increase of potash application with lower dose of nitrogen but

decreased when applied with high dose of nitrogen.

The effect of N x K on the uptake of potash is similar to the uptake of nitrogen. The similar result was reported by Prevot and Echy (1962).

The effect of N, P, K and their interaction on the growth of coconut palm.

(A) Plant height.

The results of the experiment indicated that except phosphorus no other treatment namely: N, K and interaction exhibited significant effect on height of the palm (Appendix-VII). In this result, control ($N_0 P_0 K_0$) was not taken into account. The plants were getting all the three nutrients in different ratios and the plants are of 11 years old. Therefore, the plants have attained certain height in different treatments which do not show much difference. Besides no organic manure was applied to the soil during inorganic fertiliser application. Therefore the soil was not in proper condition for absorption of all the nutrients which are applied in the form of inorganic fertiliser.

When the nutrients were applied in combination with calcium and magnesium the effect was found to be significant on the plant height. The maximum height was recorded in $N_3 P_3 K_3$ with combination with calcium and magnesium (9.46) followed by $N_1 P_1 K_1$ in combination with calcium and magnesium (7.04). Both the treatments are highly significant over $N_0 P_0 K_0$ (4.23 metre) (Table No.25) and (Figure No.11).

The above two treatments were found to be significantly superior over corresponding treatment i.e. $N_1 P_1 K_1$ (6.50) and $N_3 P_3 K_3$ (8.20) without calcium and magnesium (Table No.30). This clearly shows that the soil of the experimental plot is deficient of calcium and magnesium which promote the uptake of N, P, K. Therefore it may be recommended that the inorganic fertiliser may be applied with in combination of calcium and magnesium in sandy soils of coastal belt of Orissa. Similar results were reported by Guverier (1991).

(D) Girth

There was no significant effect of nitrogen, phosphorus, potash and their interaction on the girth of coconut palm (Appendix-VIII). This may be due to the fact that the girth might have not increased sufficiently as affected by different treatments within short period of 4 months, so as to show significant difference in girth. However all the treatments were significantly superior to control.

Number of leaves.

Phosphorus had significant effect on the leaf number of coconut palm. But neither nitrogen nor potash nor their interaction produced any significant effect on this character (Appendix -VII). The reasons of the finding are similar to as explained in plant height and girth. Additional treatments had significant effect on number of leaves. Both the treatments namely $N_3 P_3 K_3$ and $N_1 P_1 K_1$ in combination with calcium, magnesium showed no significant difference on leaf number among themselves, but showed significant difference of $N_0 P_0 K_0$ (Table No.29 & 30) (Figure No.13).

P_2 and P_3 were at par but significantly higher than P_1 . This shows that P_2 may be optimum dose for production of more number of leaves. The increase in leaf number by the application of phosphorus was reported by Thompson (1984).

Fruit bearing.

Observation were taken on the fruit bearing characters such as number of plants fruited, fruit set, and fruit drop and fruit retention as affected by different treatments of nutrient application. It was observed that only 16% of the experimental plants started fruiting so far at the time of observation. Therefore no definite conclusion could be derived at.

As a matter of fact coconut palms come to bearing within 5-7 years of planting when they are properly manured and managed. The reason for the nonbearing of palms under the present experiment may be unavailability of nutrients to the plants because of sandy soil where there might have been lot of leaching of nutrients.

SUMMARY AND CONCLUSION

The present experiment entitled " STUDY ON NUTRITIONAL UPTAKE BY COCONUT PALM " was conducted at coconut research centre, Konark of all India Co-ordinated Coconut Improvement Project, Orissa University of Agriculture & Technology, Bhubaneswar during the year 1986-87 with the following objectives ;

1. To study the uptake of nutrients (N, P and K) by the coconut palm.
2. To ascertain the status of the nutrient in the soil and in the leaf at different dates.
3. To study the effect of different treatments on the growth of the palm.
4. To findout the effect of different treatment on fruit bearing.

The design adopted for the experiment is 3^3 confounding Factorial design with the following treatments.

N = 3 levels :

- | | |
|-------|--------------------|
| N_1 | = 500 gm N/Plant |
| N_2 | = 1000 gm N/Plant |
| N_3 | = 1500 gm N/Plant. |

P_2O_5 - 3 levels :

P_1 = 250 gm P_2O_5 /Plant

P_2 = 500 gm P_2O_5 /Plant

P_3 = 750 gm P_2O_5 /Plant

K - 3 levels :

K_1 = 750 gm K_2O /Plant

K_2 = 1250 gm K_2O /Plant

K_3 = 1750 gm K_2O /Plant

They were applied in 2 split doses i.e.

1/3rd in June and 2/3 in January. In addition to the 27 treatments, 9 extra treatments were included namely :

$N_0 P_0 K_0$ = 3

$N_1 P_1 K_1$ + CaMg = 3

$N_3 P_3 K_3$ + CaMg = 3

Calcium 150 gm Ca O/Plant

Magnesium 300 gm Mg O/Plant

The data collected on various characters were statistical analysed and the results are summarised below :

1. Significant effect of nitrogen was observed at one month and three months after second dose of fertiliser application.
2. With increase of nitrogen dose the uptake of nitrogen increased upto N_2 and it was reduced in the subsequent dose.
3. Uptake of nitrogen was more one month after application of nitrogen and reduced three months after application of fertiliser.
4. Highest uptake of nitrogen was recorded at N_2 level.
5. Application of N in combination with calcium and magnesium increased the uptake of nitrogen compared to nitrogen applied without calcium and magnesium.
6. Effect of different dose of phosphorus was also found to be significant on second and third date of observation as in the case of nitrogen.

7. The uptake of Phosphorus was increased in the third date of observation unlike nitrogen which was reduced.
8. Highest uptake P was recorded with P_2 level.
9. Application of phosphorus fertiliser in combination with calcium, magnesium also improved the uptake of P.
10. Uptake of potash was increased with increase in dose of potassic fertilisers.
11. The uptake of potash was more in second date of observation than the third date of observation.
12. Application of potassic fertiliser in combination with calcium and magnesium improved the uptake of potash.
13. K content in leave was found to be much more (23.833) than the optimum K content (1.4) in the leave.
14. Uptake of nitrogen increased with high dose of K when applied with low dose of nitrogen and viceversa.
15. There was no significant effect of $N \times P$, $N \times K$ and $P \times K$ on the uptake of P on first and second date of observation. The interaction between $P \times K$ was found to be significant on the P content in the leaf.

16. When high dose of phosphorus is applied with low dose of potash the uptake of P was increased and decreased when applied with high dose of potash.
17. Uptake of potash was increased with increase in potash application with lower dose of nitrogen but decreased when applied with high dose of nitrogen.
18. Effect of nitrogen, phosphorus and potash was significant over control on the height of the plant.
19. There was a significant effect of calcium and magnesium when applied with N, P, K fertilisers.
20. Girth of the palm was increased with the application of phosphorus.
21. Application of phosphorus increased the leaf number of the coconut palm.

C O N C L U S I O N

The uptake of nitrogen was very low in the Konark sandy soils though the nitrogen applied in required quantity as indicated by leaf analysis. The leaf analysis indicated the nitrogen content as 1.499 in the N_3 level which is lower than the optimum N content in leaf (2.2%). Application of

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calcium and magnesium alongwith the N, P, K
fertiliser improved markedly the uptake of nitrogen.
Not only nitrogen but also phosphorus and potash
content in leaf increased when calcium and magnesium
applied with N, P, K fertilisers.

The soil condition should be improved by
addition of organic matter and tank silt for better
availability of nutrient to the plants. Fertiliser
should be applied in combination with calcium and
magnesium in the sandy soils.

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APPENDIX

(a)

APPENDIX-I

ANALYSIS OF VARIANCE FOR NUTRITIONAL UPTAKE
(FIRST FIVE OF OBSERVATION)

-----					-----				
Source of variance, Degree of freedom,					Uptake of N, Uptake of P ₂ O ₅ , Uptake of K ₂ O,				
-----					-----				
Block	2	0.087	0.001	5.711					
Nitrogen (N)	2	0.066	0.000031	0.099					
Phosphorus (P)	2	0.096	0.00008	21.887					
Potash (K)	2	0.071	0.00006	2.479					
N x P	4	0.018	0.00002	20.458					
N x K	4	0.071	0.00004	6.860					
P x K	4	0.044	0.00003	13.161					
Error	6	0.055	0.00001	5.384					

(b)

APPENDIX -II

ANALYSIS OF VARIANCE FOR NUTRITIONAL UPTAKES IN
PERCHNORIS (SECOND DATE OF OBSERVATION)

Sources of variance.	D.F.	Uptake of N.	Uptake of P ₂ O ₅	Uptake of K ₂ O.
Block	2	0.001	0.012	2.175
Nitrogen	2	0.036 *	0.025 *	10.56 *
Phosphorus	2	0.011	0.0265 *	16.62 *
Potash	2	0.037 *	0.0175	10.72 *
N x P	4	0.0122	0.0237	1.612
N x K	4	0.051 *	0.022	14.682 *
P x K	4	0.055 *	0.0165	0.72
Error	6	0.006	0.0046	1.466

* - Significant at 5% level.

(c)

APPENDIX -III

ANALYSIS OF VARIANCES FOR NUTRITIONAL UPTAKES IN PERCENTAGES
(THIRD DATE OF OBSERVATION)

Sources of variance.	D.F	Uptake of N.	Uptake of P ₂ O ₅ .	Uptake of K ₂ O.
Block	2	0.0135	0.002	0.87
Nitrogen	2	0.0275 *	0.006	7.64 *
Phosphorus	2	0.0760 **	0.143 **	1.85
Potash	2	0.0085	0.028	7.35 *
N x P	4	0.0007	0.002	1.97
N x K	4	0.0405 *	0.011	8.405 *
P x K	4	0.014	0.003 *	4.342
Error	6	0.0046	0.011	1.288

* - Significant at 5% level.

** - Significant at 1% level.

(4)

APPENDIX -IV

ANALYSIS OF VARIANCE FOR NITROGEN UPTAKE BY ADDITIONAL
TREATMENT VIZ. CONTROL, Ca and Mg.

Sources of variance.				D.F	First date.	Second date.	Third date.
Block	2	0.127	0.065				0.030
Treatment	2	0.193 *	0.32 **				0.332 **
Error	4	0.021	0.011				0.015
Total	8						

* - Significant at 5% level.

** - Significant at 1% level.

(0)

APPENDIX-V

ANALYSIS OF VARIANCE FOR PHOSPHORUS UPTAKE BY ADDITIONAL
TREATMENTS

Source	D.F	First date.	Second date.	Third date.
Block	2	0.0009	0.0001	0.045
Treatment	2	0.0017	0.047 **	0.479 *
Error	4	0.0006	0.0062	0.47

* - Significant at 5% level.

** - Significant at 1% level.

(2)

APPENDIX -VI

ANALYSIS OF VARIANCE FOR POTASSIUM UPTAKE BY ADDITIONAL
TREATMENTS (VIZ. C3 AND M4 AND CONTROLS)

Source	D.F	First date.	Second date.	Third date.
Block	2	6.395	13.96	5.631
Treatment	2	43.935 **	125.84 *	31.265 **
Error	4	2.74	11.465	1.342

* - Significant at 5% level.

** - Significant at 1% level.

(9)

APPENDIX-VII

ANALYSIS OF VARIANCE FOR GROWTH CHARACTERS

Sources of variance.					D.F		Plant height in mts.		Collar girth in mts.		Total number of leaves.	
Block	2	0.155	0.004	25.335								
Nitrogen	2	1.004	0.001	19.001								
Phosphorus	2	3.676 *	0.134	64.779 *								
Potash	2	0.548	0.003	8.779								
N x P	4	0.697	0.022	7.443								
N x K	4	0.762	0.042	20.443								
P x K	4	0.188	0.026	12.889								
Error	6	0.63	0.032	11.29								

* - Significant at 5% level.

(h)

APPENDIX-VIII

ANALYSIS OF VARIANCE FOR GROWTH CHARACTER FOR ADDITIONAL
TREATMENTS

Source	D.F.	Plant ht.	Coll. girth.	Number of leaves.
Block	2	0.243	0.039	44.33
Treatment	2	20.843 **	0.249 *	72.33 *
Error	4	0.712	0.03	9.14

* - Significant at 5% level.

** - Significant at 1% level.