FOLIAR DIAGNOSIS, YIELD AND QUALITY OF TURMERIC (*Curcuma longa* L.) IN RELATION TO NITROGEN, PHOSPHORUS AND POTASSIUM

BY

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THESIS

Submitted in partial fulfilment of the requirements for the Degree of

Master of Science in Agriculture

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Kerala Agricultural University

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COLLEGE OF HORTICULTURE
Vellanikkara - Trichur

1981

DECLARATION

I hereby declare that this thesis entitled "Foliar diagnosis, yield and quality of turmeric in relation to nitrogen, phosphorus and potassium" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "Foliar diagnosis, yield and quality of turmeric in relation to nitrogen, phosphorus and potassium" is a record of research work done by Shri. Saifudeen, N. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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ACKNOWLEDGEMENTS

It is my pleasant duty to express my most sincere sense of indebtedness and gratitude to Dr. A.I. Jose, Professor in charge and Head of Department of Soil Science and Agricultural Chemistry, for the invaluable help rendered during the course of the investigation, both as Chairman of the Advisory Committee and as the inspiring force, contributing critical suggestions.

I also wish to place on record, my thanks to Smt. K. Leela, Associate Professor of Soil Science and Agricultural Chemistry, Dr. R. Vikraman Nair, Associate Professor of Agronomy and Shri. P.V. Prabhakaran, Associate Professor of Agricultural Statistics, members of the Advisory Committee for the help they have rendered to me.

My profound sense of gratitude is expressed to Shri. V.K.G. Unnithan, Assistant Professor of Agricultural Statistics for the whole hearted co-operation extended to me in the statistical analysis of the data.

I had the privilege to have the sincere help from all corners, including the staff members and student friends, both post graduates and undergraduates. The voluminous amount of work that is contained in this thesis would not have been so precise and elaborate, had it not been for their help. I take this opportunity to express my heartfelt thanks I owe them.

My thanks are also to Smt. L.Lalitha, Senior Office Superintendent who have taken the pains to type the script neatly, and to Mrs. & Mr. K. Thankappan Nair, for their help during the preparation of the thesis.

Thanks are also due to Dr. P.C. Sivaraman Nair, erstwhile Associate Dean and presently Director of Research, and to Dr. P.K. Gopalakrishnan, Associate Dean in-charge for providing necessary facilities for the conduct of this work.

The award of fellowship by the Kerala Agricultural University is gratefully acknowledged.

(SAIFUDEEN, N.)

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Introduction

INTRODUCTION

Turmeric (*Curcuma longa* L.) is the underground stem or rhizome of a perennial herb of ginger family, indegenous to tropical South East Asia. India is the world's largest producer of turmeric followed by China and Pakistan. About 54 thousand hectares are under turmeric in India and the average annual production is 100-150 thousand tonnes.

Turmeric is a versatile commodity with innumerable uses. It is used as a condiment, indegenous medicine, ingredient in cosmetic preparations and as a natural dye in pharmaceutical, confectionary and food industries.

Though the crop deserves national importance in terms of foreign exchange earnings, research on turmeric is very limited. Systematic investigation on turmeric was first started in Kerala at the Horticultural Research Station, Ambalavayal. However, most of these investigations were confined to the screening of varieties suited for different agro-climatic regions while attempts to assess the nutritional requirement of the crop in relation to the pattern of uptake and the nutrient level maintained in the plant are very little.

The highly heterogenous nature of the soil and the complexities in transmission of nutrient from soil to the plant necessitate the use of tissue analysis as a better guide rather than soil analysis in predicting the crop performance. Detection of nutrient status of the plant, assessment of the nutrient need of the crop and prediction of crop performance by foliar diagnosis have been successfully followed in many crops while such a study has not been reported in turmeric. The present investigation was therefore undertaken with the following objectives in view.

1. To develop a foliar diagnosis technique in turmeric in relation to nitrogen, phosphorus and potassium;
2. To study the pattern of uptake of nitrogen, phosphorus and potassium under the influence of graded doses of these nutrients added;
3. To study the effect of nitrogen, phosphorus and potassium treatments on the yield, quality and morphological characters of turmeric; and
4. To examine the influence of increasing period of growth on the morphological characters, chemical composition and quality of turmeric.

The results of this investigation are presented and described in the following pages.

Review Of Literature

REVIEW OF LITERATURE

1. Foliar diagnosis

Foliar diagnosis is a method of establishing the levels of nutrients below which plants show deficiency symptoms and nutrient values associated with optimum growth and yield. It is used as a guide to the nutritional status of the plant.

The original definition and methods of foliar diagnosis were developed by Lagatu and Maume between 1924 and 1933 when they made several studies of the vine leaves and potato leaves. The term 'diagnostic foliare' was first used in France by Lagatu and Maume (1926) and the concept of tissue analysis as a diagnostic technique for mineral deficiencies in plants was given a rational and scientific footing by these scientists.

The capacity of the leaf to variation in composition makes it sensitive to variation in the medium, and the leaf analysis has practical advantages with perennial plants. Foliar diagnosis at a given moment is the chemical condition at that time, of a properly chosen leaf from a prescribed position, and annual foliar diagnosis is the series of chemical states of that leaf as shown by analysis at different times during the whole vegetative cycle (Forestier, 1968).

Foliar diagnosis continues to be an empirical correlation between the leaf nutrient level at a particular part of the plant at a particular growth period and the final performance of the plant. The nutrient content of a leaf is not static, but subject to changes with various factors, both external and internal. For practical convenience, a period when the leaf nutrient content is relatively stable is chosen for sampling and related to the performance of the plant in quality and quantity. The position of leaf, part of leaf and form of nutrient to be estimated are all standardised. After a good deal of analysis of leaves from plants fed with varying levels of nutrients, the deficient or responsive levels, the critical or optimum levels, and high or luxury levels are identified to give guidance for fertilisation.

Wadleigh (1949) remarked that, for any given combination of environmental factors, within a plant tissue, there is an optimum content of mineral nutrients for maximum plant growth and deviation from this affects it. This is the strong basis on which plant analysis as a diagnostic tool stands.

Singh _et al_. (1973) have stressed the necessity of a detailed examination of the differences in foliar analysis procedures in the different laboratories and periodic cross checks in the case of oil palm and rubber. To arrive at this conclusion, they have carried out two cross checks during 1972 in oil palm and rubber leaf samples at 13 laboratories.

The results showed that very good inter-laboratory agreement is obtained in the determination of leaf nitrogen (below 5% coefficient of variation). For P, K, Ca, and Mg (c.v. about 10%) the inter-laboratory agreement needed to be improved. Inter-laboratory agreement was slightly worse for Mn and Fe and was poorest (c.v. over 20%) for B, Zn and Cu.

There has been a lot of research work done in the field of tissue analysis and some of them which denote the significance of foliar diagnosis are given hereunder.

Nicholas (1947), after investigating the relation between concentration of extractable nutrients and time of sampling for crops receiving various manurial treatments suggested that tissue tests sometimes indicate the impounding mineral deficiency or toxicity.

Chubb and Atkinson (1948), investigated the foliar diagnosis method in tomato, potato, oats and maize grown in two soils of different fertility levels and under various fertiliser treatments. They could not find any direct relationship between the composition of leaves and the addition of fertilisers to the soils. Also, no relationship was found either between the intensity of nutrition values and yield or between the content of N, P or K in the leaf and yield. The distribution of NPK units on a trilinear graph showed no relation to the yield obtained.

A detailed investigation carried out by Chapman and Brown (1950) to study whether the K status of a citrus tree can be determined by leaf analysis has revealed that the leaf, of the various plant tissues tested, best reflects the varying potassium status of the nutrient medium.

Thomas <u>et al</u>. (1953) compared the concepts of foliar diagnosis and standard values, with reference to determination of fertiliser requirements of potato, tomato, runner bean, maize, apple and peach. The nutrients studied were N, P, K, Ca and Mg. They could give records of nutrient percentages in leaves associated with maximal yields and the range of each element for each crop.

Rogers <u>et al</u>. (1955) compared different plant parts of strawberry and showed that leaf was as sensitive as or even more sensitive than any other plant part as an index of the nutrient status of the crop.

In a sand culture experiment with lucerne, Omar and Kobbia (1965) found that K and Mg contents of leaves were closely related to K and Mg concentrations in the nutrient solution.

Ling (1965) studied the nutrient status of citrus nurseries in Taiwan using leaf analysis as a diagnostic method. He could show that many nurseries needed increased application of N, P and K.

Ochs (1965) has also stressed the importance of foliar diagnosis in the potassium nutrition of oil palms.

Jones (1966) attempted to define excess, optimum and deficiency limits of N, P, K, Ca and B contents of leaves in apple, black currents, raspberry and strawberry based on leaf analysis and yield records.

In a field trial on mature pepper vines, De Waard (1969) established that systematic consideration of leaf concentrations and ratios derived from foliar analysis was a satisfactory basis for fertiliser application.

During the conference on 'Chemistry and Fertility of Tropical Soils' in November, 1973 at Kualalumpur, Malaysia, Ranapathy reported that foliar diagnosis was being used extensively for oil palm and rubber. He suggested that it can also be extended to include pineapple, coconut, maize, sorghum, paddy and other crops, whereas soil analysis can be used as a rough guide to some crops. He also suggested that whole plant analysis is of limited use for fertiliser assessment except in the case of some annual crops.

1.1. Interpretation of foliar analysis data:

When interpreting the results of foliar diagnosis, the most important fact to be borne in mind is that the results of a foliar diagnosis merely indicate the existing nutritional status of the plant. They do not indicate the reasons for those particular nutrient values. Therefore, before making any recommendation, on the basis of an analysis, the results must be interpreted with due consideration of the conditions causing any particular nutrient balance. These are, climatic conditions, previous field performance and results of experiments carried out in the particular field. The whole pattern of nutrient status changes with dry weather as water becomes a limiting factor and also in very wet conditions when poor root aeration may be brought about by waterlogging. In conditions of drought, there are marked reductions in nitrogen and phosphorus content of the plant. Potassium tends to increase unless drought becomes very severe (Le Roidevin and Robinson, 1964).

Friis-Nielson (1966) reported that the interpretation of chemical plant analysis should be based on the total curves as a composite function of the absorbed nutrient and applied growth factor. Results of plant analysis belong to intervals of such yield curves, each interval being characteristic of particular inter-relationship between yield, nutrient absorption and growth factor level.

Mineral nutrition is one of the physiological mechanism of the plant. These mechanisms operate together and react simultaneously in a complex way to any given factor. The role of each element in the various functions of the plant is only imperfectly known but such preliminary understanding as we have, forms a basis for attempts to relate foliar diagnosis figures to the productivity of the plant.

1.2. Foliar diagnosis vs soil analysis:

Leverington *et al.* (1962) could not find any consistent relationship between leaf K status of sugarcane and the amount of K needed for maximum yields. They also stated that the K content of leaf blade is highly dependent on the age and on the rate of K application. Their conclusion is that unless K is very deficient, soil analysis is more reliable than leaf analysis for assessing K requirements of sugarcane.

Leaf composition in apple, raspberry and black current was related to nutrient elements in soil by Jones (1963). The soil and leaf analysis from long term field experiments and surveys of nutritional status in commercial fields showed in general a relationship between the macronutrients in the top soil and those in the leaves. In addition to the primary (direct) effects of fertiliser application on leaf composition, there were also, in some cases, large secondary (indirect) effects.

In the case of deep loam soils, with a root range several metres deep, more accurate information on the nutrient status of Coxs' orange apple trees is obtained from plants than from soil analysis (Lefevre, 1965).

Ollagnier and Giller (1965) compared foliar diagnosis with soil analysis in determining the phosphorus and potassium requirements of groundnut in Senegal. Among the 57 factorial experiments, foliar diagnosis values were more closely correlated with yields and response to P and K, than the results of soil analysis.

Champion (1966) opined that foliar diagnosis and soil analysis are both necessary in judging fertiliser requirements of banana.

In a study about the mineral deficiencies in young container cultivated palms, Ruer (1966) found that soil analysis was less sensitive than foliar analysis for detection of N and Mg deficiencies.

1.3. Sampling technique

According to Evans (1979), for foliar diagnosis to be successful, it is essential that all factors that cause variation in leaf nutrient levels are identified. There are at least ten sources of variation including climate, season, time of day, tree age, age of foliage, between tree variation, position in crown, nutrient balance, effects of diseases and other factors. Sampling procedures are to be standardised to take these factors into account and so as to permit variation due to poor tree nutrition to be isolated and made evident.

Forestier (1968) suggested that known influences on leaf composition such as the daily changes between morning and evening and washout from living leaves by heavy rains have to be eliminated by suitably designed sampling methods.

Steenbjerg (1954) stated that care should be taken to choose such organs of the plant, that the sampling should be carried out during that part of the growing season when differences in the analytical results will be greatest.

Thomas (1937) found that the whole plant analysis will not furnish a sensitive index of the differences in nutrition of plant due to heterogenous nature of tissues involved. He designated the plant part selected for foliar analysis as the 'reflect' as it reflects the mineral status of the plant as a whole. Lagatu and Maume (1934) envisaged the leaf as the ideal tissue to sample, since it was considered the chemical laboratory of the plant.

Time of day for collection of sample is also important. Ulrich (1952) opined that the best time to take samples was from 8 a.m. to 12 noon.

The sampling techniques as applied to different crops have been suggested by several research workers. Some of the important references are given hereunder.

Potato

Gallo *et al.* (1965) suggested that in pot experiments, determination of nitrate nitrogen, phosphate-phosphorus and total potassium in the petiole of the third leaf from the apical bud was a sensitive and simple method for following the mineral nutrition of potatoes.

Sugarbeet

Plant nutrient surveys of sugarbeet fields were made by Ulrich (1946) by analysing petioles of sugarbeet leaves collected during 1943 and 1944. Vomel and Ulrich (1963) in their work on leaf analysis for determination of manganese deficiency in sugarbeet reported that blades of physiologically matured middle leaves reflected the manganese status of sugarbeet better than any other tissue.

Maize

Tyner (1946) suggested tentative critical levels of nitrogen, phosphorus and potassium in the sixth leaf of maize at the bloom stage.

Sugarcane

Clements (1947) found that the young leaf sheaths were the most suitable among the index tissues tested to determine the level at which potassium must be maintained for maximum crop returns. Halais (1952) reported that P and K requirements of sugarcane in Mauritius were established mainly by foliar diagnosis of the third leaf sampled at the culmination of the vegetative period in summer, well before flowering.

Miller (1962) collected the central parts without veins, of leaves 3-6 from the top of sugarcane plant and analysed for nitrogen. The leaf nitrogen percentage 72 days after fertilising gave close correlation in the sugar production at harvest.

The determination of N, P and K deficiency trends in sugarcane by means of foliar diagnosis was undertaken by Halais (1963). He recommended the central part of the third leaf, omitting the midrib, for ratoon crops, aged five months as the best reflect.

Based on the results of 40 factorial experiments with N P and K at three levels on the main sugarcane soils in San Paulo, Malavolta et al. (1965) found that nutrient levels in the middle part of the third and fourth leaves were correlated to fertiliser response in the fields.

Barley

During a study by Goodall (1949), it was recorded that response of barley to muriate of potash in terms of grain yield was significantly correlated with the K content of the older leaf blades and stems.

Sweet potato

Leonard et al. (1949) reported that the applications of available nitrogen and available potassium were definitely associated with the N and K content of leaf blades of sweet potato.

Citrus

Chapman and Brown (1950) reported that the status of potassium of orange trees can be deduced from the potassium content of three to seven month old spring cycle leaves.

For foliar diagnosis of citrus in Trinidad, Weir (1966) recommended the analysis of the leaves aged 5-9 months.

In his studies on the sampling methods in citrus, Nadir (1967) remarked that leaves should be sampled from the beginning of September to end of October, when they are 5.5 to 7 month old. An additional sampling of ten month old leaves is essential for potassium. It has been reported that top three leaves of fruit bearing citrus plant (6-7 month old leaves) are found to be the best for foliar diagnosis.

Apple

Gachon (1952), based on his study on foliar diagnosis in apple reported that it is advisable to undertake sampling at the end of the season (September-October) and to use the first two leaves from a twig on the central part of the tree.

Groundnut

Prevot (1953) suggested that the first stage of flowering is the most suitable time for leaf sampling in groundnut.

Rice

Velasco and Novero (1953) studied nitrogen relations in rice plant by foliar diagnosis. They grew rice plants for 45 days in a nitrogen deficient sub-soil or in complete nutrient solution and then treated with ammonium sulphate or transferred into nitrogen deficient media respectively. Analysis six days after treatment showed the nitrogen level of the most recently matured leaves to be the best indicator of the nitrogen needs of the plant.

<u>Banana</u>

Leaf analysis in banana plant was first originated with the sampling of the lamina of the third youngest leaf in the succession of leaves from the top of the plant since it had the highest concentration of nutrients (Hewitt, 1955). Later, the concentrations of nitrogen, phosphorus and potassium of third, fifth and seventh leaves were determined by Simmonds (1959) and he recommended third leaf as the standard for foliar diagnosis.

<u>Wheat</u>

Boldyrev (1959) reported that the grain yield in wheat was correlated with nitrogen and potassium content of leaves. In field and plot tests in which nitrogen and phosphorus were applied to chernozems, the percentage of nitrogen in leaves at flowering was highly and positively correlated with percentage nitrogen in the mature grain. Grain yield was correlated with the nitrogen and phosphorus content of leaves. Foliar diagnosis at flowering indicated whether or not the late top dressing with nitrogen and phosphorus was necessary.

The Tserling method for rapid determination of nitrogen requirements of wheat and prediction of grain yields and quality was discussed by Opanasenkova et al. (1977). It was based on the determination of plant nitrogen contents at different stages in relation to the colour intensity of stem sections stained with phenylamine on a scale of one to six. High yields and high grain protein content could be expected when the value at the earing stage was five to six.

Coffee

Baker and Robinson (1963) studied the leaf analysis technique as applied to coffee. The results showed that samples of leaves from bearing nodes would provide the most suitable index of supply of N, P and K. Malavolta et al. (1964) recommended the third or fourth leaves of coffee for use in foliar diagnosis.

Tea

Lin (1963) remarked that the second or third leaf from the apex on the young shoot of tea reflected nitrogen status of the plant most sensitively. Sampling error was reduced if two leaves of average size were selected for each tree. Variability was least when sampling was done from May to mid July and before noon.

Results of the studies conducted by Lin (1966) on the errors involved in leaf sampling of tea showed that leaves similar in maturity and size should be selected and that samples should be selected before noon to avoid diurnal variation in leaf nitrogen.

Tomato

The application of tissue analysis in the nutrition of greenhouse tomato was studied by Ward (1963). He collected tissue samples from nine crops each week and the samples comprised a composite of the fifth leaf from the growing tip from six plants. Analytical results were correlated with visual symptoms of healthy and abnormal growth.

Jankov (1965) suggested that for diagnostic analysis of N and P nutrition in tomatoes the fifth leaf from the top of the main stem should be collected during the period between the set and ripening of fruits. His further works showed that the use of stems, fruits or roots for analysis reduced the accuracy of diagnosis.

Melons

Tyler and Lorenz (1964) studied the nutrient needs of melons through plant tissue analysis. Four melon types grown with and without added N and P were sampled periodically to determine nutrient levels in petiole and leaf blade tissues. Results showed that petioles were more sensitive to available supply of N, P and K and were more satisfactory for plant analysis than the leaf blades. Early season samples were better for N and P analysis than late season samples. Differences between melon types were small.

Oil palm

Smilde and Chapas (1963) reported that the first, 17th and 25th leaves were best suited for foliar diagnosis in oil palm.

Chemical analysis of upper and lower rank leaflets has shown that while differences in composition are generally small, they could occasionally affect the interpretation of results. Therefore, Handreck (1972) suggested that samples should contain equal numbers of upper and lower rank leaflets.

Cassava

In the nutritional studies on cassava (Manihot esculenta Crantz), Pushpadas et al. (1975) have described the sampling technique for foliar diagnosis. They reported that the petioles from the middle one-third of the total leaves would serve as the best tissue for N, P, K and Ca. The percentage of N, P and K in the petioles from middle one-third of the total leaves, collected 4.5 months after planting correlated well with the yield, thereby justifying the choice of the tissue for analysis and indicating the possibility of predicting yield by tissue analysis.

Cacao

McDonald (1934) has reported that young leaves of cacao are best for foliar diagnosis. From a study conducted in New Guinea, Schroo (1960) found that second and third leaf, fully green, from near apex of fan shoots taken in July are best for detecting phosphorus status of the crop.

<u>Pineapple</u>

The whole leaves including the white tissue from 11 as well as 33 month old plants were recommended by several workers for foliar diagnosis. According to Cibes and Samuels (1958) the critical levels are found to change depending upon the stage of the crop.

<u>Rubber</u>

Foliar diagnosis of rubber for N, P and K was done by Shorrocks (1961). He selected four leaves each from 2 mature whorls exposed to full sunlight on outside of the canopy. A composite sample from 6 trees was collected. Only the leaf laminae without petioles and midrib were used for analysis.

<u>Coconut</u>

Prevot and Ollagnier (1957) studied the N, P, K, Ca and Mg status of coconut leaves. From mature palms, they selected the first completely developed leaf showing hardly visible inflorescence for analytical purpose. Ziller and Prevot (1966) have reported that the 14th leaf of mature palms can be selected for foliar diagnosis.

Ginger

Johnson (1978) has reported the foliar diagnosis technique in relation to N, P and K in ginger. He found that the group of fifth to twelth leaves appeared to be the best suited for foliar diagnosis of N, P and K status of the crop. The period between 90th and 120th day after planting was recommended as the optimum period for the detection and amendment of the nutrient status of the crop.

Pepper

DeWaard (1969) designated the first older mature leaves with petiole from fruit bearing higher order branches as the best 'reflect' in the case of pepper.

1.4. Critical level of nutrients

The term 'critical concentration' refers to the optimum concentration of a given nutrient element in plant tissue above which response to further increments is doubtful or occurs at rapidly diminishing rates. A study of the regression trends in corn by Tyner (1946) has shown that at nutrient levels in excess of the critical concentration, extraneous factors are apt to have a greater influence on yield than nutrient content variation. Generally, it is assumed that the yield and foliar level of a given element are continuous functions dependent on the fertiliser doses applied to the soil.

The critical concentrations of different nutrient elements for different crops have been worked out by several research workers. The following are some of the important references in this regard.

Potato

Emmer (1946) suggested that for higher yields, the petioles of potato leaves should contain 1200 ppm nitrogen in the early stages.

Maize

Roche et al. (1966) could get a good correlation between nutrient deficiencies in soil and nutrient concentration in maize leaves, the critical leaf contents for a reasonable yield being 2.2% N, 0.2% P_2O_5, 1.4% K, 0.3% Ca, 0.3 to 0.4% Mg and 0.18% S. Oke (1966) has suggested 300 ppm of nitrate nitrogen in the leaves of maize as the critical level. Soluble nitrate content is a more effective index than total nitrogen content. The suggested critical levels for N, P and K in the ear leaf of maize at the dry Leeward inlands of Antigua were 2.19%, 0.25% and 2.17% respectively while at the wet islands of Dominica the values were 2.53%, 0.18% and 2.32% respectively (Forde, 1976).

Sugarbeet

Vomel and Ulrich (1963) reported that the physiologically mature middle leaves of sugarbeet should contain 15 to 25 ppm of manganese for high yields, whereas the critical concentration of manganese was 10 ppm.

Sugarcane

According to Borden (1947) the percentage K_2O in leaf-punch samples of the variety 32-8560, provides a figure which represents a critical K level. He suggested that if leaf punch samples at 3 months show 0.4 to 0.5% K_2O, K fertiliser should be applied immediately. Clements (1947) has worked out the K index which is the K content of the sheaths expressed as a percentage of the sugar free dry weight and reported that it varied from 0.17 to 5%. At 0.17% the plants were stunted and sickly, while at 5.0 they were lush but of poor quality. The minimum K-index needed for adequate growth is about 2.25. The minimum P index for healthy growth has been got at 0.080%. Halais (1963) recorded that optimum levels of 1.95% N, 0.48% P_2O_5 and 1.5% K_2O on dry matter basis in the central part of the third leaf for ratoon crops aged 5 months are sound, on his study from year to year as a follow up basis.

Barley

Goodall (1949) suggested the limiting values of 0.93% K in older leaves and 1.01% in stems at time of ear emergence.

Sweet potato

Leonard *et al.* (1949) reported that plants with leaf blades varying from 4.75 to 5% N in early summer and from 3 to 3.9% N at the harvest and with 2% K during all stages of growth produced higher yields.

Groundnut

Based on the results of fertiliser experiments conducted by Prevot (1953), the critical levels expressed as percentage of dry matter in leaves are tentatively given as 4% N, 0.2% P and 1% K.

Banana

The critical levels of nutrients reported by Hewitt (1955) were 3.6% N, 0.45% P_2O_5 and 3.3% K_2O.

Tea

The critical nitrogen concentration on third leaves in various varieties was reported to be 4.6 to 3.6% by Lin (1963). Lin (1966) remarked that the critical N, P and K concentrations in leaf dry matter were approximately 4%, 0.26% and 1.5% respectively. Akhmetov and Bairamov (1968) have suggested that the optimal N, P and K contents assuring best harvest would be 4.5 to 4.8%, 0.5 to 0.6% and 2.2 to 2.4% respectively.

Tomato

The following set of satisfactory nutrient levels were determined for tomato by Ward (1963) in America. N 5.25%, P 0.8%, K 4%, Ca 1.5%, Mg 0.45% and NK ratio 1.31. The critical levels on fifth leaf from the top on main stem during the period between the set and ripening of fruits are 3.25% N and 0.21% P_2O_5 as reported by Pankov (1965).

Oil palm

In the case of potassium fertilising of oil palms, Ochs (1965) reported that for values below critical level the relationship between yield and leaf K content is linear, an increase in 0.1% K in the leaf resulted in an yield increase of 10%. Ochs (1965) has also suggested that potassium content below 1% in the dry matter indicates K deficiency. The critical levels in soils were given as 0.15 to 0.2 m.eq. exchangeable K per 100 g in soils with a fixing capacity below 10 m.eq. per 100 g. Ruer (1966) could observe visual deficiency symptoms in below six months old container cultivated palms, at a level of 2.6 to 2.7% N and 0.06 to 0.10% Mg in the 9th leaf.

Apple

Guyon (1947) found that healthy apple leaves contained about 2.3 per cent nitrogen, whereas deficient leaves contained only 1.5 per cent.

Cacao

The values for intermediate range for N, P and K are

2.32, 0.22 and 2.19% on dry matter basis as given by McDonald (1934).

Mango

Sen *et al*. (1947) have given an intermediate composition of 2.52%, 0.17% and 0.64% for N, P and K respectively. The concentrations of N, P and K at which the plant will show deficiency symptoms are 1.09%, 0.096% and 0.3% respectively.

Pineapple

A nitrogen concentration of 1.66% on the dry matter of leaves was considered to be a low range by Samuels *et al*. (1955). They have also given the intermediate range values of P and K as 0.17% and 4.25% respectively.

Rubber

Shorrocks (1961) reported the intermediate range values of N, P and K as 3.07 to 3.34%, above 0.27% and 1.11% respectively. The deficiency level of nitrogen was below 3.3% and that of P was below 0.21% in shaded leaves.

Coconut

The critical levels of N, P, K, Ca and Mg recommended by Prevot and Ollagnier (1957) are 1.7%, below 0.1%, 0.45%, 0.5% and 0.35% respectively.

Pepper

DeWaard (1969) suggested the following nutrient percentages in the first older mature leaves of pepper for use in foliar diagnosis.

Nutrient	Healthy	Deficient
N	3.1	2.7
P	0.16	0.10
K	3.4	2.62
Ca	1.66	1.2
Mg	0.44	0.20

2. Nutritional requirements of turmeric

Reports on the nutritional requirements of turmeric show that it requires heavy manuring. But the fertiliser recommendation for turmeric in Kerala is 30, 30 and 60 kg N, P_2O_5 and K_2O per hectare respectively (Anon., 1978).

Nair (1964) reported significant effect of N and K_2O on plant height, tiller production and yield while response to P_2O_5 was rather negligible. Aiyadurai (1966) found that 100 kg/ha of ammonium sulphate doubled the yield over that of an unmanured crop. Muraleedharan and Balakrishnan (1972) have reported that the yield of turmeric was significantly affected by the application of fertilisers. The treatment 100 kg N + 100 kg P_2O_5 + 200 kg K_2O/ha produced maximum yield though the response was not linear. Under Tirupathi conditions, Rao (1973) recorded highest yield through split applications of fertilisers containing 312.5 kg N, 112.5 kg P_2O_5 and 200 kg K_2O/ha. According to Rao et al. (1975), 25 tonnes of cattle manure or compost and 63 kg N/ha as oil cake were found to be optimum. A fertiliser dose of 189:63: 126 kg of N:P:K per hectare was recommended for the best yields under Andhra conditions.

Various attributes like germination percentage, average height of plants after 3 and 6 months of germination, average number of shoots per hectare, storage quality and total yield were studied at Solan with a view to standardise the optimum requirements of N, P and K for turmeric. There was no significant response for different fertiliser combinations over the different attributes under study. The highest yield was recorded at the NPK level of 90:30:120 closely followed by the level 120:45:90 (Anon., 1977). Rao and Reddy (1977) obtained a linear response to higher doses of N and K and the highest yield was recorded with the application of 375 kg N, 175 kg P_2O_5 and 237.5 kg K_2O per hectare. Anon (1978) reported that there was no significant response to fertiliser combinations over yield and average number of shoots per plant in case of turmeric. The highest germination, average number of shoots and yield were observed with 120, 30 and 90 kg N, P and K per hectare respectively and the lowest yield was recorded with 90, 60 and 90 kg N, P and K per hectare respectively.

Subramanian **et al.** (1978) found that application of N at 124 kg/ha as urea recorded significantly higher yield over the 124 kg N/ha in the combined form of groundnut cake + urea and the other two lower levels of N application tried. It was observed that for the application of nitrogen as fertiliser, urea was not only cheaper but also gave a higher yield over the combined form of oil cake and fertiliser urea. The applied phosphorus (30 kg P_2O_5/ha) has significantly influenced the yield. However, the two levels of K_2O at 51 and 102 kg/ha had no response on the yield of turmeric.

3. Turmeric oleoresin

According to Krishnamurthy et al. (1972) the yield of oleoresin in turmeric varied from 4 to 7.5 per cent and the oleoresin contained about 18 to 25 per cent essential oil and 30 to 47 per cent curcumin. Lewis et al. (1974) reported that turmeric contained 6 to 7 per cent oleoresin and the oleoresin contained 18 to 20 per cent volatile oil and 35 per cent curcumin. Mathai (1975) estimated the oleoresin content of six types of turmeric and found the maximum oleoresin content in 'Alleppey finger turmeric' (24.3%). The bulb of 'Alleppey turmeric' contained only 16.2 per cent oleoresin. Krishnamurthy et al. (1976) tried different extractants and apparatus for oleoresin extraction and found that acetone was superior to alcohol and ethylene dichloride. In the case of coarse powder (30 mesh) Soxhlet method was found to be better while percolation and Soxhlet methods were equally efficient in the case of fine powder (60 mesh). Among 12 turmeric cultivars they noticed a variation of 5.5 to 10 per cent in oleoresin content in the case of fine powder (60 mesh) by Soxhlet method. Philip (1978) noticed a variation of 12.1 to 21.1 per cent in the content of oleoresin in turmeric.

Materials and Methods

MATERIALS AND METHODS

A field experiment on turmeric was conducted at the Horticultural College Campus, Vellanikkara, from May, 1979 to January 1980, in order to study the effect of graded doses of nitrogen, phosphorus and potassium on the yield and quality of turmeric and also to standardise the plant tissue suitable for foliar diagnosis in relation to N, P and K.

1. Field Experiment

1.1. Site, climate and soil

The location of the field experiment was at 10.32°N latitude and 76.10°E longitude at an altitude of 22.25 m. The area enjoys a typical humid tropical climate. The details of the meteorological observations for the period under the experiment are presented in Appendix I.

The site of the experiment was uniformly level in topography and the soil was deep, well drained, moderately acid and medium clay loam. The chemical characteristics of the soil are given in Appendix XIII.

1.2. Experimental design and treatments

The experiment was laid out in a 3^3 factorial design with three levels of nitrogen, phosphorus and potassium in randomised blocks confounding the effect of interaction NP^2K^2 totally. The procedure followed for the allocation of various treatments to different plots was in accordance with Yates (1937). The details of the lay out (Fig.1) are:

Total number of treatments:	27
Number of replications:	3
Number of blocks:	9
Total number of plots (beds):	81
Gross plot size:	4.2. x 1.2 m
Net plot size:	3.6 x 0.9 m
Total experimental area:	0.041 ha (408.24 m^2)
Spacing:	30 x 15 cm
Number of border rows:	1
Number of plants per plot:	112

The levels of nitrogen, phosphorus and potassium employed are:

Levels of nitrogen

1. n_0 — 0 kg N/ha (0.0 g/m^2)
2. n_1 — 20 kg N/ha (2 g/m^2)
3. n_2 — 40 kg N/ha (4 g/m^2)

Levels of phosphorus

1. p_0 — 0 kg P_2O_5/ha (0.0 g/m^2)
2. p_1 — 20 kg P_2O_5/ha (2 g/m^2)
3. p_2 — 40 kg P_2O_5/ha (4 g/m^2)

TREATMENTS

N	P_2O_5	K_2O
n_0 ~ 0 Kg/ha	P_0 ~ 0 Kg/ha	K_0 ~ 0 Kg/ha
n_1 ~ 20 Kg/ha	P_1 ~ 20 Kg/ha	K_1 ~ 40 Kg/ha
n_2 ~ 40 Kg/ha	P_2 ~ 40 Kg/ha	K_2 ~ 80 Kg/ha

gross plot size: 4.2 x 1.2 m

net plot size: 3.6 x 0.9 m

spacing : 30 x 15 cm

REP-I			REP-II			REP-III		
$n_1p_0k_0$	$n_2p_1k_2$	$n_1p_2k_2$	$n_0p_1k_0$	$n_2p_1k_0$	$n_0p_1k_2$	$n_2p_2k_2$	$n_1p_0k_1$	$n_2p_0k_0$
$n_2p_0k_1$	n_0p_0k[illegible]	$n_2p_2k_0$	$n_1p_1k_1$	$n_0p_2k_0$	$n_2p_2k_0$	$n_1p_1k_2$	$n_0p_0k_0$	$n_1p_1k_1$
$n_1p_1k_1$	$n_0p_2k_2$	$n_2p_0k_2$	$n_1p_0k_2$	$n_1p_0k_0$	$n_1p_0k_1$	$n_0p_2k_0$	$n_2p_0k_2$	$n_2p_2k_1$
$n_0p_2k_0$	$n_2p_2k_1$	$n_0p_2k_1$	$n_0p_0k_1$	$n_2p_0k_1$	$n_0p_2k_1$	$n_1p_0k_0$	$n_1p_2k_2$	$n_0p_0k_1$
$n_1p_2k_1$	$n_1p_1k_1$	$n_1p_0k_1$	$n_2p_2k_1$	$n_0p_1k_1$	$n_1p_1k_0$	$n_0p_0k_2$	$n_1p_1k_0$	$n_2p_1k_2$
$n_0p_1k_1$	$n_0p_1k_0$	$n_0p_0k_0$	$n_0p_2k_2$	$n_1p_1k_2$	$n_0p_0k_0$	$n_2p_1k_0$	$n_2p_2k_0$	$n_0p_1k_0$
$n_0p_0k_2$	$n_2p_0k_0$	$n_1p_1k_0$	$n_2p_1k_2$	$n_1p_2k_1$	$n_2p_1k_1$	$n_0p_1k_1$	$n_0p_\cdot k_2$	$n_1p_0k_2$
$n_2p_1k_0$	$n_1p_2k_0$	$n_0p_1k_2$	$n_2p_0k_0$	$n_2p_2k_2$	$n_1p_2k_2$	$n_2p_0k_1$	$n_2p_1k_1$	$n_0p_2k_2$
$n_2p_2k_2$	$n_1p_0k_2$	$n_2p_1k_1$	$n_1p_2k_0$	$n_0p_0k_2$	$n_2p_0k_2$	$n_1p_2k_1$	$n_0p_2k_1$	$n_1p_0k_0$

FIG. 1 LAYOUT PLAN OF 3^3 FACTORIAL EXPERIMENT IN RBD CONFOUNDING NP^2K^2 TOTALLY

Levels of potassium

1. k_0 0 kg K_2O/ha (0.0 g/m^2)
2. k_1 40 kg K_2O/ha (4 g/m^2)
3. k_2 80 kg K_2O/ha (8 g/m^2)

1.3. Field culture

The land was prepared by thorough ploughing and was cleaned out of stubbles. Beds of size 4.2 m x 1.2 m were taken leaving a space of 40 cm width in between and channels were provided to get sufficient drainage. Farm yard manure at the rate of 40 tonnes per hectare was applied as basal dose. The farm yard manure contained 0.39 per cent N, 0.20 per cent P_2O_5 and 0.4 per cent K_2O. Seed rhizome used was weighing 15 to 20 g each and had at least two viable healthy buds. The variety used was Kasturi Banak. Planting was done on 22nd May 1979. Effective germination was commenced by the 5th day after planting and 90 of the germination was over by 10th day. All the cultural and plant protection practices followed were in accordance with the Package of Practices of the Kerala Agricultural University, 1978.

Nitrogen, phosphorus and potassium were supplied in the form of urea, superphosphate and muriate of potash respectively. Full dose of phosphorus and half the dose of potassium were applied as basal. The second half of potassium was applied on 60th day after planting. Two-third of the nitrogen dose was applied in 30th day after planting and the remaining one-third was given on 60th day after planting.

The crop was harvested on 19th January, 1980.

1.4. Observations

Observations on number of tillers per clump, number of leaves per tiller, height of tillers, fresh weight of rhizomes, dry weight of rhizomes and total dry matter were taken at monthly intervals starting from the 90th day after planting. Accordingly the sampling periods were numbered as 1, 2, 3, 4, 5, and 6 for 90th, 120th, 150th, 180th, 210th and 240th day after planting respectively. Tissue samples were collected from the leaves, pseudostems and rhizomes of the plants at these periods for chemical analysis. Tissue samples were collected from all the three replications and made into a composite sample for the purpose of chemical analysis.

Leaf samples collected on 120th day after planting (second sampling period) were used for standardisation of leaf positions. The leaves were numbered from top to bottom of the tiller, the last fully opened leaf being referred as leaf No.1. The first six leaves from leaf positions one to six from the top of the tiller were analysed for nitrogen, phosphorus and potassium.

2. Analytical methods

2.1. Soil

For the mechanical analysis of the soil, the International Pipette method was used (Piper, 1942). The pH of 1:2.5 soil:water suspension was determined using a pH meter. Total organic carbon of the soil was estimated by the method of Walkley and Black described by Piper (1942). For the determination of nitrogen, the Kjeldahl digestion-distillation method given by Jackson (1958) was followed. Available phosphorus was determined in the Bray No.1 extract of soil, by the chloro-stannous reduced molybdo-phosphoric blue colour method in hydrochloric acid system (Jackson, 1958). The exchangeable potassium extracted by 1N neutral ammonium acetate was determined flame photometrically and reported as available potassium.

2.2. Plant material

The total nitrogen content of the plant material was determined by the micro Kjeldahl method (Jackson, 1958). For the determination of phosphorus and potassium, the plant material was digested in a mixture of perchloric, sulphuric and nitric acids (1:2:9). The phosphorus in the tripple acid extract was determined by the vanadomolybdate yellow colour method. Potassium was determined using flame photometer (Jackson, 1958).

The counter-current extraction using a Soxhlet apparatus was used for the determination of oleoresin in the freshly ground dry turmeric (A.S.T.A., 1960). The solvent used was acetone.

The data relating to each character were analysed by applying the analysis of variance technique as suggested by Panse and Sukhatme (1967) for confounded factorial experiments.

Results

RESULTS

1. Effect of NPK treatments and period of growth on the morphological characters of turmeric.

The observations and results of statistical analysis of the effect of different levels of nitrogen, phosphorus and potassium on the morphological characters of turmeric are summarised in tables 1 to 3 and in Appendices II to IV.

1.1. Number of tillers per clump

Observations on the number of tillers per clump was recorded and analysed at monthly intervals from 90th to 210th day. The results are presented in Table 1 and in Appendix II. It was revealed from the results that the production of tillers was not influenced by the fertiliser treatments at earlier stages of plant growth. But the tiller production at fourth period was found significantly affected by the levels of potassium applied. The tiller production at k_1 level was significantly superior to that at k_2 and k_0. The k_2 and k_0 levels were on par. Similarly the number of tillers at fifth period was determined by the levels of applied nitrogen. Application of incremental doses of nitrogen resulted in an increased production of tillers. Maximum tillers were produced at n_2 level followed by n_1 and n_0. Tiller production at n_1 and n_0 were on par.

1.2. Number of leaves per tiller

As evidenced from Table 2 and Appendix III, the

Table 1. Effect of NPK treatments and period of growth on the number of tillers per clump of turmeric.

Sl. No.	Treatment	Period 1	2	3	4	5
1.	$n_0p_0k_0$	1.50	1.39	1.67	1.56	1.33
2.	$n_0p_0k_1$	1.75	1.58	3.11	2.33	2.44
3.	$n_0p_0k_2$	1.75	1.50	2.22	3.00	1.33
4.	$n_0p_1k_0$	1.42	1.64	2.00	1.67	1.55
5.	$n_0p_1k_1$	1.58	1.33	2.22	2.89	2.00
6.	$n_0p_1k_2$	1.58	1.83	2.00	2.78	1.67
7.	$n_0p_2k_0$	1.67	1.50	1.66	1.55	2.00
8.	$n_0p_2k_1$	2.00	1.78	2.56	2.89	1.33
9.	$n_0p_2k_2$	1.75	1.58	1.78	2.00	2.33
10.	$n_1p_0k_0$	1.58	1.65	2.11	2.33	1.56
11.	$n_1p_0k_1$	1.50	1.33	2.11	3.22	1.66
12.	$n_1p_0k_2$	2.42	2.00	2.00	1.78	1.67
13.	$n_1p_1k_0$	1.58	1.58	1.78	3.44	1.78
14.	$n_1p_1k_1$	1.92	1.75	1.89	3.00	2.89
15.	$n_1p_1k_2$	1.58	1.67	2.56	1.78	1.22
16.	$n_1p_2k_0$	1.83	1.29	2.56	2.44	2.11
17.	$n_1p_2k_1$	2.08	2.39	2.33	3.33	2.22
18.	$n_1p_2k_2$	1.58	1.71	2.44	3.11	2.00
19.	$n_2p_0k_0$	1.33	1.92	2.11	1.66	2.45
20.	$n_2p_0k_1$	1.67	1.56	2.44	3.22	2.78
21.	$n_2p_0k_2$	1.75	1.33	2.44	2.44	1.89
22.	$n_2p_1k_0$	1.83	1.42	2.67	2.78	1.67
23.	$n_2p_1k_1$	1.67	1.21	2.22	2.44	1.56
24.	$n_2p_1k_2$	1.67	1.33	3.33	2.67	3.11
25.	$n_2p_2k_0$	2.08	1.44	1.33	2.22	2.45
26.	$n_2p_2k_1$	1.25	1.82	2.11	3.89	2.56
27.	$n_2p_2k_2$	1.58	1.53	2.66	2.55	1.78
Mean		1.71	1.59	2.23	2.50	1.97

Table 2. Effect of NPK treatments and period of growth on the number of leaves per tiller of turmeric.

Sl. No.	Treatment	Period 1	2	3	4	5
1.	$n_0p_0k_0$	5.46	5.42	6.70	7.83	8.01
2.	$n_0p_0k_1$	5.59	5.24	6.05	6.05	7.11
3.	$n_0p_0k_2$	5.13	5.54	6.97	5.57	7.57
4.	$n_0p_1k_0$	5.09	4.85	6.11	7.48	7.81
5.	$n_0p_1k_1$	5.90	6.06	6.73	6.41	8.14
6.	$n_0p_1k_2$	6.08	5.99	6.92	5.67	6.03
7.	$n_0p_2k_0$	6.14	5.53	8.11	8.18	6.62
8.	$n_0p_2k_1$	6.28	5.42	7.53	5.90	7.44
9.	$n_0p_2k_2$	5.77	3.81	6.67	6.90	6.00
10.	$n_1p_0k_0$	4.57	5.66	7.23	7.29	6.31
11.	$n_1p_0k_1$	5.60	5.66	7.64	6.23	8.46
12.	$n_1p_0k_2$	4.95	4.32	6.71	7.40	7.32
13.	$n_1p_1k_0$	4.96	4.75	7.47	6.66	6.71
14.	$n_1p_1k_1$	5.78	4.91	5.96	6.35	6.39
15.	$n_1p_1k_2$	5.64	5.24	6.73	7.25	7.58
16.	$n_1p_2k_0$	4.93	4.80	6.30	5.01	6.30
17.	$n_1p_2k_1$	4.97	5.86	5.58	6.11	5.98
18.	$n_1p_2k_2$	6.74	5.05	6.74	6.01	6.33
19.	$n_2p_0k_0$	6.30	4.00	6.77	6.26	6.68
20.	$n_2p_0k_1$	5.02	4.97	5.87	7.92	5.70
21.	$n_2p_0k_2$	4.92	5.35	6.67	7.14	6.34
22.	$n_2p_1k_0$	4.29	5.50	5.27	6.23	6.98
23.	$n_2p_1k_1$	5.43	4.63	6.56	4.89	6.38
24.	$n_2p_1k_2$	4.96	4.41	5.83	6.08	5.81
25.	$n_2p_2k_0$	4.59	5.57	8.53	7.13	6.54
26.	$n_2p_2k_1$	6.16	5.37	6.82	6.60	6.76
27.	$n_2p_2k_2$	4.78	5.40	5.64	5.34	6.37
Mean		5.40	5.15	6.69	6.58	6.87

Table 3. Effect of NPK treatments and period of growth on the height of tiller of turmeric.

Sl. No.	Treatment	Period 1	2	3	4	5
1.	$n_0p_0k_0$	63.25	79.32	99.06	99.50	115.22
2.	$n_0p_0k_1$	70.67	68.39	104.44	101.67	111.44
3.	$n_0p_0k_2$	56.67	52.78	81.95	79.56	90.89
4.	$n_0p_1k_0$	58.67	66.08	94.61	102.50	117.78
5.	$n_0p_1k_1$	55.58	61.53	89.28	103.78	111.44
6.	$n_0p_1k_2$	59.75	69.64	86.83	80.33	89.22
7.	$n_0p_2k_0$	63.33	68.81	97.89	101.06	105.33
8.	$n_0p_2k_1$	57.17	68.00	82.33	88.55	94.67
9.	$n_0p_2k_2$	43.00	57.75	83.56	86.67	107.11
10.	$n_1p_0k_0$	56.25	71.17	93.11	95.83	80.44
11.	$n_1p_0k_1$	65.83	77.00	95.56	120.61	106.89
12.	$n_1p_0k_2$	49.58	84.23	87.56	85.39	105.00
13.	$n_1p_1k_0$	60.83	71.82	90.22	107.28	103.22
14.	$n_1p_1k_1$	70.08	7[illegible].67	84.45	86.61	131.11
15.	$n_1p_1k_2$	77.42	81.75	95.94	98.67	107.33
16.	$n_1p_2k_0$	44.50	55.00	68.89	67.56	93.56
17.	$n_1p_2k_1$	62.50	66.78	85.22	72.78	98.11
18.	$n_1p_2k_2$	63.33	73.35	101.00	88.44	114.33
19.	$n_2p_0k_0$	49.33	54.86	74.78	92.11	103.89
20.	$n_2p_0k_1$	54.33	78.00	86.00	88.72	115.11
21.	$n_2p_0k_2$	56.00	71.65	83.22	106.11	110.67
22.	$n_2p_1k_0$	67.67	62.70	87.22	108.05	100.44
23.	$n_2p_1k_1$	49.83	52.50	72.11	83.50	94.89
24.	$n_2p_1k_2$	61.58	62.85	95.22	113.00	95.67
25.	$n_2p_2k_0$	81.67	86.14	108.67	104.56	121.56
26.	$n_2p_2k_1$	59.42	76.49	89.00	107.56	111.55
27.	$n_2p_2k_2$	47.75	50.90	76.33	88.95	102.78
Mean		59.48	68.65	88.68	94.79	105.17

fertilizer levels employed in the study did not influence the number of leaves per tiller of turmeric. However, the levels of nitrogen significantly influenced the number of leaves at fifth period. The treatment n_0 was significantly superior to n_1 and n_2. The leaf production per tiller at n_1 and n_2 levels was not significantly different. The number of leaves per tiller increased with increasing periods of growth, the mean values at first and last periods being 5.4 and 6.87 respectively.

1.3. Height of tiller

The results of the study presented in Table 3 and Appendix IV revealed that the height of tiller was not influenced by the incremental doses of nitrogen, phosphorus and potassium. There was marked increase in the height of tiller with advancing age of the crop, the mean values at first and last periods being 59.48 cm and 105.17 cm respectively.

2. <u>Effect of NPK treatments and period of growth on the fresh and dry weights of rhizome and total dry matter production of turmeric</u>

The observations and results on the influence of graded doses of fertilisers and age of the crop on the fresh and dry weights of rhizome and total dry matter production are presented in Tables 4 to 6 and in Appendix V.

Table 4. Effect of NPK treatments and period of growth on the fresh weight of rhizome, kg/m^2.

Sl. No.	Treatment	Period 2	3	4	5	6
1.	$n_0p_0k_0$	0.568	0.998	1.156	4.556	3.244
2.	$n_0p_0k_1$	0.865	1.180	1.481	1.896	4.326
3.	$n_0p_0k_2$	0.203	0.501	0.519	0.607	1.156
4.	$n_0p_1k_0$	0.525	0.985	1.378	4.007	2.800
5.	$n_0p_1k_1$	0.263	0.563	2.104	7.000	1.607
6.	$n_0p_1k_2$	0.625	1.323	1.844	3.037	4.185
7.	$n_0p_2k_0$	0.347	0.725	1.104	1.237	4.726
8.	$n_0p_2k_1$	0.102	0.326	1.548	1.400	2.319
9.	$n_0p_2k_2$	0.385	0.807	1.748	1.052	2.807
10.	$n_1p_0k_0$	0.391	0.825	2.067	1.970	2.593
11.	$n_1p_0k_1$	0.386	0.859	2.889	4.341	3.163
12.	$n_1p_0k_2$	0.350	0.770	0.474	2.185	3.519
13.	$n_1p_1k_0$	0.521	0.926	1.578	1.119	1.763
14.	$n_1p_1k_1$	0.216	0.536	1.674	5.896	3.186
15.	$n_1p_1k_2$	0.625	1.044	1.341	2.007	4.785
16.	$n_1p_2k_0$	0.091	0.257	0.437	0.867	2.815
17.	$n_1p_2k_1$	0.487	0.859	0.681	1.667	3.496
18.	$n_1p_2k_2$	0.326	0.790	2.348	1.563	2.726
19.	$n_2p_0k_0$	0.105	0.336	0.889	1.496	1.978
20.	$n_2p_0k_1$	0.200	0.405	0.711	3.844	3.104
21.	$n_2p_0k_2$	0.316	0.726	0.993	0.659	4.067
22.	$n_2p_1k_0$	0.629	1.158	0.911	3.193	2.052
23.	$n_2p_1k_1$	0.129	0.536	0.933	2.111	4.341
24.	$n_2p_1k_2$	0.825	1.081	1.000	1.000	5.148
25.	$n_2p_2k_0$	0.762	1.168	0.911	2.711	6.222
26.	$n_2p_2k_1$	0.421	0.696	1.044	1.067	3.015
27.	$n_2p_2k_2$	0.525	0.748	0.956	2.793	4.652

Table 5. Effect of NPK treatments and period of growth on the dry weight of rhizome, kg/m^2.

Sl. No.	Treatment	Period				
		2	3	4	5	6
1.	$n_0p_0k_0$	0.035	0.083	0.109	0.499	0.377
2.	$n_0p_0k_1$	0.009	0.091	0.124	0.212	0.296
3.	$n_0p_0k_2$	0.005	0.009	0.050	0.079	0.159
4.	$n_0p_1k_0$	0.010	0.153	0.127	0.387	0.422
5.	$n_0p_1k_1$	0.007	0.099	0.185	0.696	0.380
6.	$n_0p_1k_2$	0.034	0.031	0.187	0.307	0.286
7.	$n_0p_2k_0$	0.011	0.105	0.104	0.132	0.530
8.	$n_0p_2k_1$	0.009	0.010	0.123	0.153	0.268
9.	$n_0p_2k_2$	0.021	0.042	0.154	0.123	0.289
10.	$n_1p_0k_0$	0.011	0.084	0.175	0.199	0.149
11.	$n_1p_0k_1$	0.030	0.119	0.237	0.447	0.371
12.	$n_1p_0k_2$	0.025	0.006	0.392	0.278	0.291
13.	$n_1p_1k_0$	0.016	0.021	0.146	0.120	0.131
14.	$n_1p_1k_1$	0.019	0.025	0.151	0.589	0.335
15.	$n_1p_1k_2$	0.029	0.089	0.117	0.193	0.174
16.	$n_1p_2k_0$	0.006	0.006	0.040	0.095	0.290
17.	$n_1p_2k_1$	0.025	0.064	0.054	0.174	0.297
18.	$n_1p_2k_2$	0.019	0.063	0.224	0.156	0.364
19.	$n_2p_0k_0$	0.019	0.065	0.073	0.171	0.128
20.	$n_2p_0k_1$	0.012	0.036	0.055	0.377	0.415
21.	$n_2p_0k_2$	0.034	0.100	0.088	0.077	0.224
22.	$n_2p_1k_0$	0.020	0.100	0.088	0.356	0.313
23.	$n_2p_1k_1$	0.004	0.037	0.254	0.222	0.164
24.	$n_2p_1k_2$	0.010	0.125	0.195	0.107	0.284
25.	$n_2p_2k_0$	0.029	0.190	0.378	0.281	0.297
26.	$n_2p_2k_1$	0.037	0.084	0.230	0.116	0.222
27.	$n_2p_2k_2$	0.009	0.035	0.075	0.294	0.256

Table 6. Effect of NPK treatments and period of growth on the total dry matter production of turmeric, g/m^2.

Sl. No.	Treatment	Period 2	3	4	5	6
1.	$n_0p_0k_0$	0.331	0.662	0.636	1.558	1.160
2.	$n_0p_0k_1$	0.119	0.779	0.638	0.817	0.944
3.	$n_0p_0k_2$	0.152	0.550	0.299	0.637	0.769
4.	$n_0p_1k_0$	0.153	0.745	0.500	0.995	1.485
5.	$n_0p_1k_1$	0.196	1.065	0.999	2.158	1.371
6.	$n_0p_1k_2$	0.282	0.384	0.764	1.178	0.958
7.	$n_0p_2k_0$	0.162	0.773	0.664	0.715	2.093
8.	$n_0p_2k_1$	0.245	0.258	0.844	0.795	0.937
9.	$n_0p_2k_2$	0.179	0.464	0.644	0.733	1.216
10.	$n_1p_0k_0$	0.244	0.737	0.715	0.607	0.645
11.	$n_1p_0k_1$	0.326	0.880	1.206	1.382	1.426
12.	$n_1p_0k_2$	0.246	0.268	0.920	0.928	1.042
13.	$n_1p_1k_0$	0.236	0.294	0.665	0.587	0.618
14.	$n_1p_1k_1$	0.289	0.464	0.754	2.039	1.311
15.	$n_1p_1k_2$	0.377	0.705	0.813	0.719	0.739
16.	$n_1p_2k_0$	0.143	0.250	0.331	0.418	1.018
17.	$n_1p_2k_1$	0.187	0.632	0.556	0.801	1.077
18.	$n_1p_2k_2$	0.257	0.593	1.153	0.644	1.403
19.	$n_2p_0k_0$	0.197	0.457	0.733	0.750	0.659
20.	$n_2p_0k_1$	0.247	0.487	0.714	1.418	1.417
21.	$n_2p_0k_2$	0.260	0.770	0.486	0.836	0.839
22.	$n_2p_1k_0$	0.217	0.711	0.623	1.250	1.259
23.	$n_2p_1k_1$	0.115	0.533	0.464	0.872	0.820
24.	$n_2p_1k_2$	0.175	1.021	0.789	0.569	0.904
25.	$n_2p_2k_0$	0.314	0.849	1.156	1.220	1.288
26.	$n_2p_2k_1$	0.435	1.164	0.723	0.714	0.974
27.	$n_2p_2k_2$	0.147	0.371	0.557	0.949	1.007
Mean		0.234	0.625	0.717	0.974	1.090

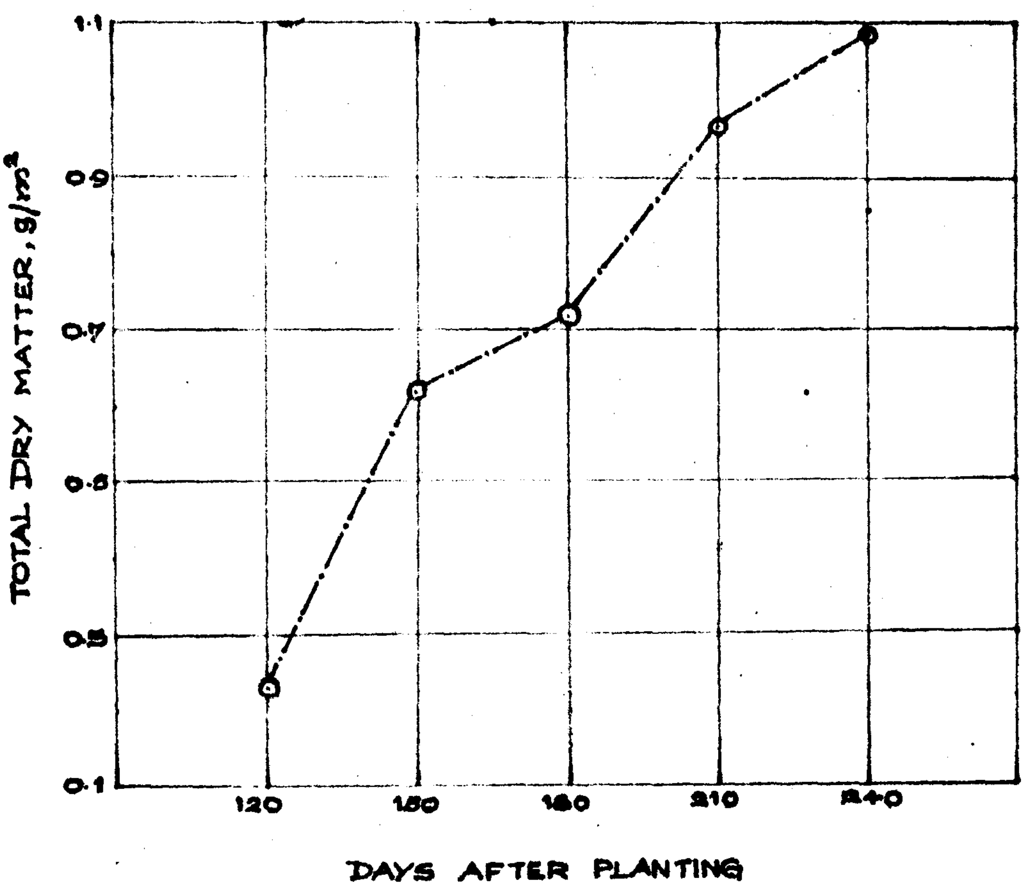

FIG.2. RELATIONSHIP BETWEEN PERIOD

OF GROWTH AND TOTAL DRY MATTER

2.1. Fresh weight of rhizome

The effect of fertiliser treatments on the fresh weight of rhizome (yield) at harvest has been examined and presented separately.

It was observed that different levels of nitrogen, phosphorus and potassium and their interactions could not influence the fresh weight of rhizome at different periods. Further, it was revealed that the fresh weight of rhizome was determined by the age of the crop. There was a steady increase in the fresh weight of rhizome with increasing periods of growth. However, the increase in fresh weight between second and third periods was not significant. Thereafter, marked increases were noticed in fresh weight of rhizome between progressing periods of crop growth, the fresh weight of rhizome being the highest at the last period.

2.2. Dry weight of rhizome

As in the case of fresh weight, the dry weight of rhizome also increased significantly with increasing period of growth, except at the sixth period (Table 5 and Appendix V). The dry weight at sixth period was the highest and was on par with that at the fifth period. The different levels of nitrogen, phosphorus and potassium applied to the crop could not influence the dry weight of rhizome.

2.3. Total dry matter

The results pertaining to the total dry matter production are given in Table 6 and in Appendix V. The influence of periods of growth on the total dry matter production was also significant as in the case of fresh and dry weights of rhizome. The dry matter production increased continuously with increasing periods of growth. The increase from third to fourth period was not statistically significant. The total dry matter production increased significantly at all other periods, the highest value being at the sixth period. The maximum production of dry matter took place during the period from 120th day to 150th day after planting (0.391 kg/m^2) which accounted for 35.87 per cent of the total dry matter accumulated. The levels of applied potassium also significantly influenced the total dry matter production (Appendix V). The total dry matter production was highest at the k_1 level which was on par with k_0 and significantly superior to k_2.

3. Rhizome yield of turmeric at harvest

The data on the yield of turmeric at harvest are presented in Table 7 and the analysis of variance in Appendix VI.

Statistical analysis of the data revealed that the levels of nitrogen, phosphorus and potassium and their interactions involved in the study could not influence the rhizome yield of turmeric at harvest, significantly. However, the highest yield was observed at $n_1p_0k_0$ level (3.46 kg/m^2),

Table 7. Rhizome yield of turmeric at harvest, fresh weight, kg/m^2.

Sl. No.	Treatments	Replication I	Replication II	Replication III	Mean
1.	$n_0p_0k_0$	2.51	2.32	3.46	2.76
2.	$n_0p_0k_1$	4.15	3.12	2.41	3.23
3.	$n_0p_0k_2$	1.88	1.48	3.43	2.26
4.	$n_0p_1k_0$	2.85	2.70	2.22	2.59
5.	$n_0p_1k_1$	2.49	3.13	2.89	2.84
6.	$n_0p_1k_2$	1.97	2.69	2.83	2.50
7.	$n_0p_2k_0$	2.64	2.84	3.02	2.83
8.	$n_0p_2k_1$	2.64	3.37	2.25	2.75
9.	$n_0p_2k_2$	3.26	1.65	2.65	2.52
10.	$n_1p_0k_0$	2.93	3.33	4.12	3.46
11.	$n_1p_0k_1$	2.30	3.04	3.84	3.06
12.	$n_1p_0k_2$	2.16	3.18	2.49	2.61
13.	$n_1p_1k_0$	1.86	3.28	3.7[illegible]	2.97
14.	$n_1p_1k_1$	3.21	3.61	2.65	3.16
15.	$n_1p_1k_2$	2.93	1.50	3.88	2.77
16.	$n_1p_2k_0$	1.94	1.34	1.69	1.66
17.	$n_1p_2k_1$	3.15	1.69	1.96	2.26
18.	$n_1p_2k_2$	3.11	2.10	3.01	2.74
19.	$n_2p_0k_0$	2.77	1.81	2.66	2.41
20.	$n_2p_0k_1$	3.02	3.13	1.96	2.70
21.	$n_2p_0k_2$	3.62	1.59	4.15	3.12
22.	$n_2p_1k_0$	1.38	3.93	2.77	2.69
23.	$n_2p_1k_1$	2.01	2.60	2.89	2.50
24.	$n_2p_1k_2$	2.95	1.65	2.93	2.51
25.	$n_2p_2k_0$	4.18	2.88	3.03	3.36
26.	$n_2p_2k_1$	3.07	2.92	3.71	3.23
27.	$n_2p_2k_2$	1.88	2.12	3.80	2.60

n_0	2.70	p_0	2.25	k_0	2.75
n_1	2.74	p_1	2.73	k_1	2.85
n_2	2.79	p_2	2.66	k_2	2.62

C.D. for comparing levels of N, P and K – N.S.

closely followed by $n_2p_2k_0$ (3.36 kg/m^2).

4. Effect of NPK treatments and period of growth on the nitrogen content of turmeric

The content and uptake of nitrogen in leaf, pseudostem and rhizome are presented in Tables 8 to 14 and their mean values summarised in Table 15. The results obtained from statistical analysis are presented in Appendix VII. The relationship between period of growth and uptake of nitrogen is graphically represented in Fig. 3.

4.1. Nitrogen content of leaf

The observations revealed that the incremental doses of nitrogen significantly influenced the nitrogen percentage of leaf, while the application of phosphorus and potassium at different levels did not influence this parameter significantly. However, the difference between n_0 and n_2 levels was not statistically significant. In fact, n_0 recorded the highest leaf nitrogen percentage, eventhough it was on par with the nitrogen percentage at n_2 level. The percentages of nitrogen at both n_0 and n_2 levels were significantly superior to that at n_1 level. With respect to the effect of increasing periods of growth on nitrogen percentage of leaf it was seen that the nitrogen percentage increased upto the fourth period (180 days after planting) and then decreased during the fifth period (210 days after planting) and thereafter increased at the last period. Upto the fourth

Table 8. Effect of NPK treatments and period of growth on nitrogen content of turmeric.
Nitrogen content of leaf, % on moisture free basis.

Sl. No.	Treatment	Period 1	2	3	4	5	6
1.	$n_0p_0k_0$	1.54	1.68	3.50	4.06	2.80	2.66
2.	$n_0p_0k_1$	1.40	0.84	3.36	4.34	2.52	3.08
3.	$n_0p_0k_2$	1.40	1.68	3.50	3.36	3.08	2.94
4.	$n_0p_1k_0$	1.26	1.68	3.36	3.64	2.52	3.08
5.	$n_0p_1k_1$	0.98	1.54	3.08	3.92	2.52	2.80
6.	$n_0p_1k_2$	1.12	1.40	3.22	3.92	2.66	2.80
7.	$n_0p_2k_0$	1.12	1.40	3.22	3.92	2.94	2.94
8.	$n_0p_2k_1$	1.54	1.82	3.36	3.78	2.94	3.08
9.	$n_0p_2k_2$	1.54	1.40	3.50	3.78	2.66	3.08
10.	$n_1p_0k_0$	1.12	1.40	3.50	3.08	2.66	3.22
11.	$n_1p_0k_1$	1.26	1.40	3.22	2.94	2.80	2.66
12.	$n_1p_0k_2$	1.26	1.54	3.36	2.94	3.08	2.52
13.	$n_1p_1k_0$	1.54	1.68	3.36	2.66	2.38	2.66
14.	$n_1p_1k_1$	1.54	1.40	3.08	2.66	2.52	2.80
15.	$n_1p_1k_2$	1.68	1.54	3.50	2.80	2.52	2.94
16.	$n_1p_2k_0$	1.68	1.68	2.24	2.80	2.52	2.94
17.	$n_1p_2k_1$	1.40	1.68	3.64	3.64	2.80	3.08
18.	$n_1p_2k_2$	1.40	1.68	3.50	3.36	2.66	2.80
19.	$n_2p_0k_0$	1.54	1.68	3.36	3.36	2.38	2.80
20.	$n_2p_0k_1$	1.68	1.82	3.36	2.94	2.66	2.94
21.	$n_2p_0k_2$	1.82	1.26	3.64	3.08	2.38	2.66
22.	$n_2p_1k_0$	1.40	1.40	3.08	3.78	2.80	2.80
23.	$n_2p_1k_1$	1.54	1.54	3.36	3.64	2.80	2.94
24.	$n_2p_1k_2$	1.82	1.54	3.36	3.50	3.08	2.94
25.	$n_2p_2k_0$	1.68	1.40	3.08	3.78	3.08	2.94
26.	$n_2p_2k_1$	1.54	1.68	3.08	3.50	2.80	3.08
27.	$n_2p_2k_2$	1.40	1.12	2.94	3.78	2.66	3.22

period, the nitrogen percentage at each period was significantly higher than the previous period, the increase in nitrogen content from the second period to the third period being very conspicuous. The percentages of nitrogen at fifth and sixth periods were significantly lower than the third and fourth periods while the nitrogen content at sixth period was significantly higher than that at the fifth period. The percentage of nitrogen at first and second periods did not differ significantly. The nitrogen percentage of leaf varied from 0.92 to 3.92, the average being 2.55. The nitrogen content of the leaf was also influenced by the interaction between levels of nitrogen and the different periods.

4.2. Nitrogen content of pseudostem

The results revealed that the increasing doses of nitrogen significantly influenced the nitrogen percentage in the pseudostem of turmeric, while the application of different levels of phosphorus and potassium did not influence the same significantly. The treatment n_2 recorded the highest nitrogen percentage and was on par with n_1. The treatments n_2 and n_1 were significantly superior to n_0 in the nitrogen content of the pseudostem. The nitrogen content of pseudostem significantly differed with the period of growth. The percentage of this element decreased considerably at the second period and thereafter increased

Table 9. Effect of NPK treatments and period of growth on nitrogen content of turmeric.

Nitrogen content of pseudostem, % on moisture free basis.

Sl. No.	Treatment	Period					
		1	2	3	4	5	6
1.	$n_0p_0k_0$	2.24	1.12	2.24	3.22	2.52	2.38
2.	$n_0p_0k_1$	3.08	1.26	2.66	3.08	2.80	2.80
3.	$n_0p_0k_2$	2.80	1.12	2.52	3.08	2.94	2.66
4.	$n_0p_1k_0$	2.66	2.10	1.96	2.80	2.38	2.80
5.	$n_0p_1k_1$	2.80	2.10	1.82	2.80	2.80	1.96
6.	$n_0p_1k_2$	2.52	1.68	2.52	2.66	2.80	2.66
7.	$n_0p_2k_0$	2.38	1.96	2.10	2.80	2.80	2.66
8.	$n_0p_2k_1$	2.94	1.96	2.10	2.80	3.08	2.80
9.	$n_0p_2k_2$	2.24	1.68	1.54	2.80	2.80	2.94
10.	$n_1p_0k_0$	3.08	1.82	3.22	2.66	2.80	2.94
11.	$n_1p_0k_1$	2.38	1.82	2.66	3.08	3.08	2.94
12.	$n_1p_0k_2$	3.36	1.68	2.52	2.80	2.66	2.80
13.	$n_1p_1k_0$	2.94	1.82	2.80	2.94	2.52	2.80
14.	$n_1p_1k_1$	2.80	1.68	2.52	2.94	2.38	2.66
15.	$n_1p_1k_2$	2.38	1.68	2.94	3.08	2.66	2.52
16.	$n_1p_2k_0$	2.80	1.96	2.94	2.94	2.80	2.66
17.	$n_1p_2k_1$	2.66	1.68	3.50	2.80	2.52	2.80
18.	$n_1p_2k_2$	3.36	2.24	2.66	2.80	2.94	2.94
19.	$n_2p_0k_0$	2.80	1.68	2.94	2.94	3.08	3.08
20.	$n_2p_0k_1$	3.08	1.68	3.08	3.08	3.08	2.80
21.	$n_2p_0k_2$	3.64	2.52	2.80	3.08	2.94	2.66
22.	$n_2p_1k_0$	2.66	1.96	2.80	3.08	2.80	2.80
23.	$n_2p_1k_1$	2.66	1.82	3.22	2.94	2.52	2.94
24.	$n_2p_1k_2$	2.66	1.82	2.80	2.80	2.38	2.94
25.	$n_2p_2k_0$	3.64	1.54	3.08	2.80	2.66	2.80
26.	$n_2p_2k_1$	2.80	1.40	3.22	2.94	2.80	2.66
27.	$n_2p_2k_2$	2.52	1.96	3.22	2.94	2.80	2.80

reaching a maximum at the fourth period. The content of nitrogen at fifth and sixth periods was significantly lower than that at the fourth and first periods. The values for nitrogen percentage ranged from 1.12 to 3.50, the average being 2.61. The combined effect of the levels of nitrogen and different periods also influenced the nitrogen percentage of pseudostem significantly.

4.3. Nitrogen content of rhizome

It was observed that the application of incremental doses of phosphorus influenced the nitrogen content significantly while the application of nitrogen and potassium had no significant effect on this parameter. The phosphorus level p_2 which was on par with p_1 recorded the highest nitrogen percentage. Phosphorus levels p_2 and p_1 were significantly superior to p_0. The nitrogen content of rhizomes differed markedly with varying periods of growth. The mean nitrogen percentage of 1.42 at the second period was increased to 3.32 at the third period. Thereafter, the nitrogen percentage slightly decreased with increasing period, the decrease being significant only at the fifth period. The nitrogen percentage ranged from 0.98 to 3.64, the average value being 2.88.

4.4. Nitrogen uptake in leaf

Studies conducted on the nitrogen uptake in leaf revealed that the effect of fertiliser treatments could not

Table 10. Effect of NPK treatments and period of growth on nitrogen content of turmeric.

Nitrogen content of rhizome, % on moisture free basis.

Sl. No.	Treatment	Period 2	3	4	5	6
1.	$n_0p_0k_0$	1.12	1.54	3.08	2.80	3.08
2.	$n_0p_0k_1$	0.98	3.22	3.22	3.36	3.08
3.	$n_0p_0k_2$	1.68	3.22	2.94	3.08	2.94
4.	$n_0p_1k_0$	1.26	2.94	3.36	2.80	3.22
5.	$n_0p_1k_1$	1.40	3.36	3.64	3.08	3.50
6.	$n_0p_1k_2$	1.12	3.50	3.08	3.22	3.22
7.	$n_0p_2k_0$	1.54	3.36	3.36	3.22	3.22
8.	$n_0p_2k_1$	1.40	3.64	3.36	3.08	3.08
9.	$n_0p_2k_2$	1.26	4.34	3.36	3.08	3.36
10.	$n_1p_0k_0$	1.54	3.22	3.22	3.22	3.50
11.	$n_1p_0k_1$	1.26	3.64	3.64	3.08	3.22
12.	$n_1p_0k_2$	1.26	3.36	2.94	3.36	3.08
13.	$n_1p_1k_0$	1.40	3.50	2.94	3.36	3.08
14.	$n_1p_1k_1$	1.54	3.22	3.22	3.08	3.22
15.	$n_1p_1k_2$	1.68	3.64	3.08	2.94	3.36
16.	$n_1p_2k_0$	1.40	3.36	3.36	2.80	3.22
17.	$n_1p_2k_1$	1.26	3.22	3.64	3.08	3.22
18.	$n_1p_2k_2$	1.54	3.08	3.22	3.22	3.50
19.	$n_2p_0k_0$	1.26	3.22	3.50	3.36	3.36
20.	$n_2p_0k_1$	1.68	3.36	3.36	3.36	3.08
21.	$n_2p_0k_2$	1.26	3.08	3.22	3.08	3.22
22.	$n_2p_1k_0$	1.54	3.36	3.36	2.94	3.22
23.	$n_2p_1k_1$	2.24	3.50	3.22	2.94	3.22
24.	$n_2p_1k_2$	1.12	3.64	3.22	3.08	3.36
25.	$n_2p_2k_0$	1.40	3.50	3.50	3.22	3.36
26.	$n_2p_2k_1$	1.54	3.50	3.64	3.22	3.50
27.	$n_2p_2k_2$	1.68	3.08	3.22	3.08	3.22

Table 11. Effect of NPK treatments and period of growth on nitrogen content of turmeric.
Nitrogen uptake in leaf, g/m^2.

Sl. No.	Treatment	Period 1	2	3	4	5	6
1.	$n_0p_0k_0$	1.74	3.02	12.96	13.95	17.08	12.89
2.	$n_0p_0k_1$	2.34	1.09	15.53	13.62	8.64	11.70
3.	$n_0p_0k_2$	1.51	1.61	13.45	5.35	10.87	10.24
4.	$n_0p_1k_0$	1.30	1.61	14.21	8.55	9.39	18.73
5.	$n_0p_1k_1$	0.96	2.00	19.28	19.89	23.50	18.91
6.	$n_0p_1k_2$	1.45	2.44	8.29	14.62	32.86	12.99
7.	$n_0p_2k_0$	1.46	1.44	15.30	14.02	11.31	28.11
8.	$n_0p_2k_1$	1.65	2.91	6.14	17.26	11.00	12.00
9.	$n_0p_2k_2$	1.27	1.47	10.51	11.87	9.26	18.25
10.	$n_1p_0k_0$	1.81	2.23	15.90	10.65	6.70	9.86
11.	$n_1p_0k_1$	1.24	2.81	17.16	17.46	9.75	19.14
12.	$n_1p_0k_2$	1.26	2.28	6.72	9.95	13.93	13.30
13.	$n_1p_1k_0$	1.95	2.50	7.14	8.78	7.25	8.92
14.	$n_1p_1k_1$	3.49	2.55	8.95	10.13	22.59	18.77
15.	$n_1p_1k_2$	2.92	3.63	14.44	12.62	8.52	10.66
16.	$n_1p_2k_0$	1.15	1.61	4.04	5.39	6.56	14.65
17.	$n_1p_2k_1$	1.76	1.86	13.52	8.94	12.03	16.20
18.	$n_1p_2k_2$	1.50	2.62	12.18	18.52	9.12	20.25
19.	$n_2p_0k_0$	1.13	2.07	12.67	12.67	8.83	9.60
20.	$n_2p_0k_1$	1.94	3.04	10.24	11.81	19.23	17.42
21.	$n_2p_0k_2$	2.00	2.08	16.10	7.59	12.02	12.72
22.	$n_2p_1k_0$	2.04	1.86	13.15	11.97	18.09	18.72
23.	$n_2p_1k_1$	1.19	1.23	12.14	4.47	13.39	13.29
24.	$n_2p_1k_2$	2.26	1.74	20.11	17.06	9.85	11.23
25.	$n_2p_2k_0$	3.28	2.80	11.54	12.05	18.25	19.49
26.	$n_2p_2k_1$	1.50	4.89	25.13	11.20	12.25	15.76
27.	$n_2p_2k_2$	1.15	1.14	7.20	9.75	12.25	16.25

influence the uptake significantly. The nitrogen uptake in leaf increased with increasing period of growth with a slight decrease during fourth period and a continuous increase thereafter. The uptake was highest at the sixth period, being on par with the uptake at the fifth period. The nitrogen uptake at sixth period was significantly higher to all the previous periods except the fifth. The uptake of nitrogen in leaf ranged from 1.15 g/m^2 to 28.11 g/m^2, the average being 9.48 g/m^2.

4.5. Nitrogen uptake in pseudostem

The results on the nitrogen uptake in pseudostem showed that the different fertiliser treatments, did not have any influence on the uptake of this nutrient in the pseudostem. It was also observed that the uptake of nitrogen in the pseudostem progressively increased with increasing period of growth, except a slight decrease during the second period. However the differences in uptake between first and second periods and fifth and sixth periods were not significant. The nitrogen uptake in pseudostem ranged from 0.47 g/m^2 to 18.53 g/m^2, the average value being 4.95.

4.6. Nitrogen uptake in rhizome

Observations on the uptake of nitrogen in rhizome indicated that the treatment combinations employed in the study had no effect on the uptake of nitrogen in the rhizome.

Table 12. Effect of NPK treatments and period of growth on nitrogen content of turmeric.
Nitrogen uptake in pseudostem, g/m^2.

Sl. No.	Treatment	Period 1	2	3	4	5	6
1.	$n_0p_0k_0$	1.48	1.30	4.68	5.88	11.32	7.09
2.	$n_0p_0k_1$	3.25	0.76	6.00	6.16	7.34	7.50
3.	$n_0p_0k_2$	1.19	0.56	3.95	2.76	6.03	18.53
4.	$n_0p_1k_0$	1.78	1.01	3.33	3.86	5.61	12.73
5.	$n_0p_1k_1$	1.60	1.24	6.19	8.57	14.82	6.19
6.	$n_0p_1k_2$	1.84	1.24	2.42	5.43	11.39	5.54
7.	$n_0p_2k_0$	1.46	0.92	4.07	5.58	5.56	14.82
8.	$n_0p_2k_1$	1.75	1.49	1.38	7.40	8.25	7.84
9.	$n_0p_2k_2$	0.91	0.89	4.17	4.93	7.33	9.83
10.	$n_1p_0k_0$	2.69	1.35	6.42	5.16	4.37	5.58
11.	$n_1p_0k_1$	1.29	1.73	6.05	11.56	18.09	9.86
12.	$n_1p_0k_2$	1.50	1.23	1.57	5.32	5.27	6.25
13.	$n_1p_1k_0$	2.46	1.29	1.70	5.56	4.11	4.25
14.	$n_1p_1k_1$	3.94	1.48	3.55	6.52	13.18	6.13
15.	$n_1p_1k_2$	2.19	1.88	5.99	7.55	11.21	5.09
16.	$n_1p_2k_0$	1.02	0.82	1.88	2.88	1.77	6.11
17.	$n_1p_2k_1$	2.16	0.86	6.89	5.19	4.96	7.10
18.	$n_1p_2k_2$	2.30	1.86	4.83	10.56	4.20	9.29
19.	$n_2p_0k_0$	1.26	0.94	3.88	8.34	6.39	5.00
20.	$n_2p_0k_1$	3.24	1.16	4.51	7.93	5.74	11.46
21.	$n_2p_0k_2$	2.58	2.04	6.35	4.67	8.34	4.98
22.	$n_2p_1k_0$	1.36	1.25	5.15	6.72	6.96	7.78
23.	$n_2p_1k_1$	0.47	0.56	4.35	2.57	4.32	5.99
24.	$n_2p_1k_2$	1.73	0.96	8.32	8.91	3.38	7.01
25.	$n_2p_2k_0$	4.36	1.31	8.77	8.36	9.21	9.18
26.	$n_2p_2k_1$	1.59	1.50	8.48	4.43	4.48	6.39
27.	$n_2p_2k_2$	1.07	0.71	2.92	6.58	5.46	6.90

Table 13. Effect of NPK treatments and period of growth on nitrogen content of turmeric.
Nitrogen uptake in rhizome, g/m^2.

Sl. No.	Treatment	Period 2	3	4	5	6
1.	$n_0p_0k_0$	0.39	1.28	3.37	13.96	11.64
2.	$n_0p_0k_1$	0.09	2.92	4.00	6.99	9.13
3.	$n_0p_0k_2$	0.10	0.29	1.48	2.43	4.68
4.	$n_0p_1k_0$	0.13	4.49	4.26	10.85	13.58
5.	$n_0p_1k_1$	0.10	3.31	4.62	21.44	13.29
6.	$n_0p_1k_2$	0.38	1.07	5.74	9.87	9.21
7.	$n_0p_2k_0$	0.17	3.52	3.48	4.25	18.66
8.	$n_0p_2k_1$	0.13	3.53	4.15	4.72	8.25
9.	$n_0p_2k_2$	0.26	1.84	5.19	3.77	9.71
10.	$n_1p_0k_0$	0.17	2.69	5.62	6.41	5.22
11.	$n_1p_0k_1$	0.38	4.34	8.63	13.76	11.95
12.	$n_1p_0k_2$	0.32	1.92	11.52	9.36	8.96
13.	$n_1p_1k_0$	0.22	0.74	4.30	4.03	4.03
14.	$n_1p_1k_1$	0.29	0.80	4.87	18.14	10.78
15.	$n_1p_1k_2$	0.49	3.23	3.61	5.66	5.86
16.	$n_1p_2k_0$	0.08	0.22	1.36	2.66	9.33
17.	$n_1p_2k_1$	0.32	2.65	1.97	5.37	9.57
18.	$n_1p_2k_2$	0.29	1.94	7.27	5.09	12.75
19.	$n_2p_0k_0$	0.24	2.03	2.54	5.76	4.29
20.	$n_2p_0k_1$	0.20	1.21	1.85	12.68	12.78
21.	$n_2p_0k_2$	0.43	3.08	2.84	2.36	7.22
22.	$n_2p_1k_0$	0.31	3.37	2.95	10.45	10.07
23.	$n_2p_1k_1$	0.09	1.30	8.18	6.53	5.29
24.	$n_2p_1k_2$	0.10	4.57	6.28	3.29	9.53
25.	$n_2p_2k_0$	0.41	6.64	4.16	9.06	9.99
26.	$n_2p_2k_1$	0.57	2.97	8.36	3.74	7.75
27.	$n_2p_2k_2$	0.15	1.08	2.43	9.04	8.24

However, the age of the plant considerably influenced the uptake of this element in rhizome. The uptake increased continuously with increasing period of growth. The maximum uptake of nitrogen took place during the period from 180th to 210th day when nitrogen uptake in rhizome increased by 69.33 per cent over the previous period. The uptake of nitrogen during this period accounted for 34.44 per cent of the total nitrogen accumulated in rhizome.

4.7. Total uptake of nitrogen

The results of the data revealed that the total uptake of nitrogen was influenced by the levels of potassium applied. The varying levels of nitrogen and phosphorus applied did not influence the total uptake of nitrogen by the crop. Maximum uptake was noticed at k_1 level which was significantly higher than those at k_0 and k_2 levels. The uptakes at k_0 and k_2 levels were statistically on par. It could be noted that the maximum yield of turmeric was also obtained at the k_1 level though the differences in yield between levels were not statistically significant. The total nitrogen uptake progressively increased with advancing period of growth, the maximum uptake being at the sixth period. There was remarkable intake of nitrogen by the crop during the period from 120th to 150th day. The uptake value of 3.69 g/m^2 at 120th day shot upto 19.22 g/m^2 at 150th day with an increase of 439.84 per cent over the

Table 14. Effect of NPK treatments and period of growth on nitrogen content of turmeric. Total uptake of nitrogen, g/m^2.

Sl. No.	Treatment	Period 2	3	4	5	6
1.	$n_0p_0k_0$	4.71	18.92	23.20	42.36	31.62
2.	$n_0p_0k_1$	1.94	24.45	23.78	22.97	28.35
3.	$n_0p_0k_2$	2.27	17.69	9.59	19.35	33.45
4.	$n_0p_1k_0$	2.75	22.03	16.67	25.83	45.04
5.	$n_0p_1k_1$	3.34	28.78	33.08	59.76	30.39
6.	$n_0p_1k_2$	4.06	11.78	25.79	54.12	27.74
7.	$n_0p_2k_0$	2.53	22.39	23.18	21.12	61.59
8.	$n_0p_2k_1$	4.53	11.05	28.81	23.97	28.09
9.	$n_0p_2k_2$	2.62	16.52	21.99	20.36	37.79
10.	$n_1p_0k_0$	3.75	25.01	21.43	17.48	20.66
11.	$n_1p_0k_1$	4.92	27.55	37.65	41.60	40.65
12.	$n_1p_0k_2$	3.85	10.21	26.79	26.56	28.51
13.	$n_1p_1k_0$	4.01	9.58	18.64	15.39	17.20
14.	$n_1p_1k_1$	4.32	13.30	21.52	53.91	37.68
15.	$n_1p_1k_2$	6.00	23.66	23.78	25.39	21.61
16.	$n_1p_2k_0$	2.51	6.14	9.63	16.94	30.09
17.	$n_1p_2k_1$	3.04	23.05	16.10	22.36	32.87
18.	$n_1p_2k_2$	4.77	18.95	36.35	16.41	42.29
19.	$n_2p_0k_0$	3.25	18.58	23.55	26.96	19.69
20.	$n_2p_0k_1$	4.40	15.96	21.59	41.65	41.66
21.	$n_2p_0k_2$	4.55	25.53	15.10	22.74	24.92
22.	$n_2p_1k_0$	3.42	21.67	21.64	35.50	36.57
23.	$n_2p_1k_1$	1.88	17.79	15.22	24.24	24.57
24.	$n_2p_1k_2$	2.00	33.00	23.25	16.52	27.77
25.	$n_2p_2k_0$	4.52	26.95	24.57	36.52	38.66
26.	$n_2p_2k_1$	6.96	36.58	23.99	20.47	29.90
27.	$n_2p_2k_2$	2.00	11.20	18.76	26.75	31.39

Table 15. Effect of NPK treatments and period of growth on nitrogen content of turmeric.

Summary

Treatment groups	N % on moisture free basis			Uptake of nitrogen, g/m^2			
	Leaf	Pseudo-stem	Rhizome	Leaf	Pseudo-stem	Rhizome	Total
n_0	2.61	2.45	2.35	10.07	5.17	5.26	22.91
n_1	2.46	2.65	2.41	8.70	4.82	4.87	20.09
n_2	2.58	2.72	2.44	9.68	4.87	4.59	21.09
p_0	2.53	2.66	2.12	8.94	5.27	4.75	20.87
p_1	2.52	2.55	2.41	10.01	4.86	5.37	22.24
p_2	2.59	2.62	2.45	9.50	4.72	4.60	20.97
k_0	2.53	2.61	2.35	8.96	4.61	4.74	20.29
k_1	2.56	2.62	2.45	10.31	5.43	5.64	23.75
k_2	2.56	2.61	2.13	9.17	4.81	4.35	20.06
Periods							
1	1.45	2.81	-	1.75	1.94	-	-
2	1.51	1.77	1.42	2.24	1.20	0.25	3.69
3	3.29	2.68	3.32	12.74	4.73	2.48	19.92
4	3.44	2.91	3.29	11.86	6.28	4.63	22.43
5	2.71	2.75	3.12	13.13	7.52	7.84	28.49
6	2.90	2.75	3.25	15.19	8.04	9.32	32.55
C.D.(0.05) for comparing levels of N, P and K	0.105	0.105	0.106	N.S.	N.S.	N.S.	3.245
C.D. (0.05) for comparing periods	0.127	0.148	0.137	2.115	1.219	1.415	4.189

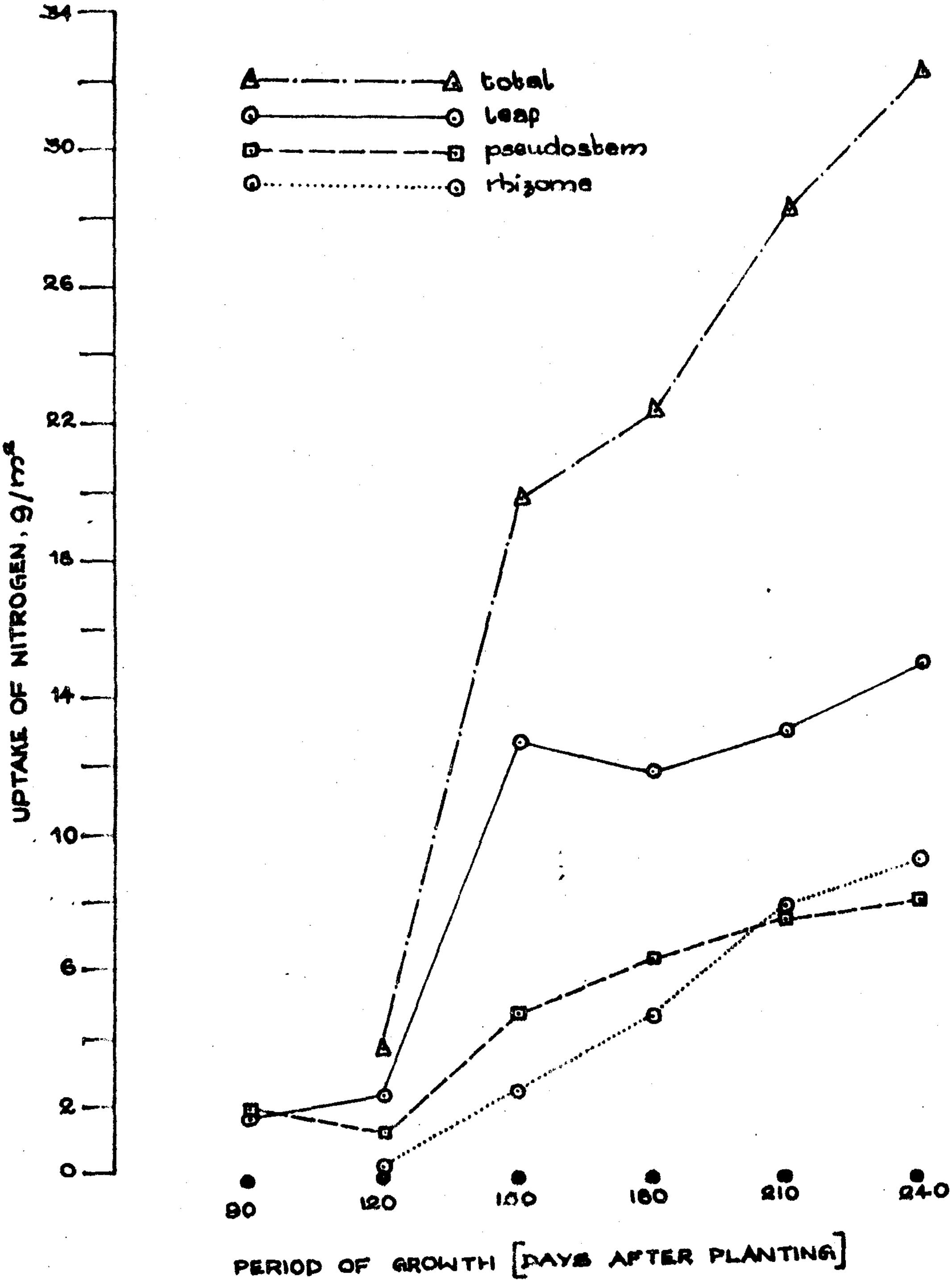

FIG.3. RELATIONSHIP BETWEEN PERIOD OF GROWTH AND UPTAKE OF NITROGEN

previous period. Out of the maximum nitrogen uptake by the crop of 32.55 g/m^2, 16.23 g/m^2 was taken up during the period of these 30 days (49.86 per cent). The quantity taken up between 150th and 180th day was also significant. The values for total nitrogen uptake at fifth and sixth periods were statistically on par.

5. Effect of NPK treatments and period of growth on phosphorus content of turmeric

The effects of levels of nitrogen, phosphorus and potassium and period of growth on the phosphorus content of turmeric are presented as Tables 16 to 22 and their summary furnished in Table 23. Details of analysis of variance are abstracted in Appendix VIII.

5.1. Phosphorus content of leaf

The results showed that the effect of the nutrient doses given was not significant in influencing this parameter except in the case of levels of nitrogen. Both n_2 and n_0 levels were significantly superior to n_1 in increasing the phosphorus content of leaf. The level n_2 recorded the highest phosphorus content in leaf, which was but statistically on par with the effect of n_0 level. It was also observed that the phosphorus content of the leaf varied significantly between periods of growth. There was a continuous decrease in the content of phosphorus with advancing periods of growth upto the fifth period.

Table 16. Effect of NPK treatments and period of growth on phosphorus content of turmeric.

Phosphorus content of leaf, % moisture free basis.

Sl. No.	Treatment	Period 1	2	3	4	5	6
1.	$n_0p_0k_0$	0.231	0.250	0.190	0.189	0.180	0.160
2.	$n_0p_0k_1$	0.209	0.261	0.184	0.186	0.173	0.135
3.	$n_0p_0k_2$	0.211	0.242	0.195	0.188	0.174	0.162
4.	$n_0p_1k_0$	0.190	0.277	0.198	0.185	0.160	0.165
5.	$n_0p_1k_1$	0.197	0.222	0.194	0.189	0.135	0.160
6.	$n_0p_1k_2$	0.207	0.228	0.188	0.193	0.162	0.170
7.	$n_0p_2k_0$	0.216	0.230	0.193	0.188	0.165	0.180
8.	$n_0p_2k_1$	0.219	0.238	0.185	0.186	0.160	0.173
9.	$n_0p_2k_2$	0.220	0.222	0.193	0.191	0.170	0.174
10.	$n_1p_0k_0$	0.231	0.210	0.193	0.188	0.143	0.143
11.	$n_1p_0k_1$	0.208	0.234	0.194	0.190	0.143	0.147
12.	$n_1p_0k_2$	0.216	0.200	0.184	0.190	0.136	0.146
13.	$n_1p_1k_0$	0.207	0.218	0.189	0.184	0.152	0.144
14.	$n_1p_1k_1$	0.198	0.220	0.186	0.185	0.147	0.152
15.	$n_1p_1k_2$	0.241	0.194	0.189	0.191	0.137	0.167
16.	$n_1p_2k_0$	0.226	0.180	0.173	0.186	0.180	0.137
17.	$n_1p_2k_1$	0.231	0.176	0.173	0.188	0.187	0.156
18.	$n_1p_2k_2$	0.232	0.190	0.183	0.190	0.146	0.165
19.	$n_2p_0k_0$	0.252	0.200	0.189	0.188	0.172	0.182
20.	$n_2p_0k_1$	0.247	0.212	0.173	0.185	0.173	0.193
21.	$n_2p_0k_2$	0.261	0.198	0.185	0.185	0.143	0.175
22.	$n_2p_1k_0$	0.266	0.192	0.195	0.190	0.175	0.176
23.	$n_2p_1k_1$	0.217	0.194	0.189	0.190	0.170	0.170
24.	$n_2p_1k_2$	0.256	0.223	0.186	0.188	0.177	0.187
25.	$n_2p_2k_0$	0.261	0.212	0.191	0.185	0.167	0.177
26.	$n_2p_2k_1$	0.227	0.223	0.190	0.193	0.170	0.183
27.	$n_2p_2k_2$	0.241	0.202	0.189	0.185	0.152	0.162

The phosphorus content at the sixth period increased slightly over the fifth period, though the difference was not statistically significant. Similarly the phosphorus contents at third and fourth periods were also on par. Period x N, period x P and period x K combinations have also influenced the phosphorus content of leaf significantly. The phosphorus content of leaf varied from 0.143 to 0.266 per cent, the mean value being 0.191.

5.2. Phosphorus content of pseudostem

The results furnished in Table 17 revealed that the varying levels of nutrient elements employed had no effect on the percentage of phosphorus in pseudostem. But the level of this nutrient in pseudostem, as in the case of leaf, varied significantly according to the period of growth. However, the values failed to indicate any definite trend with increasing period of growth. The lowest value was recorded at the first period which then progressed to the highest value at the second period and then dropped through the third and fourth to remain almost constant at the subsequent periods. Phosphorus content of pseudostem ranged from 0.155 to 0.590 per cent, the average being 0.229.

5.3. Phosphorus content of rhizome

The results of the experiment, on the percentage of phosphorus in rhizome, as influenced by the levels of nutrients and the sampling period, are furnished in Table 18

Table 17. Effect of NPK treatments and period of growth on phosphorus content of turmeric.

Phosphorus content of pseudostem, % on moisture free basis.

Sl. No.	Treatment	Period 1	2	3	4	5	6
1.	$n_0p_0k_0$	0.161	0.362	0.317	0.191	0.183	0.183
2.	$n_0p_0k_1$	0.169	0.428	0.292	0.190	0.182	0.192
3.	$n_0p_0k_2$	0.164	0.420	0.296	0.199	0.183	0.187
4.	$n_0p_1k_0$	0.159	0.588	0.197	0.199	0.122	0.191
5.	$n_0p_1k_1$	0.171	0.352	0.225	0.188	0.137	0.145
6.	$n_0p_1k_2$	0.171	0.320	0.336	0.199	0.243	0.210
7.	$n_0p_2k_0$	0.164	0.448	0.320	0.189	0.250	0.241
8.	$n_0p_2k_1$	0.151	0.433	0.215	0.180	0.226	0.250
9.	$n_0p_2k_2$	0.173	0.379	0.202	0.191	0.198	0.195
10.	$n_1p_0k_0$	0.154	0.350	0.272	0.186	0.121	0.162
11.	$n_1p_0k_1$	0.149	0.368	0.229	0.193	0.117	0.187
12.	$n_1p_0k_2$	0.163	0.342	0.312	0.186	0.151	0.121
13.	$n_1p_1k_0$	0.163	0.380	0.245	0.189	0.144	0.143
14.	$n_1p_1k_1$	0.165	0.433	0.301	0.188	0.169	0.182
15.	$n_1p_1k_2$	0.158	0.329	0.267	0.196	0.159	0.212
16.	$n_1p_2k_0$	0.168	0.288	0.310	0.184	0.417	0.153
17.	$n_1p_2k_1$	0.164	0.280	0.306	0.191	0.247	0.231
18.	$n_1p_2k_2$	0.141	0.370	0.257	0.191	0.172	0.211
19.	$n_2p_0k_0$	0.170	0.304	0.257	0.195	0.232	0.192
20.	$n_2p_0k_1$	0.166	0.278	0.257	0.185	0.225	0.234
21.	$n_2p_0k_2$	0.166	0.429	0.273	0.185	0.108	0.162
22.	$n_2p_1k_0$	0.164	0.389	0.170	0.179	0.234	0.212
23.	$n_2p_1k_1$	0.168	0.330	0.250	0.190	0.224	0.192
24.	$n_2p_1k_2$	0.166	0.381	0.283	0.189	0.202	0.175
25.	$n_2p_2k_0$	0.161	0.360	0.225	0.188	0.164	0.241
26.	$n_2p_2k_1$	0.163	0.335	0.230	0.189	0.212	0.224
27.	$n_2p_2k_2$	0.155	0.345	0.311	0.189	0.182	0.216

Table 18. Effect of NPK treatments and period of growth on phosphorus content of turmeric.

Phosphorus content of rhizome, % on moisture free basis.

Sl. No.	Treatment	Period				
		2	3	4	5	6
1.	$n_0p_0k_0$	0.378	0.389	0.291	0.337	0.312
2.	$n_0p_0k_1$	0.342	0.344	0.256	0.316	0.342
3.	$n_0p_0k_2$	0.389	0.304	0.309	0.293	0.351
4.	$n_0p_1k_0$	0.458	0.256	0.282	0.306	0.294
5.	$n_0p_1k_1$	0.293	0.264	0.290	0.293	0.265
6.	$n_0p_1k_2$	0.300	0.350	0.314	0.305	0.341
7.	$n_0p_2k_0$	0.378	0.338	0.295	0.350	0.281
8.	$n_0p_2k_1$	0.432	0.314	0.326	0.320	0.312
9.	$n_0p_2k_2$	0.400	0.309	0.256	0.335	0.318
10.	$n_1p_0k_0$	0.334	0.248	0.272	0.282	0.324
11.	$n_1p_0k_1$	0.330	0.225	0.316	0.284	0.379
12.	$n_1p_0k_2$	0.301	0.285	0.301	0.280	0.361
13.	$n_1p_1k_0$	0.322	0.310	0.296	0.318	0.318
14.	$n_1p_1k_1$	0.358	0.354	0.291	0.320	0.299
15.	$n_1p_1k_2$	0.347	0.264	0.305	0.311	0.282
16.	$n_1p_2k_0$	0.339	0.276	0.312	0.379	0.321
17.	$n_1p_2k_1$	0.340	0.287	0.314	0.302	0.257
18.	$n_1p_2k_2$	0.369	0.324	0.308	0.299	0.305
19.	$n_2p_0k_0$	0.391	0.269	0.321	0.311	0.316
20.	$n_2p_0k_1$	0.350	0.312	0.298	0.321	0.295
21.	$n_2p_0k_2$	0.380	0.332	0.325	0.257	0.298
22.	$n_2p_1k_0$	0.348	0.235	0.341	0.329	0.313
23.	$n_2p_1k_1$	0.332	0.234	0.332	0.324	0.341
24.	$n_2p_1k_2$	0.430	0.277	0.298	0.339	0.351
25.	$n_2p_2k_0$	0.352	0.266	0.318	0.295	0.318
26.	$n_2p_2k_1$	0.438	0.323	0.321	0.298	0.320
27.	$n_2p_2k_2$	0.370	0.276	0.336	0.313	0.311

and their mean values in Table 23. As with pseudostem, the percentage of phosphorus in rhizome also remained unaffected by the levels of applied nitrogen, phosphorus and potassium. But as growth proceeded, the per cent of phosphorus in rhizome varied significantly. The phosphorus content at 120 days after planting was the highest and significantly superior to all other periods. The third period recorded the lowest value and thereafter there was a gradual increase in the phosphorus content over advancing periods of growth. The phosphorus content of rhizome ranged from 0.225 to 0.460 per cent, the average being 0.316.

5.4. Uptake of phosphorus in leaf

Table 19 indicates the uptake of phosphorus in leaf at different stages of growth of turmeric, and at different nutrient levels. Table 23 furnishes the mean values of the same. The results presented in Appendix VIII revealed that, among the different levels of nutrients applied, the levels of potassium and NK interaction affected the uptake of phosphorus significantly. The uptake at the level k_1 was significantly higher than those at k_0 and k_2, the latter two being statistically on par. The uptake of phosphorus in leaf increased significantly with increasing periods of growth.

5.5. Uptake of phosphorus in pseudostem

The statistical analysis of the results presented in

Table 19. Effect of NPK treatments and period of growth on phosphorus content of turmeric.

Uptake of phosphorus in leaf, g/m^2.

Sl. No.	Treatment	Period					
		1	2	3	4	5	6
1.	$n_0p_0k_0$	0.26	0.45	0.70	0.19	1.09	0.74
2.	$n_0p_0k_1$	0.35	0.34	0.65	0.58	0.42	0.51
3.	$n_0p_0k_2$	0.23	0.23	0.75	0.30	0.61	0.56
4.	$n_0p_1k_0$	0.20	0.27	0.84	0.40	0.59	1.00
5.	$n_0p_1k_1$	0.19	0.29	1.21	0.93	1.26	1.08
6.	$n_0p_1k_2$	0.27	0.40	0.48	0.72	0.75	0.78
7.	$n_0p_2k_0$	0.28	0.24	0.92	0.67	0.63	1.72
8.	$n_0p_2k_1$	0.23	0.38	0.34	0.85	0.60	0.67
9.	$n_0p_2k_2$	0.18	0.23	0.58	0.60	0.59	1.03
10.	$n_1p_0k_0$	0.23	0.33	0.88	0.65	0.36	0.43
11.	$n_1p_0k_1$	0.34	0.46	1.03	1.13	0.49	1.06
12.	$n_1p_0k_2$	0.22	0.30	0.37	0.64	0.62	0.77
13.	$n_1p_1k_0$	0.26	0.33	0.40	0.61	0.45	0.48
14.	$n_1p_1k_1$	0.45	0.40	0.55	0.70	1.31	1.01
15.	$n_1p_1k_2$	0.42	0.45	0.78	0.66	0.45	0.61
16.	$n_1p_2k_0$	0.15	0.17	0.31	0.36	0.47	0.68
17.	$n_1p_2k_1$	0.29	0.20	0.64	0.60	0.80	0.82
18.	$n_1p_2k_2$	0.25	0.30	0.64	1.05	0.50	1.17
19.	$n_2p_0k_0$	0.19	0.25	0.50	0.71	0.63	0.62
20.	$n_2p_0k_1$	0.29	0.35	0.53	0.74	1.25	1.14
21.	$n_2p_0k_2$	0.29	0.35	0.82	0.46	0.72	0.84
22.	$n_2p_1k_0$	0.39	0.25	0.83	0.60	1.13	1.17
23.	$n_2p_1k_1$	0.17	0.15	0.68	0.23	0.81	0.77
24.	$n_2p_1k_2$	0.32	0.25	1.11	0.41	0.57	0.71
25.	$n_2p_2k_0$	0.51	0.42	0.72	0.56	0.99	1.17
26.	$n_2p_2k_1$	0.22	0.64	1.55	0.66	0.74	0.94
27.	$n_2p_2k_2$	0.20	0.20	0.46	0.48	0.70	[illegible]

Table 20. Effect of NPK treatments and period of growth on phosphorus content of turmeric.
Uptake of phosphorus in pseudostem, g/m^2.

Sl. No.	Treatment	Period					
		1	2	3	4	5	6
1.	$n_0p_0k_0$	0.11	0.41	0.66	0.35	0.82	0.54
2.	$n_0p_0k_1$	0.18	0.26	0.66	0.38	0.48	0.51
3.	$n_0p_0k_2$	0.07	0.21	0.46	0.18	0.38	0.49
4.	$n_0p_1k_0$	0.11	0.24	0.33	0.27	0.29	0.87
5.	$n_0p_1k_1$	0.10	0.21	0.77	0.58	0.73	0.46
6.	$n_0p_1k_2$	0.12	0.24	0.32	0.41	0.99	0.44
7.	$n_0p_2k_0$	0.10	0.21	0.62	0.38	0.50	1.34
8.	$n_0p_2k_1$	0.09	0.33	0.14	0.48	0.61	0.67
9.	$n_0p_2k_2$	0.07	0.20	0.24	0.34	0.52	0.65
10.	$n_1p_0k_0$	0.13	0.26	0.54	0.36	0.19	0.31
11.	$n_1p_0k_1$	0.08	0.37	0.52	0.72	0.69	0.63
12.	$n_1p_0k_2$	0.07	0.25	0.19	0.35	0.30	0.32
13.	$n_1p_1k_0$	0.14	0.27	0.15	0.36	0.23	0.22
14.	$n_1p_1k_1$	0.23	0.38	0.42	0.42	0.94	0.56
15.	$n_1p_1k_2$	0.15	0.37	0.54	0.48	0.32	0.43
16.	$n_1p_2k_0$	0.06	0.12	0.20	0.18	0.26	0.35
17.	$n_1p_2k_1$	0.13	0.14	0.61	0.35	0.49	0.59
18.	$n_1p_2k_2$	0.10	0.30	0.47	0.72	0.25	0.67
19.	$n_2p_0k_0$	0.08	0.17	0.34	0.55	0.48	0.36
20.	$n_2p_0k_1$	0.17	0.19	0.38	0.48	0.71	0.96
21.	$n_2p_0k_2$	0.12	0.35	0.62	0.28	0.27	0.30
22.	$n_2p_1k_0$	0.09	0.25	0.32	0.39	0.58	0.59
23.	$n_2p_1k_1$	0.03	0.10	0.34	0.16	0.38	0.39
24.	$n_2p_1k_2$	0.11	0.20	0.84	0.28	0.29	0.42
25.	$n_2p_2k_0$	0.19	0.30	0.64	0.25	0.57	0.79
26.	$n_2p_2k_1$	0.09	0.35	0.61	0.28	0.34	0.54
27.	$n_2p_2k_2$	0.07	0.13	0.28	0.42	0.35	0.53

Table 20 showed that the uptake of phosphorus in pseudostem was significantly affected by NK interaction as in the case of uptake in leaf. All other levels of nutrients and interactions failed to influence the uptake of this element in pseudostem. The uptake of phosphorus in pseudostem was also significantly influenced by age of the crop. The phosphorus uptake increased with advancing period of growth, barring a slight decrease at the fourth period. The uptake was the highest at the sixth period.

5.6. Uptake of phosphorus in rhizome

The observations and the results of statistical analysis given in Table 21 and Appendix VIII indicate that the uptake of phosphorus in rhizome was significantly influenced by the interaction of nitrogen and potassium as in the case of leaf and pseudostem. But the varying levels of nitrogen, phosphorus and potassium and other interactions could not influence this parameter significantly. However, significant differences were noticed between values recorded at varying periods of crop growth. The uptake of phosphorus in rhizome steadily increased with increasing age of the crop.

5.7. Total uptake of phosphorus

It was seen that NK interaction had a significant influence on the total uptake of phosphorus as in the case of leaf, pseudostem and rhizome. Among the other treatments,

Table 21. Effect of NPK treatments and period of growth on phosphorus content of turmeric.

Uptake of phosphorus in rhizome, g/m^2

Sl. No.	Treatment	Period 2	3	4	5	6
1.	$n_0p_0k_0$	0.13	0.32	0.32	1.68	1.17
2.	$n_0p_0k_1$	0.03	0.31	0.32	0.67	1.01
3.	$n_0p_0k_2$	0.02	0.03	0.16	0.23	0.56
4.	$n_0p_1k_0$	0.05	0.39	0.36	1.18	1.24
5.	$n_0p_1k_1$	0.02	0.26	0.54	2.04	1.01
6.	$n_0p_1k_2$	0.10	0.10	0.59	0.40	0.98
7.	$n_0p_2k_0$	0.04	0.35	0.31	0.46	1.63
8.	$n_0p_2k_1$	0.04	0.03	0.40	0.49	0.84
9.	$n_0p_2k_2$	0.08	0.13	0.40	0.41	0.92
10.	$n_1p_0k_0$	0.04	0.21	0.47	0.57	0.48
11.	$n_1p_0k_1$	0.10	0.27	0.75	1.27	1.41
12.	$n_1p_0k_2$	0.08	0.02	1.18	0.77	1.05
13.	$n_1p_1k_0$	0.05	0.07	0.44	0.38	0.42
14.	$n_1p_1k_1$	0.07	0.09	0.44	1.88	1.00
15.	$n_1p_1k_2$	0.10	0.23	0.36	0.60	0.49
16.	$n_1p_2k_0$	0.02	0.02	0.13	0.36	0.93
17.	$n_1p_2k_1$	0.09	0.18	0.17	0.53	0.76
18.	$n_1p_2k_2$	0.07	0.17	0.69	0.47	1.11
19.	$n_2p_0k_0$	0.07	0.19	0.23	0.53	0.40
20.	$n_2p_0k_1$	0.04	0.11	0.16	1.21	1.22
21.	$n_2p_0k_2$	0.13	0.33	0.29	1.99	0.67
22.	$n_2p_1k_0$	0.07	0.24	0.30	1.17	0.98
23.	$n_2p_1k_1$	0.01	0.09	0.84	0.72	0.55
24.	$n_2p_1k_2$	0.04	0.35	0.31	0.36	1.00
25.	$n_2p_2k_0$	0.10	0.50	0.32	0.83	0.95
26.	$n_2p_2k_1$	0.16	0.27	0.74	0.34	0.71
27.	$n_2p_2k_2$	0.03	0.10	0.25	0.92	0.80

Table 22. Effect of NPK treatments and period of growth on phosphorus content of turmeric.
Total uptake of phosphorus, g/m^2.

Sl. No.	Treatment	Period 2	3	4	5	6
1.	$n_0p_0k_0$	0.99	1.68	0.86	3.59	2.45
2.	$n_0p_0k_1$	0.63	1.82	1.28	1.57	2.03
3.	$n_0p_0k_2$	0.46	1.24	0.64	1.22	1.61
4.	$n_0p_1k_0$	0.56	1.56	1.03	2.06	3.11
5.	$n_0p_1k_1$	0.52	2.24	2.05	4.03	2.55
6.	$n_0p_1k_2$	0.74	0.90	1.72	2.14	2.20
7.	$n_0p_2k_0$	0.49	1.89	1.36	1.59	4.69
8.	$n_0p_2k_1$	0.75	0.51	1.73	1.70	2.18
9.	$n_0p_2k_2$	0.51	0.95	1.34	1.52	2.60
10.	$n_1p_0k_0$	0.63	1.63	1.48	1.12	1.22
11.	$n_1p_0k_1$	0.93	1.82	2.60	2.45	3.10
12.	$n_1p_0k_2$	0.63	0.58	2.17	1.69	2.14
13.	$n_1p_1k_0$	0.65	0.62	1.41	1.07	1.12
14.	$n_1p_1k_1$	0.85	1.06	1.56	4.13	2.57
15.	$n_1p_1k_2$	0.92	1.55	1.70	1.38	1.53
16.	$n_1p_2k_0$	0.31	0.53	0.67	1.09	1.96
17.	$n_1p_2k_1$	0.43	1.43	1.12	1.82	2.17
18.	$n_1p_2k_2$	0.67	1.28	2.46	1.22	2.95
19.	$n_2p_0k_0$	0.49	1.03	1.49	1.64	1.38
20.	$n_2p_0k_1$	0.58	1.02	1.38	3.17	3.32
21.	$n_2p_0k_2$	0.83	1.77	1.03	2.98	1.81
22.	$n_2p_1k_0$	0.57	1.39	1.29	2.88	2.74
23.	$n_2p_1k_1$	0.26	1.11	1.23	1.91	1.72
24.	$n_2p_1k_2$	0.49	2.30	1.00	1.22	2.13
25.	$n_2p_2k_0$	0.82	1.86	1.13	2.39	2.91
26.	$n_2p_2k_1$	1.15	2.43	1.68	1.42	2.19
27.	$n_2p_2k_2$	0.36	0.84	1.15	1.97	2.15

Table 23. Effect of NPK treatments and period of growth on the phosphorus content of turmeric.

Summary

Treatment groups	P % on moisture free basis			Uptake of phosphorus, g/m^2			
	Leaf	Pseudo-stem	Rhizome	Leaf	Pseudo-stem	Rhizome	Total
n_0	0.193	0.238	0.269	0.584	0.410	0.506	1.629
n_1	0.183	0.224	0.258	0.560	0.350	0.466	1.476
n_2	0.196	0.226	0.268	0.615	0.357	0.479	1.569
p_0	0.191	0.224	0.264	0.558	0.375	0.516	1.560
p_1	0.190	0.227	0.262	0.606	0.368	0.509	1.595
p_2	0.191	0.237	0.270	0.595	0.374	0.426	1.519
k_0	0.193	0.232	0.265	0.563	0.360	0.467	1.498
k_1	0.189	0.227	0.263	0.652	0.415	0.538	1.738
k_2	0.190	0.228	0.267	0.545	0.342	0.446	1.438
Periods							
1	0.227	0.162	-	0.273	0.111	-	-
2	0.216	0.372	0.363	0.320	0.252	0.066	0.638
3	0.188	0.264	0.289	0.721	0.452	0.198	1.372
4	0.188	0.189	0.305	0.618	0.385	0.424	1.428
5	0.161	0.193	0.312	0.724	0.480	0.831	2.036
6	0.164	0.194	0.316	0.663	0.553	0.900	2.316
C.D.(0.05) for comparing levels of N, P and K.	0.004	N.S.	N.S.	0.083	N.S.	N.S.	0.246
C.D.(0.05) for comparing periods	0.005	0.024	0.017	0.117	0.084	0.158	0.317

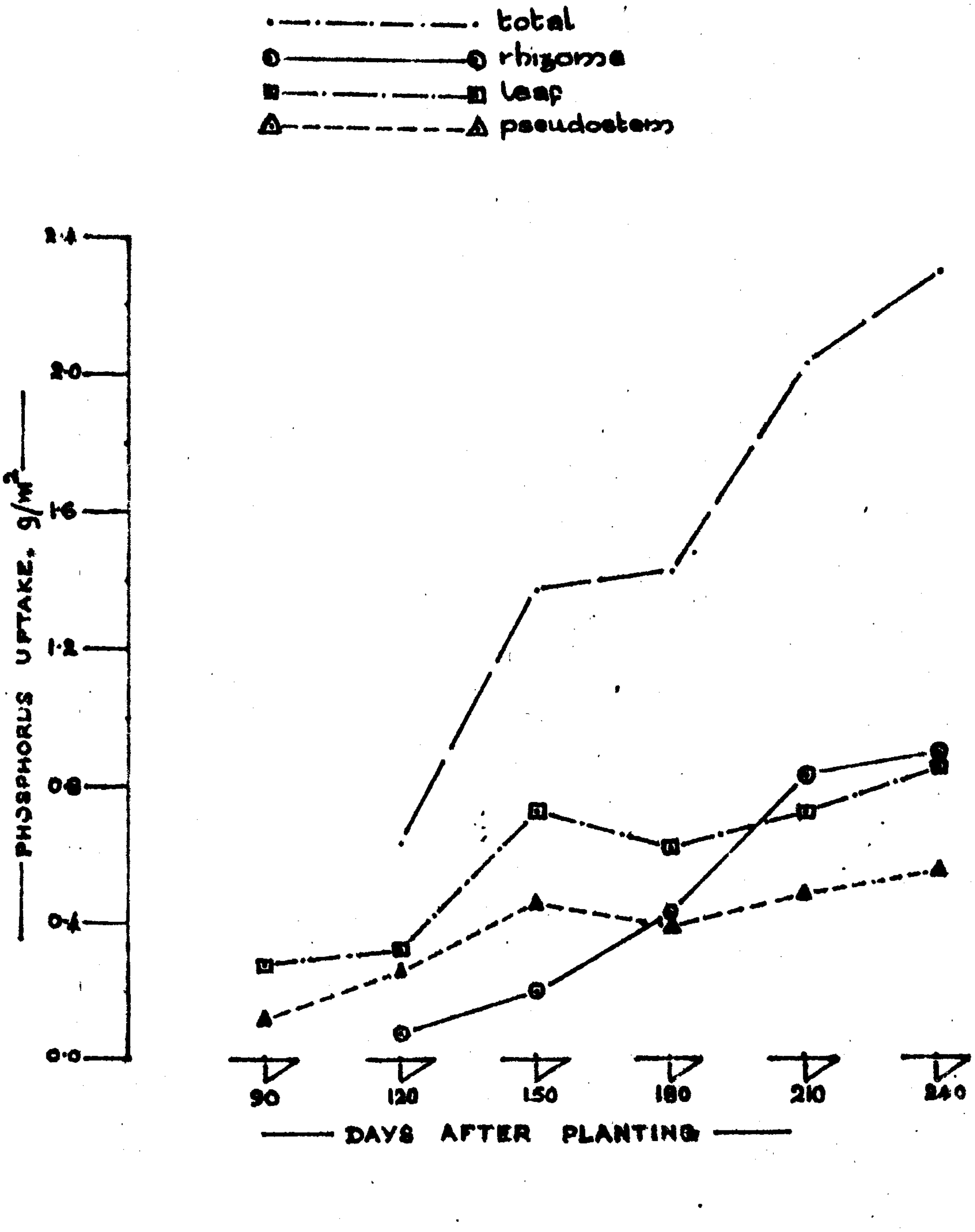

FIG.4. RELATIONSHIP BETWEEN PERIOD OF GROWTH AND UPTAKE OF PHOSPHORUS

the varying levels of potassium applied affected the total phosphorus uptake significantly. Maximum uptake was recorded at k_1 level which was significantly higher than that at k_2 level. The uptakes at k_1 and k_0 levels and k_0 and k_2 levels were on par. The age of the plant also had a significant effect on the uptake of phosphorus. The values progressively increased with advancing period of growth.

6. Effect of NPK treatments and period of growth on potassium content of turmeric

The data on percentage and uptake of potassium as influenced by levels of nitrogen, phosphorus and potassium and period of growth are furnished in Tables 24 to 30 and their summary in Table 31. The analysis of variance is given in Appendix IX.

6.1. Potassium content of leaf

The results on the percentage of potassium in leaf given in Table 24 and Appendix IX revealed that incremental doses of potassium significantly influenced the potassium content in leaf while application of varying levels of nitrogen and phosphorus did not influence this parameter significantly. The treatment k_2 recorded the highest potassium percentage and was significantly superior to k_0. The k_2 and k_1 levels were statistically on par. The age of the plant considerably influenced the content of

Table 24. Effect of NPK treatments and period of growth on potassium content of turmeric.

Potassium content of leaf, % on moisture free basis.

Sl. No.	Treatment	Period 1	2	3	4	5	6
1.	$n_0p_0k_0$	3.05	3.75	2.90	3.70	5.70	5.80
2.	$n_0p_0k_1$	3.15	3.60	2.90	4.10	6.70	6.10
3.	$n_0p_0k_2$	3.30	4.00	3.40	3.90	6.40	6.70
4.	$n_0p_1k_0$	3.10	3.65	3.30	3.50	5.60	6.00
5.	$n_0p_1k_1$	3.55	3.80	3.70	3.70	5.70	6.30
6.	$n_0p_1k_2$	3.70	3.60	3.50	3.50	6.30	5.80
7.	$n_0p_2k_0$	3.25	3.65	3.70	3.50	5.80	6.30
8.	$n_0p_2k_1$	3.35	4.05	3.30	2.60	6.30	6.70
9.	$n_0p_2k_2$	3.50	3.90	3.70	3.60	5.90	7.70
10.	$n_1p_0k_0$	3.45	3.60	3.20	2.50	6.10	6.60
11.	$n_1p_0k_1$	3.70	4.05	3.50	3.20	5.80	6.20
12.	$n_1p_0k_2$	3.80	3.65	4.40	3.10	6.10	6.50
13.	$n_1p_1k_0$	3.45	3.70	3.80	2.80	6.00	5.80
14.	$n_1p_1k_1$	3.65	3.70	3.70	3.40	6.10	6.10
15.	$n_1p_1k_2$	3.70	3.85	3.90	3.40	6.50	6.00
16.	$n_1p_2k_0$	3.50	3.95	3.20	2.80	6.20	6.20
17.	$n_1p_2k_1$	3.30	3.75	3.80	2.90	6.60	6.40
18.	$n_1p_2k_2$	3.45	3.80	3.80	2.95	7.70	5.90
19.	$n_2p_0k_0$	3.40	3.80	3.10	2.90	5.60	6.50
20.	$n_2p_0k_1$	3.60	3.50	3.70	3.20	8.10	6.50
21.	$n_2p_0k_2$	3.70	3.55	3.10	1.70	5.60	6.80
22.	$n_2p_1k_0$	3.40	3.65	3.00	2.80	5.60	6.40
23.	$n_2p_1k_1$	3.60	4.15	3.50	2.60	6.50	5.90
24.	$n_2p_1k_2$	3.80	3.75	3.10	2.70	6.50	6.10
25.	$n_2p_2k_0$	3.65	3.45	3.40	2.40	5.90	6.20
26.	$n_2p_2k_1$	3.80	3.60	3.30	2.70	5.90	6.00
27.	$n_2p_2k_2$	3.90	3.65	3.30	2.40	6.40	6.50

potassium in leaf. But the values at different periods of growth failed to give a definite trend. The highest potassium content was recorded at sixth period, closely followed by the content at fifth period. Period x N combination was also found to influence the potassium percentage in leaf. The potassium percentage in leaf ranged from 1.7 to 6.8, the average being 4.38.

6.2. Potassium content of pseudostem

Observations on the potassium content of pseudostem are given in Table 25 and the analysis of variance in Appendix IX. The results indicated that the varying levels of potassium applied significantly influenced the percentage of this element in pseudostem. The potassium content was highest at k_1 level closely followed by that at k_2 level. The k_1 and k_2 levels were statistically on par and they were significantly superior to k_0. Potassium content in leaf was also influenced by the period of growth. However, no regular pattern of variation was observed with increasing age of the crop. In general the potassium percentage was found higher at the later stage of crop growth. The percentage of potassium in the pseudostem of turmeric ranged from 2.65 to 7.7, the average value being 4.55.

6.3. Potassium content of rhizome

The results given in Table 26 indicated that incremental doses of nitrogen, phosphorus or potassium could not

Table 25. Effect of NPK treatments and period of growth on potassium content of turmeric.

Potassium content of pseudostem, % on moisture free basis.

Sl. No.	Treatment	Period 1	2	3	4	5	6
1.	$n_0p_0k_0$	3.08	4.20	4.55	4.70	3.90	4.30
2.	$n_0p_0k_1$	2.80	4.55	3.40	5.00	5.40	4.40
3.	$n_0p_0k_2$	3.03	5.25	5.10	5.50	6.30	4.30
4.	$n_0p_1k_0$	3.20	4.55	4.70	3.60	5.10	3.20
5.	$n_0p_1k_1$	2.50	5.20	4.70	4.20	4.20	5.70
6.	$n_0p_1k_2$	3.20	4.60	4.90	5.10	6.70	7.50
7.	$n_0p_2k_0$	2.85	4.50	4.00	6.05	3.20	6.80
8.	$n_0p_2k_1$	3.00	5.65	3.70	5.70	5.70	7.70
9.	$n_0p_2k_2$	3.20	5.05	4.10	3.30	7.50	5.00
10.	$n_1p_0k_0$	2.60	4.25	3.70	3.70	5.30	3.00
11.	$n_1p_0k_1$	3.20	5.00	4.30	5.70	4.60	7.30
12.	$n_1p_0k_2$	2.80	4.10	5.90	5.00	4.80	5.40
13.	$n_1p_1k_0$	2.80	4.40	4.40	3.40	4.50	3.20
14.	$n_1p_1k_1$	2.65	4.20	4.90	5.30	4.30	5.50
15.	$n_1p_1k_2$	2.90	4.75	5.30	5.60	5.80	5.10
16.	$n_1p_2k_0$	3.25	5.05	5.60	6.50	7.70	4.60
17.	$n_1p_2k_1$	3.00	4.50	3.70	5.90	6.80	4.80
18.	$n_1p_2k_2$	3.20	5.05	3.30	3.90	7.30	5.10
19.	$n_2p_0k_0$	2.65	4.55	3.50	5.70	5.40	4.10
20.	$n_2p_0k_1$	3.00	5.15	4.50	3.90	7.30	4.40
21.	$n_2p_0k_2$	3.10	4.15	4.30	2.80	3.70	4.30
22.	$n_2p_1k_0$	2.90	4.20	2.80	6.30	3.20	4.30
23.	$n_2p_1k_1$	2.85	5.45	4.40	6.70	5.50	5.00
24.	$n_2p_1k_2$	3.25	4.45	4.40	5.40	5.10	7.70
25.	$n_2p_2k_0$	2.80	3.90	3.70	5.50	4.10	3.20
26.	$n_2p_2k_1$	2.75	3.60	3.40	5.60	4.40	5.70
27.	$n_2p_2k_2$	2.98	4.35	4.30	5.30	4.30	4.80

Table 26. Effect of NPK treatments and period of growth on potassium content of turmeric.

Potassium content of rhizome, % on moisture free basis.

Sl. No.	Treatment	Period 2	3	4	5	6
1.	$n_0p_0k_0$	4.10	4.20	5.60	6.30	6.00
2.	$n_0p_0k_1$	4.30	3.60	5.80	6.70	6.10
3.	$n_0p_0k_2$	5.65	4.10	6.10	6.40	6.50
4.	$n_0p_1k_0$	2.35	4.10	6.40	7.00	6.30
5.	$n_0p_1k_1$	2.40	4.60	5.90	7.00	6.70
6.	$n_0p_1k_2$	3.95	4.80	6.30	7.60	6.40
7.	$n_0p_2k_0$	4.15	4.50	6.20	6.50	7.00
8.	$n_0p_2k_1$	4.85	4.80	6.50	6.20	7.00
9.	$n_0p_2k_2$	4.65	4.90	5.90	7.30	7.60
10.	$n_1p_0k_0$	3.65	4.50	5.80	6.80	6.80
11.	$n_1p_0k_1$	4.40	3.60	6.10	6.90	6.90
12.	$n_1p_0k_2$	3.90	4.40	6.30	5.50	5.50
13.	$n_1p_1k_0$	4.00	4.50	5.60	6.90	7.80
14.	$n_1p_1k_1$	4.10	4.70	6.10	6.90	6.80
15.	$n_1p_1k_2$	4.50	4.20	6.50	7.30	5.90
16.	$n_1p_2k_0$	3.95	4.60	6.00	7.00	6.00
17.	$n_1p_2k_1$	4.20	4.20	6.10	6.80	7.70
18.	$n_1p_2k_2$	4.25	3.90	5.90	7.90	7.30
19.	$n_2p_0k_0$	4.35	2.80	6.30	6.00	7.30
20.	$n_2p_0k_1$	4.30	5.00	6.50	7.70	7.80
21.	$n_2p_0k_2$	4.10	4.10	6.20	7.30	6.80
22.	$n_2p_1k_0$	4.50	3.10	5.80	6.10	7.60
23.	$n_2p_1k_1$	4.50	4.10	6.40	6.70	6.50
24.	$n_2p_1k_2$	4.95	3.80	6.10	6.80	6.20
25.	$n_2p_2k_0$	3.90	4.00	6.20	6.00	6.30
26.	$n_2p_2k_1$	4.20	4.10	6.40	6.10	6.70
27.	$n_2p_2k_2$	4.35	3.20	6.50	6.50	6.40

influence the content of potassium in rhizome. But the percentage of this element varied significantly with advancing age of the crop, eventhough the values failed to give a regular pattern. As in the cases of leaf and pseudostem, higher content of potassium was observed during the later part of crop growth.

6.4. Uptake of potassium in leaf

The results of investigation on the uptake of potassium in leaf are presented in Table 27 and the analysis of variance in Appendix IX. It was observed that the uptake of potassium in leaf was determined by the levels of potassium applied and NK interaction. The potassium uptake at k_1 level was significantly superior to those of k_2 and k_0 levels. There was no significant difference between the uptake values at k_0 and k_2 levels. This parameter was also influenced by age of the crop. There was continuous increase in the uptake of potassium in leaf with increasing period of growth except a slight decrease at the fourth period.

6.5. Uptake of potassium in pseudostem

The observations recorded in Table 28 revealed that the uptake of potassium in pseudostem was significantly influenced by the levels of potassium applied. The uptake at k_1 level was significantly higher than the uptake at k_2 and k_0 levels. There was no significant difference

Table 27. Effect of NPK treatments and period of growth on potassium content of turmeric.
Uptake of potassium in leaf, g/m^2.

Sl. No.	Treatment	Period 1	2	3	4	5	6
1.	$n_0p_0k_0$	3.45	6.75	10.74	12.72	34.77	28.10
2.	$n_0p_0k_1$	5.27	4.68	13.40	12.87	22.97	23.17
3.	$n_0p_0k_2$	3.57	3.84	13.06	6.21	22.58	23.32
4.	$n_0p_1k_0$	3.21	3.50	13.95	8.22	20.87	36.50
5.	$n_0p_1k_1$	3.49	4.94	23.16	18.78	53.16	42.56
6.	$n_0p_1k_2$	4.79	6.26	9.01	13.06	22.96	21.90
7.	$n_0p_2k_0$	4.25	3.80	17.58	12.52	22.31	60.25
8.	$n_0p_2k_1$	3.59	6.48	6.03	11.87	23.51	26.10
9.	$n_0p_2k_2$	2.89	4.10	11.10	11.30	20.54	45.63
10.	$n_1p_0k_0$	3.40	5.72	14.54	8.65	15.36	20.22
11.	$n_1p_0k_1$	5.98	8.14	18.65	19.00	20.16	44.60
12.	$n_1p_0k_2$	3.81	5.40	9.19	10.49	27.59	34.31
13.	$n_1p_1k_0$	4.37	5.51	8.07	9.24	18.27	19.46
14.	$n_1p_1k_1$	8.28	6.73	11.03	12.94	34.67	40.69
15.	$n_1p_1k_2$	6.42	9.09	16.01	15.32	21.97	21.76
16.	$n_1p_2k_0$	2.40	3.75	5.77	5.39	16.13	30.69
17.	$n_1p_2k_1$	4.14	4.16	14.11	5.26	26.36	33.06
18.	$n_1p_2k_2$	3.70	5.93	13.22	16.26	26.40	42.06
19.	$n_2p_0k_0$	2.50	4.67	8.12	11.12	20.78	22.29
20.	$n_2p_0k_1$	4.16	5.85	14.24	12.85	58.57	38.52
21.	$n_2p_0k_2$	4.06	5.86	13.72	4.19	28.27	32.51
22.	$n_2p_1k_0$	4.96	4.85	12.80	8.87	36.19	42.79
23.	$n_2p_1k_1$	2.78	3.32	12.64	3.19	31.06	26.69
24.	$n_2p_1k_2$	4.72	4.24	18.55	14.51	20.00	23.31
25.	$n_2p_2k_0$	7.12	6.90	12.73	15.00	34.96	41.10
26.	$n_2p_2k_1$	3.70	10.48	26.92	8.22	25.82	30.71
27.	$n_2p_2k_2$	3.19	3.72	8.08	6.19	29.47	32.00

Table 28. Effect of NPK treatments and period of growth on potassium content of turmeric.

Uptake of potassium in pseudostem, g/m^2.

Sl. No.	Treatment	Period 1	2	3	4	5	6
1.	$n_0p_0k_0$	2.03	4.87	9.50	8.59	17.51	12.80
2.	$n_0p_0k_1$	2.95	2.73	7.67	10.00	14.15	11.79
3.	$n_0p_0k_2$	1.29	2.63	8.00	4.93	12.92	11.26
4.	$n_0p_1k_0$	2.14	2.18	7.98	4.96	12.02	14.54
5.	$n_0p_1k_1$	1.43	3.07	14.28	12.86	22.23	18.02
6.	$n_0p_1k_2$	2.34	3.40	4.89	10.41	27.27	15.63
7.	$n_0p_2k_0$	1.74	2.12	11.72	12.27	6.36	37.90
8.	$n_0p_2k_1$	1.79	4.29	3.75	15.07	15.27	21.57
9.	$n_0p_2k_2$	1.31	2.68	6.50	2.29	19.64	19.38
10.	$n_1p_0k_0$	2.28	3.15	7.38	7.18	8.28	7.21
11.	$n_1p_0k_1$	1.73	4.75	12.97	21.41	27.01	24.48
12.	$n_1p_0k_2$	1.25	2.99	3.62	11.02	9.50	12.05
13.	$n_1p_1k_0$	2.35	3.12	2.67	5.16	7.33	4.86
14.	$n_1p_1k_1$	3.73	3.70	6.91	11.75	23.81	16.81
15.	$n_1p_1k_2$	2.67	5.32	10.79	13.73	10.93	10.29
16.	$n_1p_2k_0$	1.19	2.12	3.57	6.37	4.86	10.56
17.	$n_1p_2k_1$	2.43	2.30	7.28	10.93	13.38	12.18
18.	$n_1p_2k_2$	2.19	5.19	5.99	14.71	10.43	3.21
19.	$n_2p_0k_0$	1.19	2.55	4.62	16.17	11.20	7.73
20.	$n_2p_0k_1$	3.16	3.55	6.59	10.13	23.08	18.00
21.	$n_2p_0k_2$	2.20	3.36	9.76	4.25	9.39	8.04
22.	$n_2p_1k_0$	1.48	2.69	8.09	13.73	7.95	11.94
23.	$n_2p_1k_1$	0.50	1.69	5.94	5.86	9.42	11.81
24.	$n_2p_1k_2$	2.11	2.36	13.07	10.26	7.25	18.37
25.	$n_2p_2k_0$	3.35	3.32	10.54	13.71	14.19	10.49
26.	$n_2p_2k_1$	1.51	3.85	8.95	8.44	7.04	13.69
27.	$n_2p_2k_2$	1.27	1.57	4.81	11.86	8.38	11.82

between the uptake values at k_0 and k_2 levels though the uptake at k_2 level was higher than that at k_0 level. As in the case of other parameters, the age of the crop significantly affected the uptake of potassium in pseudostem. The uptake steadily increased with increasing period of growth till harvest. The values for uptake at fifth and sixth periods were on par. Potassium uptake in pseudostem was also influenced by the period x N combination.

6.6. Uptake of potassium in rhizome

The data on the uptake of potassium in rhizome are presented in Table 29 and Appendix IX. It was observed that levels of potassium applied to the crop significantly influenced the uptake of this element in rhizome. The k_1 level recorded the maximum uptake (11.78 g/m^2) which was on par with k_0 level (9.71 g/m^2). The uptake was least at k_2 level (8.64 g/m^2) eventhough the difference in uptake between k_2 and k_0 levels was not statistically significant. It was found that the uptake of potassium significantly increased with increasing age of the crop. After the fifth period, the increase in uptake was not significant. Potassium uptake in rhizome was also found affected by the period x P combination.

6.7. Total uptake of potassium

The observations on the total uptake of potassium are presented in Table 30 and the results of statistical

Table 29. **Effect of NPK treatments and period of growth on potassium content of turmeric.**

Uptake of potassium in rhizome, g/m^2.

Sl. No.	Treatment	Period 2	3	4	5	6
1.	$n_0p_0k_0$	1.44	3.48	6.13	31.41	22.66
2.	$n_0p_0k_1$	0.39	3.26	7.21	14.19	13.07
3.	$n_0p_0k_2$	0.34	3.74	3.07	5.07	10.35
4.	$n_0p_1k_0$	0.24	6.26	8.13	27.07	26.58
5.	$n_0p_1k_1$	0.17	4.54	10.93	48.74	25.44
6.	$n_0p_1k_2$	1.34	1.47	11.75	23.30	16.31
7.	$n_0p_2k_0$	0.46	4.71	6.43	8.58	40.57
8.	$n_0p_2k_1$	0.44	4.70	6.74	9.51	16.74
9.	$n_0p_2k_2$	0.98	2.07	9.11	8.94	21.96
10.	$n_1p_0k_0$	0.40	3.76	10.13	12.92	10.13
11.	$n_1p_0k_1$	1.32	4.30	14.46	30.82	25.61
12.	$n_1p_0k_2$	0.98	2.50	24.69	15.31	16.00
13.	$n_1p_1k_0$	0.64	9.60	6.49	8.28	6.09
14.	$n_1p_1k_1$	0.78	11.73	9.22	40.64	22.77
15.	$n_1p_1k_2$	1.31	3.72	7.62	14.05	10.29
16.	$n_1p_2k_0$	0.24	2.96	2.42	7.40	17.35
17.	$n_1p_2k_1$	1.05	2.68	3.30	11.66	22.88
18.	$n_1p_2k_2$	0.81	2.46	13.24	12.49	26.58
19.	$n_2p_0k_0$	0.85	1.76	4.58	10.20	9.35
20.	$n_2p_0k_1$	0.52	1.80	3.57	29.05	32.36
21.	$n_2p_0k_2$	1.39	4.10	5.47	5.64	15.24
22.	$n_2p_1k_0$	0.90	3.11	5.09	21.69	25.76
23.	$n_2p_1k_1$	0.18	1.52	17.01	14.89	10.68
24.	$n_2p_1k_2$	0.45	4.77	11.89	6.62	17.58
25.	$n_2p_2k_0$	1.13	7.59	12.24	17.75	16.72
26.	$n_2p_2k_1$	1.55	3.48	14.70	7.79	14.64
27.	$n_2p_2k_2$	0.39	1.13	4.91	19.06	16.38

Table 30. Effect of NPK treatments and period of growth on potassium content of turmeric.
Total uptake of potassium, g/m^2.

Sl. No.	Treatment	Period 2	3	4	5	6
1.	$n_0p_0k_0$	13.06	23.72	27.44	83.69	63.56
2.	$n_0p_0k_1$	7.80	24.33	30.08	51.31	53.03
3.	$n_0p_0k_2$	6.81	24.80	14.21	40.57	44.93
4.	$n_0p_1k_0$	5.92	28.19	21.31	59.96	77.62
5.	$n_0p_1k_1$	8.18	41.98	42.51	124.13	86.02
6.	$n_0p_1k_2$	11.00	15.37	35.22	73.53	60.84
7.	$n_0p_2k_0$	6.38	34.01	31.22	37.25	138.72
8.	$n_0p_2k_1$	11.21	14.48	33.68	48.35	66.41
9.	$n_0p_2k_2$	7.76	19.67	22.70	49.12	86.97
10.	$n_1p_0k_0$	9.27	25.68	25.96	36.56	37.56
11.	$n_1p_0k_1$	14.21	35.92	54.87	78.02	94.69
12.	$n_1p_0k_2$	9.37	15.31	46.20	52.40	62.36
13.	$n_1p_1k_0$	9.27	20.34	22.89	33.88	33.21
14.	$n_1p_1k_1$	11.21	29.67	33.91	119.12	80.47
15.	$n_1p_1k_2$	15.72	30.52	36.67	46.95	42.34
16.	$n_1p_2k_0$	6.11	12.30	14.18	28.39	59.38
17.	$n_1p_2k_1$	7.51	24.07	19.49	53.60	68.72
18.	$n_1p_2k_2$	11.93	21.67	44.21	49.32	72.45
19.	$n_2p_0k_0$	8.05	14.50	31.87	42.26	39.35
20.	$n_2p_0k_1$	9.92	22.63	26.45	110.70	88.86
21.	$n_2p_0k_2$	10.61	27.58	13.91	43.30	55.79
22.	$n_2p_1k_0$	8.74	24.00	27.69	65.83	76.49
23.	$n_2p_1k_1$	5.19	20.10	26.06	55.39	49.18
24.	$n_2p_1k_2$	7.05	36.39	36.66	34.67	59.26
25.	$n_2p_2k_0$	11.35	30.86	41.75	66.88	70.31
26.	$n_2p_2k_1$	15.85	39.35	31.36	40.65	59.24
27.	$n_2p_2k_2$	5.68	14.02	22.96	56.93	56.30

Table 31. Effect of NPK treatments and period of growth on the potassium content of turmeric.

Summary

Treatment groups	K % on moisture free basis			Uptake of potassium, g/m²			
	Leaf	Pseudo-stem	Rhizome	Leaf	Pseudo-stem	Rhizome	Total
n_0	4.41	4.66	4.65	19.85	9.46	10.87	40.20
n_1	4.43	4.64	4.70	19.32	8.02	10.21	36.84
n_2	4.29	4.37	4.63	16.23	7.74	9.06	36.53
p_0	4.39	4.47	4.61	15.17	8.50	9.56	36.74
p_1	4.35	4.57	4.65	16.23	8.52	11.39	39.84
p_2	4.40	4.62	4.73	16.00	8.21	9.20	36.99
k_0	4.23	4.28	4.55	14.80	7.52	9.71	35.31
k_1	4.44	4.70	4.72	17.90	9.88	11.79	43.78
k_2	4.47	4.69	4.72	14.70	7.83	8.64	34.49
Periods							
1	3.51	3.13	-	4.23	1.99	-	-
2	3.64	4.62	4.17	5.51	3.17	0.77	9.45
3	3.45	4.28	4.16	13.20	7.70	3.97	24.87
4	3.06	4.97	6.25	10.93	10.29	8.98	30.20
5	6.17	5.26	6.78	28.10	13.36	17.16	58.62
6	6.30	5.14	6.74	32.84	13.94	19.36	66.15
C.D. (0.05) for comparing levels of N, P and K	0.133	0.358	N.S.	2.397	1.453	2.478	6.018
C.D. (0.05) for comparing periods	0.186	0.507	0.267	3.390	2.055	3.199	7.769

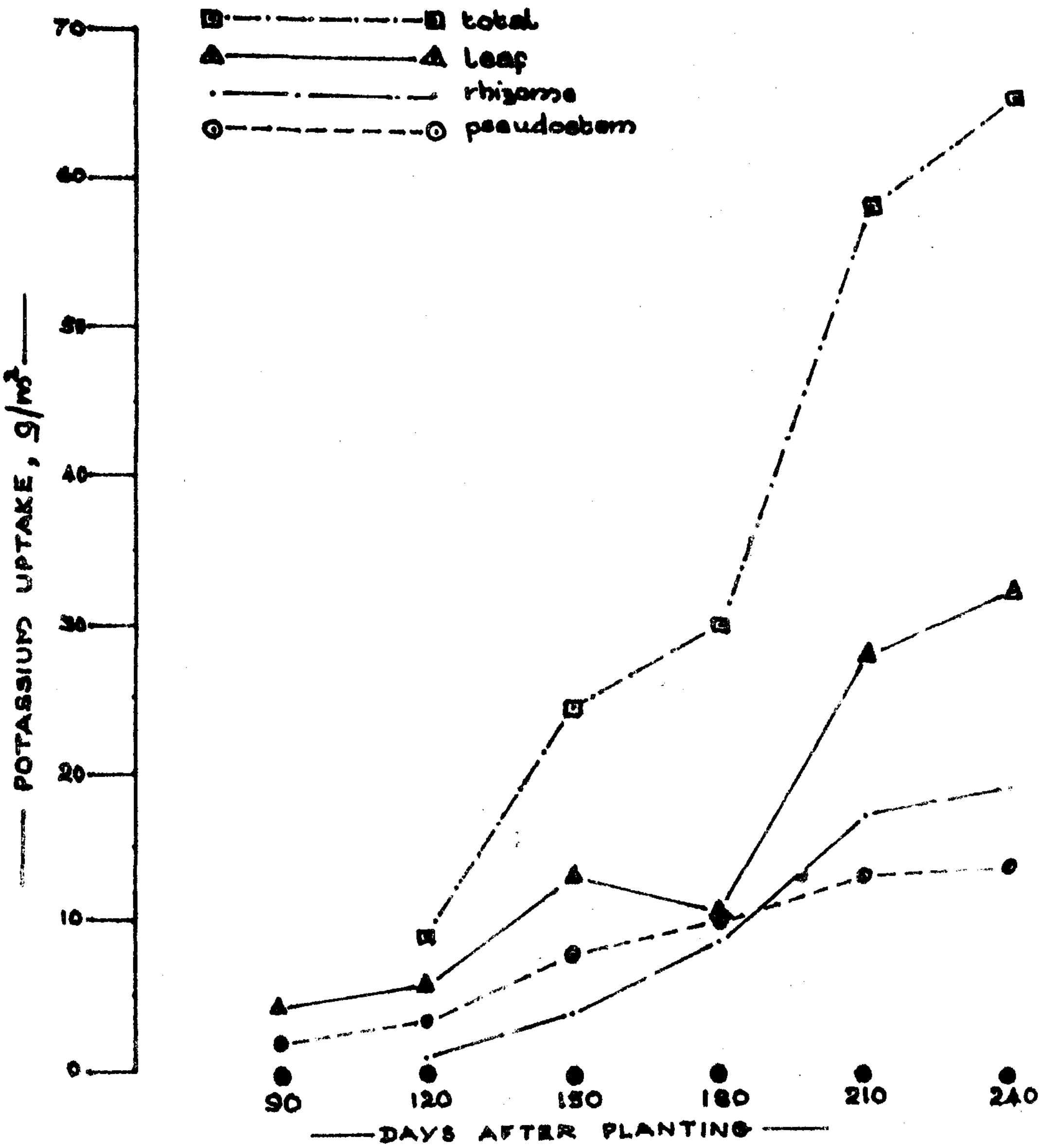

FIG. 5. RELATIONSHIP BETWEEN PERIOD OF GROWTH AND UPTAKE OF POTASSIUM

analysis in Appendix IX. As in the case of uptake in leaf, pseudostem and rhizome, the total uptake of potassium was also significantly influenced by the different levels of potassium applied. The total uptake at k_1 level was the highest (43.78 g/m^2) and was significantly superior to k_0 and k_2 levels. The uptake at k_0 level (35.31 g/m^2) was slightly higher than that at k_2 level (34.49 g/m^2) eventhough the difference was not significant. The total uptake of potassium was significantly influenced by the NP interaction also, while the other nutrient interactions and levels of nitrogen and phosphorus could not influence this parameter. In the case of total uptake also, it was seen that the age of the plant significantly affected the uptake. The total uptake continuously increased with increasing period of growth. The increase in total uptake was not significant between the fifth and sixth periods, and also between third and fourth periods.

7. Effect of NPK treatments on the nutrient content of leaf in relation to leaf positions

The values for nitrogen, phosphorus and potassium percentage of leaf in relation to leaf positions are presented in Tables 32 to 34 and the corresponding analysis of variance in Appendix X.

7.1. Nitrogen content of leaf in relation to leaf positions

There was significant difference in the nitrogen content of leaves from different positions as evidenced by the analysis of variance given in Appendix X. Numbering the last fully opened leaf as the first leaf, the percentage of nitrogen continuously decreased with increasing number of leaf positions. First leaf position recorded the highest leaf nitrogen and the sixth leaf contained the least amount. The differences in nitrogen content between adjacent leaf positions were not statistically significant. However, there was significant difference in nitrogen content between first and third, second and fourth, third and fifth, and fourth and sixth leaf positions. The varying levels of nutrient application could not influence the nitrogen percentage of leaves in different leaf positions.

7.2. Phosphorus content of leaf in relation to leaf positions

Observations indicated that the leaves from different positions differed significantly in respect of the percentage of phosphorus in them. The pattern of variation was similar to that of nitrogen. The highest percentage of phosphorus was noticed in the first leaf which steadily decreased with increasing number of the leaf position. The decrease in phosphorus content between each leaf position was statistically significant. The levels of nitrogen and

Table 32. Effect of NPK treatments on nitrogen content of leaf in relation to leaf positions, % on moisture free basis.

Sl. No.	Treatment	Leaf positions 1	2	3	4	5	6
1.	$n_0p_0k_0$	3.08	1.26	2.94	0.98	1.68	0.42
2.	$n_0p_0k_1$	0.42	2.24	0.42	1.54	0.42	0.28
3.	$n_0p_0k_2$	0.42	1.26	2.10	3.08	1.96	1.26
4.	$n_0p_1k_0$	2.52	2.24	1.54	1.68	0.70	1.12
5.	$n_0p_1k_1$	2.38	2.66	0.42	1.40	1.12	1.12
6.	$n_0p_1k_2$	1.80	1.80	1.68	1.26	0.98	0.84
7.	$n_0p_2k_0$	2.10	0.98	2.10	0.98	0.98	0.84
8.	$n_0p_2k_1$	2.10	1.96	1.96	2.80	0.98	1.26
9.	$n_0p_2k_2$	1.82	1.82	1.26	0.84	1.26	0.98
10.	$n_1p_0k_0$	1.82	1.54	1.54	0.98	1.12	1.12
11.	$n_1p_0k_1$	1.96	2.24	1.68	0.28	0.98	0.98
12.	$n_1p_0k_2$	2.24	1.26	1.40	1.54	1.54	1.12
13.	$n_1p_1k_0$	2.38	1.68	1.68	1.40	1.40	1.40
14.	$n_1p_1k_1$	2.52	1.96	0.42	0.28	1.54	1.40
15.	$n_1p_1k_2$	2.24	1.96	1.68	1.82	1.26	0.28
16.	$n_1p_2k_0$	2.52	2.10	1.96	1.82	1.40	0.28
17.	$n_1p_2k_1$	2.24	1.96	1.82	1.68	1.54	0.98
18.	$n_1p_2k_2$	2.10	2.38	1.68	1.68	1.40	1.12
19.	$n_2p_0k_0$	2.24	2.10	1.96	1.68	1.40	0.98
20.	$n_2p_0k_1$	1.68	1.54	2.38	1.68	1.68	1.26
21.	$n_2p_0k_2$	0.70	1.40	1.96	1.40	0.28	1.68
22.	$n_2p_1k_0$	2.10	1.96	0.98	1.26	1.54	0.28
23.	$n_2p_1k_1$	2.24	1.54	1.68	0.98	1.40	1.40
24.	$n_2p_1k_2$	1.40	1.82	1.68	1.68	1.54	1.12
25.	$n_2p_2k_0$	2.24	0.84	1.82	1.26	1.40	1.12
26.	$n_2p_2k_1$	2.24	2.10	1.82	1.40	1.40	1.40
27.	$n_2p_2k_2$	0.56	1.54	0.42	0.56	0.70	0.98

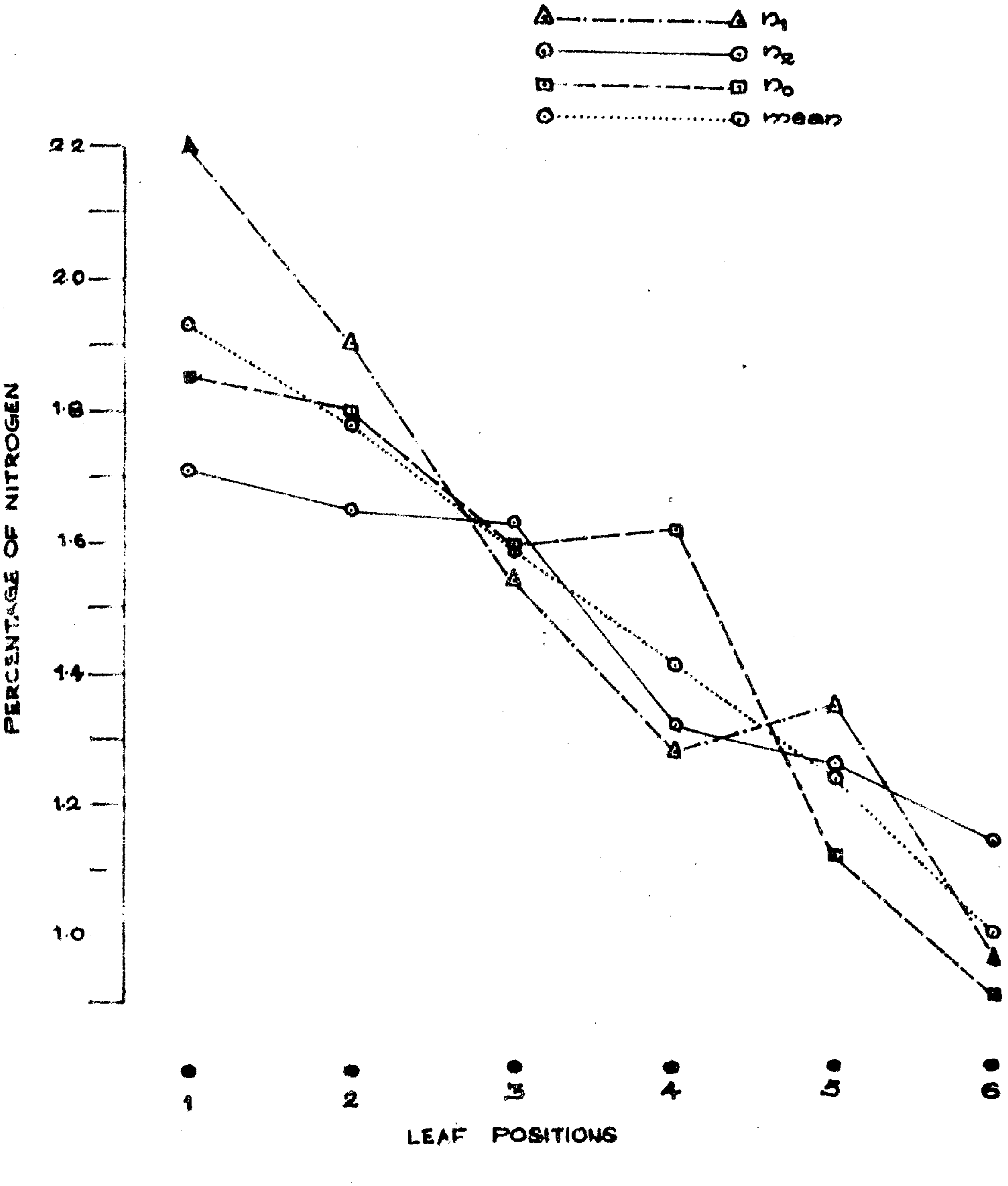

FIG. 6. RELATIONSHIP BETWEEN LEAF POSITIONS AND PERCENTAGE OF NITROGEN

Table 33. Effect of NPK treatments on phosphorus content of leaf in relation to leaf positions, on moisture free basis.

Sl. No.	Treatment	Leaf positions 1	2	3	4	5	6
1.	$n_0p_0k_0$	0.36	0.30	0.27	0.22	0.20	0.17
2.	$n_0p_0k_1$	0.37	0.31	0.23	0.23	0.21	0.20
3.	$n_0p_0k_2$	0.31	0.32	0.23	0.22	0.19	0.19
4.	$n_0p_1k_0$	0.41	0.31	0.27	0.20	0.22	0.18
5.	$n_0p_1k_1$	0.32	0.25	0.21	0.19	0.19	0.16
6.	$n_0p_1k_2$	0.37	0.24	0.21	0.18	0.17	0.19
7.	$n_0p_2k_0$	0.31	0.28	0.22	0.22	0.17	0.16
8.	$n_0p_2k_1$	0.36	0.28	0.23	0.21	0.19	0.18
9.	$n_0p_2k_2$	0.37	0.25	0.22	0.14	0.18	0.15
10.	$n_1p_0k_0$	0.32	0.23	0.19	0.19	0.18	0.17
11.	$n_1p_0k_1$	0.35	0.26	0.24	0.21	0.17	0.16
12.	$n_1p_0k_2$	0.32	0.23	0.21	0.18	0.15	0.14
13.	$n_1p_1k_0$	0.34	0.27	0.21	0.19	0.16	0.14
14.	$n_1p_1k_1$	0.33	0.24	0.21	0.19	0.17	0.16
15.	$n_1p_1k_2$	0.32	0.21	0.18	0.16	0.15	0.14
16.	$n_1p_2k_0$	0.32	0.19	0.17	0.16	0.14	0.12
17.	$n_1p_2k_1$	0.30	0.20	0.19	0.15	0.15	0.13
18.	$n_1p_2k_2$	0.29	0.23	0.19	0.17	0.15	0.13
19.	$n_2p_0k_0$	0.37	0.23	0.19	0.16	0.15	0.12
20.	$n_2p_0k_1$	0.33	0.27	0.20	0.16	0.14	0.14
21.	$n_2p_0k_2$	0.33	0.24	0.20	0.18	0.14	0.14
22.	$n_2p_1k_0$	0.30	0.21	0.17	0.17	0.14	0.13
23.	$n_2p_1k_1$	0.31	0.22	0.17	0.15	0.14	0.13
24.	$n_2p_1k_2$	0.35	0.24	0.21	0.18	0.18	0.15
25.	$n_2p_2k_0$	0.34	0.22	0.22	0.18	0.15	0.13
26.	$n_2p_2k_1$	0.38	0.27	0.22	0.17	0.14	0.13
27.	$n_2p_2k_2$	0.36	0.22	0.20	0.17	0.14	0.14

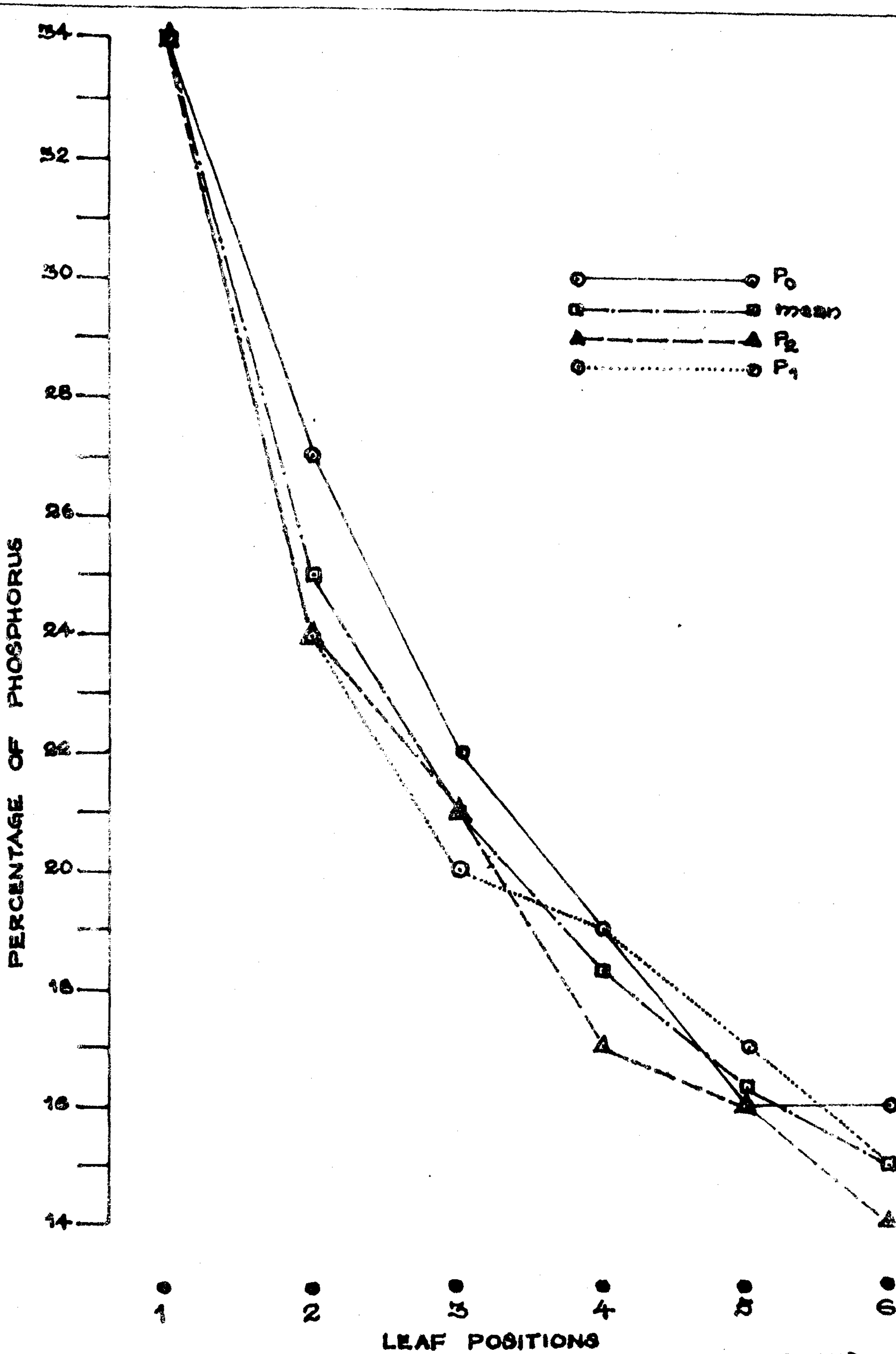

FIG.7. RELATIONSHIP BETWEEN LEAF POSITIONS AND PERCENTAGE OF PHOSPHORUS

phosphorus application and all their two-factor interactions significantly influenced the phosphorus content of leaf at different positions (Appendix X). The treatment n_0 recorded the highest phosphorus content followed by n_1 and n_2 in the decreasing order. The difference between n_1 and n_2 levels was not statistically significant. The increased application of phosphorus also resulted in a significant decrease in the percentage of phosphorus in leaf. The content of p_0 level was the highest followed by those at p_1 and p_2 levels, the differences between p_0 and p_1 and p_1 and p_2 being statistically significant.

7.3. Potassium content of leaf in relation to leaf positions

The results of statistical analysis revealed that the leaf positions differed significantly in respect of the percentage of potassium in leaf. The highest percentage of potassium was recorded in the first leaf which was significantly superior to that of other leaf positions. However, the variation in potassium content between leaf positions did not give any definite trend. The leaves from positions second to sixth did not vary significantly in the percentage of potassium in them. The percentage of potassium in leaf with respect to leaf positions was significantly influenced by the levels of nitrogen and potassium applied to the crop and also by the NK and NP interactions. The potassium content was highest at n_1 level of nitrogen which was

Table 34. **Effect of NPK treatments on potassium content of leaf in relation to leaf positions, % on moisture free basis.**

Sl. No.	Treatment	Leaf positions 1	2	3	4	5	6
1.	$n_0p_0k_0$	4.10	3.50	3.50	3.70	3.70	3.90
2.	$n_0p_0k_1$	4.20	3.50	3.25	3.40	3.50	3.70
3.	$n_0p_0k_2$	4.30	4.10	3.85	3.85	4.05	3.80
4.	$n_0p_1k_0$	4.25	3.40	3.55	3.60	3.50	3.60
5.	$n_0p_1k_1$	4.30	3.80	3.80	3.80	3.60	3.50
6.	$n_0p_1k_2$	3.90	3.65	3.55	3.30	3.60	3.70
7.	$n_0p_2k_0$	4.00	3.70	3.60	3.50	3.65	3.40
8.	$n_0p_2k_1$	4.40	4.00	3.80	4.00	4.10	3.90
9.	$n_0p_2k_2$	4.50	3.80	4.00	3.80	3.75	3.60
10.	$n_1p_0k_0$	4.15	3.45	3.60	3.60	3.60	3.25
11.	$n_1p_0k_1$	4.75	3.85	3.80	3.85	4.00	3.90
12.	$n_1p_0k_2$	4.20	3.50	3.70	3.60	3.65	3.30
13.	$n_1p_1k_0$	4.20	3.70	3.30	3.55	3.70	3.70
14.	$n_1p_1k_1$	4.20	3.60	3.45	3.60	3.90	3.45
15.	$n_1p_1k_2$	4.50	3.70	3.60	3.80	3.70	3.80
16.	$n_1p_2k_0$	4.55	3.70	3.80	3.65	3.90	4.00
17.	$n_1p_2k_1$	4.30	3.60	3.70	3.75	3.75	3.30
18.	$n_1p_2k_2$	4.00	3.70	3.60	3.70	4.00	3.70
19.	$n_2p_0k_0$	4.50	3.80	3.60	3.50	3.65	3.70
20.	$n_2p_0k_1$	3.85	3.40	3.45	3.35	3.40	3.60
21.	$n_2p_0k_2$	4.10	3.35	3.30	3.65	3.20	3.60
22.	$n_2p_1k_0$	4.35	3.50	3.50	3.50	3.55	3.60
23.	$n_2p_1k_1$	4.70	3.90	3.95	4.00	4.00	4.20
24.	$n_2p_1k_2$	4.60	3.60	3.50	3.90	3.80	3.20
25.	$n_2p_2k_0$	4.30	3.25	3.10	3.45	3.35	3.30
26.	$n_2p_2k_1$	4.10	3.50	3.40	3.30	3.70	3.60
27.	$n_2p_2k_2$	4.35	3.70	3.40	3.55	3.60	3.30

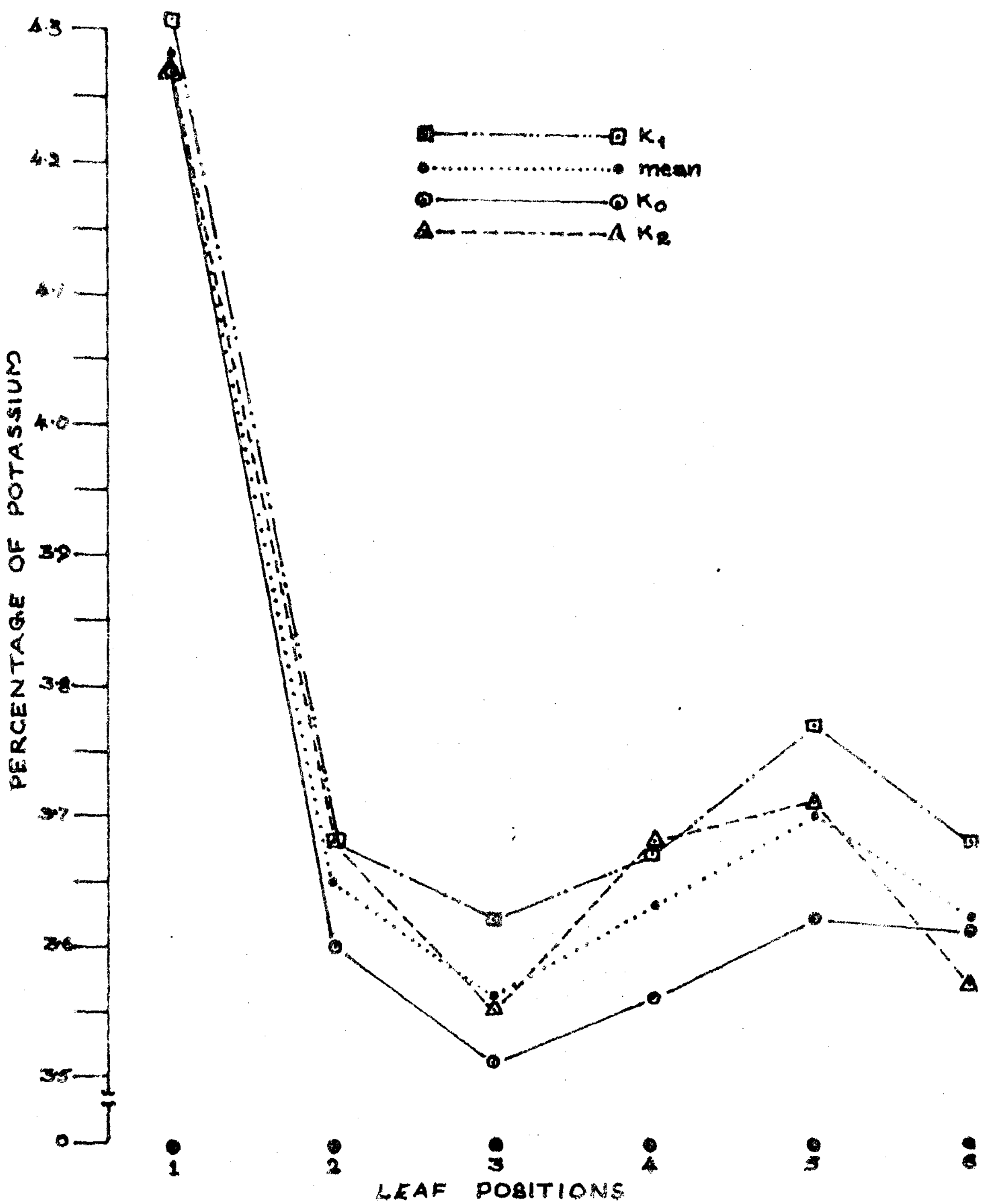

FIG. 8. RELATIONSHIP BETWEEN LEAF POSITIONS AND PERCENTAGE OF POTASSIUM

statistically on par with n_0 level. Both n_1 and n_0 levels were significantly superior to n_2. The treatment level k_1 recorded the highest leaf potassium but was on par with k_2 level statistically. The k_1 level was significantly superior to k_0 level. However, the percentage at k_2 level was on par with that at k_0 level.

8. Effect of NPK treatments on the nutrient contents of third leaf in relation to period of growth

8.1. Nitrogen percentage of third leaf in relation to period of growth

The data on the effect of NPK treatments on the nitrogen percentage of third leaf in relation to period of growth are given in Table 35 and the analysis of variance in Appendix XII. It was revealed that out of the different levels of nutrients applied to the crop the nitrogen percentage of third leaf was influenced only by the graded doses of nitrogen. The nitrogen percentages at n_2 and n_1 levels were on par and significantly superior to that at n_0. The nitrogen percentage of third leaf was significantly influenced by the advancing age of the crop with the highest value recorded at fourth period (180 days after planting) and the lowest at the second period (120 days after planting). The difference in nitrogen percentage between each period was highly significant.

Table 35. Effect of NPK treatments on the nutrient contents of third leaf in relation to period of growth.

Nitrogen percentage of third leaf.

Sl. No.	Treatment	Period 1	2	3	4
1.	$n_0p_0k_0$	1.96	2.94	2.80	3.64
2.	$n_0p_0k_1$	2.10	0.42	2.38	3.22
3.	$n_0p_0k_2$	1.82	2.10	2.94	3.36
4.	$n_0p_1k_0$	1.96	1.54	3.00	3.50
5.	$n_0p_1k_1$	1.82	0.42	2.38	3.36
6.	$n_0p_1k_2$	1.82	1.68	2.66	3.78
7.	$n_0p_2k_0$	1.54	2.10	2.52	3.08
8.	$n_0p_2k_1$	1.68	1.96	2.38	3.92
9.	$n_0p_2k_2$	1.26	1.26	2.80	3.22
10.	$n_1p_0k_0$	1.96	1.54	2.94	3.78
11.	$n_1p_0k_1$	2.24	1.68	3.08	4.06
12.	$n_1p_0k_2$	2.10	1.40	2.24	3.50
13.	$n_1p_1k_0$	2.10	1.68	3.22	3.92
14.	$n_1p_1k_1$	1.96	0.42	3.08	4.20
15.	$n_1p_1k_2$	1.68	1.68	3.22	3.78
16.	$n_1p_2k_0$	2.10	1.96	3.22	3.50
17.	$n_1p_2k_1$	2.38	1.82	3.36	3.36
18.	$n_1p_2k_2$	2.24	1.68	3.08	3.22
19.	$n_2p_0k_0$	2.10	1.96	2.66	3.50
20.	$n_2p_0k_1$	1.96	2.38	2.94	3.64
21.	$n_2p_0k_2$	2.38	1.96	3.36	3.36
22.	$n_2p_1k_0$	2.10	0.98	3.50	3.92
23.	$n_2p_1k_1$	2.24	1.68	2.94	4.06
24.	$n_2p_1k_2$	1.82	1.68	2.94	3.50
25.	$n_2p_2k_0$	1.68	1.82	3.08	3.92
26.	$n_2p_2k_1$	2.38	1.82	3.36	4.34
27.	$n_2p_2k_2$	1.82	0.42	3.08	3.78

8.2. Phosphorus percentage of third leaf in relation to period of growth

Observations and results of statistical analysis on the percentage of phosphorus in third leaf in relation to period of growth are given in Table 36 and Appendix XII. The results revealed that the incremental doses of nitrogen, phosphorus and potassium could not influence the percentage of phosphorus in the third leaf at different periods. However, it was found that the age of the crop significantly influenced the phosphorus content of third leaf. The phosphorus content significantly decreased with advancing period of growth. The highest phosphorus content was recorded at the first period which was significantly superior to all other treatments. The difference in phosphorus percentage between second and third periods was not significant. The phosphorus percentage at fourth period was significantly lower than that at all other periods.

8.3. Potassium content of third leaf in relation to period of growth

Data on the effect of NPK treatments on the potassium content of third leaf in relation to periods of growth are given in Table 37 and the analysis of variance in Appendix XII. It was found that the potassium content of third leaf was significantly influenced by the levels of potassium applied to the crop. The level k_2 recorded the highest potassium percentage and was on par with k_1. The potassium percentage

Table 36. **Effect of NPK treatments on the nutrient contents of third leaf in relation to period of growth.**

Phosphorus percentage of third leaf

Sl. No.	Treatment	Period 1	2	3	4
1.	$n_0p_0k_0$	0.231	0.270	0.216	0.196
2.	$n_0p_0k_1$	0.241	0.230	0.205	0.181
3.	$n_0p_0k_2$	0.233	0.230	0.213	0.188
4.	$n_0p_1k_0$	0.227	0.270	0.199	0.205
5.	$n_0p_1k_1$	0.245	0.210	0.221	0.211
6.	$n_0p_1k_2$	0.251	0.210	0.218	0.180
7.	$n_0p_2k_0$	0.255	0.220	0.220	0.171
8.	$n_0p_2k_1$	0.241	0.230	0.231	0.165
9.	$n_0p_2k_2$	0.256	0.220	0.216	0.185
10.	$n_1p_0k_0$	0.233	0.190	0.211	0.191
11.	$n_1p_0k_1$	0.241	0.240	0.224	0.156
12.	$n_1p_0k_2$	0.252	0.210	0.199	0.223
13.	$n_1p_1k_0$	0.261	0.210	0.198	0.199
14.	$n_1p_1k_1$	0.234	0.210	0.201	0.181
15.	$n_1p_1k_2$	0.241	0.180	0.192	0.188
16.	$n_1p_2k_0$	0.253	0.170	0.221	0.182
17.	$n_1p_2k_1$	0.242	0.190	0.222	0.201
18.	$n_1p_2k_2$	0.232	0.190	0.231	0.200
19.	$n_2p_0k_0$	0.253	0.190	0.224	0.198
20.	$n_2p_0k_1$	0.246	0.200	0.215	0.183
21.	$n_2p_0k_2$	0.231	0.200	0.234	0.197
22.	$n_2p_1k_0$	0.245	0.170	0.215	0.201
23.	$n_2p_1k_1$	0.226	0.170	0.226	0.202
24.	$n_2p_1k_2$	0.235	0.210	0.235	0.198
25.	$n_2p_2k_0$	0.256	0.220	0.225	0.183
26.	$n_2p_2k_1$	0.261	0.220	0.231	0.173
27.	$n_2p_2k_2$	0.221	0.200	0.226	0.166

Table 37. Effect of NPK treatments on the nutrient contents of third leaf in relation to period of growth.

Potassium content of third leaf, %.

Sl. No.	Treatment	Period 1	2	3	4
1.	$n_0p_0k_0$	3.4	3.5	3.1	2.9
2.	$n_0p_0k_1$	3.1	3.3	3.3	3.2
3.	$n_0p_0k_2$	3.7	3.9	3.8	3.7
4.	$n_0p_1k_0$	3.2	3.6	3.3	3.4
5.	$n_0p_1k_1$	3.5	3.8	3.3	3.2
6.	$n_0p_1k_2$	3.3	3.6	3.5	3.1
7.	$n_0p_2k_0$	3.5	3.6	3.4	3.0
8.	$n_0p_2k_1$	3.8	3.8	3.2	3.2
9.	$n_0p_2k_2$	3.9	4.0	3.7	3.4
10.	$n_1p_0k_0$	3.6	3.6	3.9	3.5
11.	$n_1p_0k_1$	3.7	3.8	3.2	3.3
12.	$n_1p_0k_2$	3.4	3.7	3.6	3.4
13.	$n_1p_1k_0$	3.6	3.3	3.2	3.3
14.	$n_1p_1k_1$	3.6	3.5	3.7	3.7
15.	$n_1p_1k_2$	3.5	3.6	4.0	3.2
16.	$n_1p_2k_0$	3.2	3.8	3.8	2.9
17.	$n_1p_2k_1$	3.5	3.7	3.6	3.0
18.	$n_1p_2k_2$	3.9	3.6	3.3	3.4
19.	$n_2p_0k_0$	3.3	3.6	3.5	3.5
20.	$n_2p_0k_1$	3.2	3.5	3.2	2.9
21.	$n_2p_0k_2$	3.6	3.3	3.1	3.2
22.	$n_2p_1k_0$	3.8	3.5	3.6	2.9
23.	$n_2p_1k_1$	3.6	4.0	3.7	3.0
24.	$n_2p_1k_2$	3.4	3.5	3.9	3.3
25.	$n_2p_2k_0$	3.5	3.1	3.8	3.0
26.	$n_2p_2k_1$	3.3	3.4	4.0	3.1
27.	$n_2p_2k_2$	3.6	3.4	3.6	3.2

Table 38. Effect of NPK treatments on oleoresin content of turmeric.

Sl.No.	Treatments	Oleoresin (%)
1.	$n_0p_0k_0$	13.64
2.	$n_0p_0k_1$	14.02
3.	$n_0p_0k_2$	11.20
4.	$n_0p_1k_0$	13.02
5.	$n_0p_1k_1$	12.33
6.	$n_0p_1k_2$	11.91
7.	$n_0p_2k_0$	10.41
8.	$n_0p_2k_1$	9.33
9.	$n_0p_2k_2$	13.70
10.	$n_1p_0k_0$	14.83
11.	$n_1p_0k_1$	14.90
12.	$n_1p_0k_2$	17.17
13.	$n_1p_1k_0$	10.64
14.	$n_1p_1k_1$	13.06
15.	$n_1p_1k_2$	14.84
16.	$n_1p_2k_0$	11.85
17.	$n_1p_2k_1$	16.40
18.	$n_1p_2k_2$	12.25
19.	$n_2p_0k_0$	11.09
20.	$n_2p_0k_1$	12.47
21.	$n_2p_0k_2$	10.41
22.	$n_2p_1k_0$	13.01
23.	$n_2p_1k_1$	11.56
24.	$n_2p_1k_2$	13.24
25.	$n_2p_2k_0$	13.07
26.	$n_2p_2k_1$	10.43
27.	$n_2p_2k_2$	11.02

n_0	12.17	p_0	13.31	k_0	12.40
n_1	14.00	p_1	12.62	k_1	12.72
n_2	11.81	p_2	12.05	k_2	12.86

C.D. for comparing levels of N, P and K - N.S.

at k_2 level was significantly superior to that at k_0 level. The levels k_1 and k_0 were on par. The percentage of potassium in the third leaf was influenced by the increasing period of growth as in the case of nitrogen and phosphorus contents. There was no significant difference in potassium content between the first, second and third periods. But the potassium content of third leaf at fourth period was significantly superior to all the previous periods.

9. Effect of NPK treatments on the oleoresin content of turmeric

The data on the oleoresin content of turmeric as influenced by the levels of nitrogen, phosphorus and potassium are given in Table 38 and the analysis of variance in Appendix XI. The results revealed that the oleoresin content of turmeric was not influenced by incremental doses of N, P and K and their interactions.

Discussion

DISCUSSION

1. Effect of NPK treatments and period of growth on morphological characters of turmeric

1.1. Effect of NPK treatments

Results presented in Table 1, 2 and 3 and analysis of variance in Appendix II, III and IV revealed that, among the morphological characters examined, the number of tillers per clump and the number of leaves per tiller at fifth period were significantly influenced by the varying levels of nitrogen applied while the application of phosphorus and potassium could not influence these characters. The levels of nitrogen, phosphorus and potassium employed could not affect the height of tillers. As regards the effect of nitrogen levels on the number of tillers at the last period observed (210 days after planting), it is seen that the number of tillers increased with increasing levels of nitrogen application. However, the difference between n_1 and n_0 levels was not statistically significant. It is interesting to observe that though the higher level of nitrogen application resulted in the increased number of tillers, the effect of nitrogen on the number of leaves per tiller was found to be in a strictly reverse order, with maximum number of leaves at the n_0 level and the minimum at the n_2 level. These observations lend support to the possible explanation that an increase in the number of tillers per clump is at the expense of the number of leaves, thereby nullifying the effect of nitrogen level on the total content of these vegetative parts accumulated. This is further supported by the fact that levels of nitrogen could not influence the total dry matter produced. Lack of response of crop in terms of morphological characters, to application of nitrogen, phosphorus and potassium has been often reported (Anon., 1977; Anon., 1978). Johnson (1978) observed that the number of tillers per clump and the number of leaves per tiller in ginger were not reflected by the levels of nitrogen, phosphorus and potassium. The lack of response of turmeric to the fertiliser levels employed in the present study can be attributed to the high level of available nutrients in soil and the relatively heavy dose of organic manure applied viz., 40 tonnes/ha. This is further supported by the observation that none of the fertiliser treatments could bring about a significant increase in the rhizome yield of the crop.

1.2. Effect of period of growth

Observations recorded on the morphological features of the plant in relation to increasing period of growth elucidate that all the three growth parameters viz., number of tillers per clump, number of leaves per tiller and height of tiller steadily progressed with the increasing period of growth. However, the rate of increase in these characters was different over different periods. On observing the progress of tiller production with increasing age of the crop it is seen that maximum tillers were put forth during the period from 120th day to 150th day, the addition in number of tillers produced during this period being 26 per cent of the total. The increase in the number of tillers produced after this period was only marginal and it reached a maximum at the 180th day, thereafter remaining constant. The pattern of variation in the number of leaves per tiller was almost similar to that of the number of tillers per clump, except that the number of leaves per clump went on increasing till the last period. A continuous increase in the height of the tiller was also observed with increasing age of the crop. It should be pointed out that the rate of increase during 120th day to 150th day in respect of all these three growth characters was conspicuous as compared to the rest of the period. This illustrates the existence of a period of active vegetative growth ranging from 120th day to 150th day. This observation is further corroborated by a marked increase in the total dry matter accumulation during this period. Johnson (1978) recognised three stages during the growth of ginger viz., a phase of active vegetative growth, a phase of slow vegetative growth and a phase approaching senescence. Examining the present data on a similar angle, it is possible to divide the total growth period into four phases with respect to the development of aerial plant tissues; 1) a phase of moderate vegetative growth which occurred from the 90th day to 120th day during which the rate of growth was relatively fast but lesser than that at the next phase; 2) a phase of active vegetative growth which occurred during the period from 120th day to 150th day during which 26 per cent of the tillers per clump was elaborated. This period of 30 days accounted for 19.05 per cent of the total height of the tillers and 35.87 per cent of the total dry matter accumulated; 3) a period of slow vegetative growth which occurred during the period from 150th day to 180th day; and 4) a phase approaching senescence commencing from 180th day and extending upto harvest during which the elaboration of aerial plant parts was practically insignificant. n_1-0, n_2-20, n_3-40 kg/ha

It should be borne in mind that even the second dose of fertiliser application (1/3rd of nitrogen and half of potassium) was over by the 60th day after planting. In the light of the present study in which the maximum period of crop growth was found to be from 120th day to 150th day it will be worthwhile to examine the possibility of better utilisation of fertilisers by the crop by extending the split application of nitrogen and potassium to match with the period of maximum plant growth.

2. Effect of NPK treatments and period of growth on the fresh and dry weight of rhizome and total dry matter yield

2.1. Effect of NPK treatments

Data presented in Table 4, 5 and 6 and Appendix V indicate that the levels of N, P and K failed to influence the fresh and dry weight of rhizome. The total dry matter produced was found to be influenced by the levels of potassium and NK interaction. As already pointed out, the nitrogen and potassium requirement of the crop would have been met even at the lowest level of nutrient employed, by the nutrients contained in the organic matter supplied and also by the available nutrients present in the soil. Of the potassium levels, k_1 was superior to k_0 and k_2. This observation tends to remark that the optimum level of potassium for the maximum production of dry matter is already attained at the k_1 level since further increase in the quantity of applied potassium could only depress the yield of dry matter. Among the NK combinations, $n_1 k_1$ was found to be superior to other treatment combinations.

2.2. Effect of period of growth

The patterns of variation in the fresh and dry weight of rhizome and the total dry matter production with increasing period of crop growth were almost similar. A steady increase in these parameters was observed as the age of the crop progressed. The pattern of rhizome development did not follow the same trend as that of the aerial parts in relation to the incfeasing age of the crop. Instead of a final phase of senescence or insignificant growth in the case of aerial tissue, the enlargement of rhizome continued till harvest. Similar trends in dry matter production and rhizome development have been observed by Nair (1964).

3. Rhizome yield of turmeric at harvest

Results presented in Table 7 and Appendix VI show that the levels of nitrogen, phosphorus and potassium and their interactions could not effect any significant difference in the yield of turmeric at harvest. It is rather interesting to observe that the yield at the lowest level of NPK tried was statistically on par with that at the highest level. The lack of response of the crop to the graded doses of these nutrient elements can be attributed to (1) the high fertility status of the experimental field; and (2) the high dose of organic manure applied viz., 40 tonnes/ha. This is evidenced by the heavy uptake of nitrogen, phosphorus and potassium irrespective of the levels of these nutrients employed in the experiment. It is worth mentioning that the total uptake of nitrogen at the last period by plants receiving nitrogen at n_0 level (0 kg, 20, 40 kg NPK/ha) was 368.9 kg/ha whereas the mean uptake of nitrogen irrespective of nitrogen treatments was 325.5 kg/ha. This reveals that the uptake of nitrogen was not decisively influenced by the levels of nitrogen. Also, the total uptake of phosphorus and potassium was not in progressive order corresponding to the increasing levels of these nutrients. Therefore, it is conclusively proved that even at the lowest level of nutrient tried, the crop could perform in terms of yield as it could do at the higher levels of nutrients supplied; obviously meeting the nutrient requirements from the organic matter supplied and that originally present in the soil. The lack of response of turmeric to application of fertilisers has been reported by a few workers (Anon., 1977 and Anon., 1978).

4. <u>Uptake of nitrogen</u>

4.1. Effect of fertiliser treatments

Results of the study indicate that the levels of nitrogen, phosphorus and potassium employed could not influence the uptake of nitrogen in any of the plant part examined viz., the leaf, pseudostem and rhizome. This is evidently due to the fact that the crop could meet its nitrogen requirement through sources other than the fertiliser nitrogen supplied. The high level of available nitrogen in the soil and the heavy dose of organic manure given to the crop are the factors which accounts for the lack of response of the crop to the fertiliser treatments. Though the levels of nitrogen, phosphorus and potassium had no influence on the uptake of nitrogen in different plant parts, the total uptake of nitrogen was found to be significantly higher at the k_1 level. It should be pointed out that the maximum yield of turmeric was also obtained at the k_1 level though the differences in yield between levels were not statistically significant.

4.2. Effect of period of growth

The nitrogen uptake progressively increased with advancing period of crop growth and the maximum uptake was achieved at the last period (240th day) apparently due to the increased accumulation of dry matter with increasing period of growth. This trend of increasing uptake of nitrogen with increasing period was seen in all the plant parts separately examined.

When the total uptake of nitrogen was appropriated over different periods of crop growth, it was seen that 49.98 per cent of the total uptake took place within a period of 30 days from 120th day to 150th day. This enhanced uptake of nutrient has resulted in the active growth of the crop during this period. When the influence of period of growth on the morphological characters of the crop was discussed, it was stated that the total period of growth can be divided into a phase of moderate vegetative growth, a phase of active vegetative growth, a period of slow vegetative growth and a phase approaching senescence. As expected, the phase of active vegetative growth is also the period during which maximum uptake of nutrients took place. However, the uptake cannot be divided into four distinct regions as that was done in the case of the rate of growth of aerial tissues, since the uptake of nutrients especially in rhizome continued even during the period of senescence. The marked uptake of nitrogen to the extent of half the total crop requirement during a relatively narrow period of 30 days from 120th day to 150th day tends to suggest a modification in the split application of nitrogen to the crop. At present, 2/3rd of the nitrogen is applied on the 30th day after planting and the remaining 1/3rd is given on the 60th day. The fact that maximum uptake of nitrogen took place after 120th day eventhough the application of entire quantity of fertiliser nitrogen was completed by the 60th day, strongly indicate a possible increased uptake of nitrogen if a third split application is introduced or the timings of the two split applications are altered in such a way to provide nitrogen to meet its enhanced requirement during the period of active growth.

5. Uptake of phosphorus

5.1. Effect of NPK treatments

Result of the study on uptake of phosphorus show that the uptake of phosphorus is not influenced by the levels of nitrogen and phosphorus tried. However, levels of potassium decisively influenced the total uptake of phosphorus as well as the uptake of phosphorus in leaf. The failure of the crop to respond to the increasing levels of phosphorus in terms of phosphorus uptake can be attributed to the sufficient supply of this element through sources other then the fertiliser supplied. Such a situation is provided by the relatively high content of available phosphorus in soil and also the phosphorus mobilised by the mineralisation of organic matter. The uptake of phosphorus was found to be maximum at k_1 level. It should be pointed out that the yield of total dry matter and uptake of nitrogen were also higher at this level. Probably, the influence of potassium on the production of total dry matter would have resulted in an increased uptake of nitrogen and phosphorus so as to maintain a relatively constant percentage of these nutrients in plant.

5.2. **Effect of period of growth**

The uptake of phosphorus steadily increased with increasing age of the plant irrespective of the plant parts examined. As in the case of nitrogen, the uptake of phosphorus was at a comparatively enhanced rate during the period of active plant growth (120th day to 150th day). This is evidently due to the higher rate of dry matter production during this period as compared to later stages of growth.

Observations on the uptake of phosphorus in leaf, pseudostem and rhizome in relation to the increasing age of the plant reveal that phosphorus uptake in all these plant parts progressively increased as in the case of total phosphorus uptake. Such a trend in the uptake of nutrient is expected since the dry matter accumulation irrespective of the plant part selected progressed with advancing period of crop maturity.

6. Uptake of potassium

6.1. Effect of NPK treatments

Results reveal that though the levels of nitrogen and phosphorus failed to influence the total uptake of potassium by the crop significantly, the levels of potassium and NK interaction decisively influenced the uptake of this nutrient element. It is interesting to observe that the influence of levels of potassium is apparent in the uptake of this element in leaf, pseudostem and rhizome uniformly as in the case of total uptake. The k_1 level was found to be superior to k_2 and k_0 in this respect. It should be pointed out that the levels of potassium influenced not only the uptake of potassium but also the uptake of nitrogen and phosphorus. Similarly the total dry matter production was significantly higher at k_1 level. The rhizome yield of turmeric also was higher at k_1 level than those at k_2 and k_0 levels, though the difference was not statistically significant. These observations tend to conclude that among the major nutrients and their levels employed in the study, only the application of potassium at k_1 level could influence the rate of growth and the uptake of nutrients.

Response of turmeric to application of potassium has been reported by different research workers (Nair, 1964; Muraleedharan and Balakrishnan, 1972; Rao, 1973).

6.2. Effect of period of growth

As in the case of nitrogen and phosphorus the uptake of potassium in leaf, pseudostem and rhizome steadily progressed with advancing age of the crop. The pattern of nitrogen uptake with advancing period of crop growth was slightly different from the pattern of uptake in the case of nitrogen and phosphorus. Though the uptake of potassium during the active period of vegetative growth viz., 120th to 150th day after planting was fairly good (21.31 per cent of the total), the maximum uptake took place during the period from 180th day to 210th day accounting for 42.96 per cent of the total. Since the elaboration of aerial tissues during this period (180th day to 120th day) was only at a moderate rate, this heavy uptake of potassium resulted in the accumulation of the element in leaf thereby shooting the mean potassium per cent of leaf from 3.06 to 6.17. A part of the potassium taken up during this period (28.78 per cent) was located in rhizome. Luxury consumption of potassium resulting from the heavy uptake of the element without any perceptible increase in yield has been reported in many crops.

A comparison of crop removal in respect of nitrogen, phosphorus and potassium irrespective of the fertiliser levels employed reveals that the removal of nitrogen, phosphorus and potassium by the crop at the last period was in the order of 325.5, 23.2 and 661.5 kg/ha respectively. This works out to an N:P:K ratio of 14.03:1:28.51 which projects the heavy consumption of nitrogen and potassium as compared to phosphorus. In the present study, since no response was noticed in terms of yield by the application of different levels of nitrogen, phosphorus and potassium, optimum crop removal or crop requirement cannot be worked out. However the observations lead to assume that the crop will respond to application of nitrogen and potassium if it solely or mainly depends on applied sources rather than that originally available in soil.

7. Standardisation of leaf position for foliar diagnosis

One of the objectives of the present investigation was to select an index leaf or reflect for foliar diagnosis in relation to nitrogen, phosphorus and potassium. Samples collected from different leaf positions were examined for this purpose.

For the selection of the index leaf the following attributes of an ideal reflect are kept in mind. 1) The reflect should contain sufficient amount of the nutrient element for its easy determination. 2) The reflect should respond to varying levels of the nutrient element supplied or its uptake by the plant. 3) The sampling error should be minimum, that is, the index leaf should belong to the plateau of the curve when the nutrient percentage of the leaf is plotted against the leaf positions. 4) As far as possible, the nutrient percentage of the leaf should correlate with the yield of the crop.

However, it is rather difficult to meet all the above requirements of an ideal reflect at a particular set of conditions. In the present study, different levels of nitrogen, phosphorus and potassium were tried on the assumption that it will produce different uptake in plants and varying yield in relation to the levels of nutrients applied. Unfortunately, the crop failed to respond to the levels of nutrients employed both in terms of yield and uptake of nutrients. This has imposed restriction on the variation in the content of nutrient elements at different leaf positions thereby considerably reducing the chances of establishing correlation between nutrient content of leaf positions and the yield or between the nutrient content of leaf positions and uptake of nutrients. However, from the available data, the index leaf is selected keeping in mind the attributes of an ideal reflect.

The nitrogen percentage of leaf decreased with increasing age of the leaf or leaf position, the rate of decrease being steady and constant. Mean values of nitrogen percentage varied from 1.93 at the first leaf to 1.00 at the last leaf. The differences in nitrogen percentage of leaves at alternate leaf numbers were found to be statistically significant. Johnson (1978) also observed the highest percentage of nitrogen in the first group of leaves in ginger which continuously decreased with increasing number of leaf positions. He could however locate a region of stabilised nitrogen percentage at which differences between adjacent positional groups were negligible. But in the present investigation no such plateau was located, the values being decreased continuously rather at a uniform rate with increasing number of the leaf positions. As regard the influence of levels of nitrogen on the nitrogen percentage at different leaf positions, it was seen that differences between leaf positions were not statistically significant presumably due to the fact that these levels employed could influence neither the total dry matter production nor the total uptake of nitrogen. The coefficient of correlation between nitrogen percentage of leaf positions and total nitrogen uptake was the highest for the first leaf (0.361) closely followed by the third (0.297). However, these coefficients of correlation were not statistically significant. No significant correlation could be established between nitrogen percentage of leaf positions and the rhizome yield.

As in the case of nitrogen, maximum percentage of phosphorus was noticed in the first leaf which progressively decreased with increasing number of leaf positions, the rate of decrease being marked for the first three positions. Though no region of stabilised phosphorus percentage could be located, the rate of decrease in phosphorus percentage from leaf position three to six was comparatively lower than that at initial leaf positions. It is interesting to note that differences in phosphorus percentage between all the leaf positions were statistically significant. As regards the influence of levels of phosphorus on the phosphorus content of leaf positions, it was seen that these levels could not influence the content of this nutrient element significantly. Examination of the coefficients of correlation between phosphorus uptake and phosphorus percentage of leaf positions revealed that the highest correlation was established in the case of the third leaf (0.342) though the value was not statistically significant. The highest value for the coefficient of correlation between yield and phosphorus percentage of leaf positions was also recorded by the third leaf (0.253).

As in the case of nitrogen and phosphorus, the highest percentage of potassium was observed in the first leaf which considerably dropped at the second, thereafter maintaining almost a constant level. Thus potassium content of leaf position second to the last did not differ significantly. Coefficients of correlation between potassium content of leaf and total uptake of potassium were not significant for any of the leaf positions examined. Potassium percentage of leaf positions also failed to correlate significantly with the rhizome yield.

The foregoing observations tend to select the third leaf as the index leaf for foliar diagnosis in turmeric in relation to nitrogen, phosphorus and potassium status of the plant.

8. <u>Standardisation of period for foliar diagnosis</u>

The nitrogen, phosphorus and potassium percentages of third leaf were examined at different periods of growth with a view to establishing relationship between the content of nutrients in them and the yield or the total uptake of nutrients, so as to select the best period suitable for foliar diagnosis. Results revealed that the values for nitrogen, phosphorus and potassium of the third leaf at different periods of plant growth failed to give significant coefficients of correlation with the rhizome yield and the total uptake of these nutrients. However, the period between 90th day and 120th day after planting appears to be the ideal range on the following grounds.

i) This period immediately preceeds the phase of active vegetative growth and the period of maximum uptake of nutrients.

ii) Application of fertilisers for adjusting the nutrient status of the crop will be effective only if they are applied prior to the commencement of the phase of active growth and uptake.

9. Effect of NPK treatment on the oleoresin content of turmeric

The results given in Table 35 revealed that the levels of nitrogen, phosphorus and potassium and their interaction had no significant influence on the oleoresin content of turmeric. The levels of nitrogen, phosphorus and potassium perhaps cannot be expected to influence the oleoresin content of turmeric in the present investigation since they could not effect any marked increase in the uptake of these nutrients. Also, it is probable that the synthesis of the components of oleoresin is not significantly governed by the levels of these nutrients available in plant tissue.

Summary

SUMMARY

A field experiment was conducted at the College of Horticulture Campus, Vellanikkara between May 1979 and January 1980 to study the effect of graded doses of nitrogen, phosphorus and potassium on the growth, yield, quality, chemical composition and uptake of nutrients of turmeric and also to develop suitable foliar diagnosis technique in relation to these nutrient elements. The treatments comprised of three levels each of nitrogen (0, 20 and 40 kg N/ha), phosphorus (0, 20 and 40 kg P_2O_5/ha) and potassium (0, 40 and 80 kg K_2O/ha). The experiment was laid out in a 3^3 factorial experiment in randomised block design confounding the effect of interaction NP^2K^2 totally. The important findings are summarised below.

1) Among the morphological characters studied, the number of tillers per clump increased with increasing levels of nitrogen applied whereas the number of leaves per tiller decreased with increasing levels of nitrogen. Levels of phosphorus and potassium could not influence these characters. The height of tiller remained unaffected irrespective of the fertiliser treatments employed.

2) Levels of nitrogen, phosphorus and potassium failed to influence the fresh and dry weights of rhizome. The total dry matter yield was influenced by the levels of K and

NK interaction. Maximum production of dry matter occurred at the k_1 level which was superior to those at k_0 and k_2 levels.

3) The levels of nitrogen, phosphorus and potassium and their interaction could not effect any significant difference in the yield of turmeric at harvest.

4) Uptake of nitrogen in any of the plant part examined viz., the leaf, pseudostem and rhizome was not found influenced by the levels of nitrogen, phosphorus and potassium. However, the total uptake of nitrogen was found to be significantly higher at the k_1 level.

5) Uptake of phosphorus was not affected by the levels of nitrogen and phosphorus. But levels of potassium decisively influenced the uptake of phosphorus, the k_1 level being superior to k_0 and k_2.

6) The levels of nitrogen and phosphorus failed to influence the total uptake of potassium while the levels of potassium and NK interaction decisively influenced the uptake of this nutrient element, the k_1 level being superior to k_2 and k_0.

7) The number of tillers per clump, number of leaves per tiller and height of tiller steadily progressed with increasing period of growth. A conspicuous phase of active vegetative growth occurred during the period from 120th day to 150th day after planting.

8) The fresh and dry weights of rhizome increased with increasing period of growth and reached a maximum at harvest.

9) The uptake of nitrogen progressed with increasing age of the crop. About half of the total nitrogen uptake (49.98 per cent) took place within a period of thirty days from 120th day to 150th day after planting.

10) Uptake of phosphorus steadily increased with increasing period of crop growth and the uptake was pronounced during the period of active vegetative growth.

11) Uptake of potassium increased with increasing maturity of the crop and maximum uptake occurred during the period from 180th day to 210th day after planting (42.96 per cent).

12) On an average, the crop removed 325.5 kg N, 23.2 kg P and 661.5 kg K per hectare.

13) The content of nitrogen, phosphorus and potassium was highest in the top most leaf and decreased with increasing number of leaf positions. Differences between leaf positions were significant in respect of the percentage of nitrogen, phosphorus and potassium in them. Based on the qualities of an ideal index leaf, the third leaf was found to be superior to the leaves at other positions. Regarding the optimum age of the plant for sampling, it appeared that the period between 90th day to 120th day after planting was the

References

REFERENCES

Aiyadurai, S.G. (1966). A Review of Research on Spices and Cashewnut. Indian Council of Agricultural Research, New Delhi. pp. 209.

Akhmetov, G.S. and Bairamov, B.I. (1968). Foliar diagnosis of the nutritional status of the tea plant. Fertilite. (Dec.'67-Jan.'68) pp. 65-69.

Anonymous (1977). Progress Report of the Dept. of Vegetable Crops and Floriculture, H.P. University Agricultural Complex, Solan. 4: 8-10.

Anonymous (1978). Package of Practices Recommendations. Directorate of Extension Education, Kerala Agricultural University, Trichur. pp. 91-93.

Anonymous (1978). Progress Report of the Dept. of Vegetable Crops and Floriculture, H.P. University Agricultural Complex, Solan. 5: 4-7.

A.S.T.A. (1960). Official Analytical Methods of the American Trade Association, New York, pp. 41-42.

Baker, R.M. and Robinson, J.B.D.* (1963). Progress with leaf analysis in coffee research. 1) General principles and choice of suitable indices of plant nutrient status. Res. Rep. Coff. Res. Stn. Lyamungu, pp. 39-49.

Boldyrev, N.K.*(1959). The diagnosis of N and P requirement of wheat during flowering by means of the general chemical analysis of the leaves. Pochvovedenie, 11: 104-114.

Borden, R.J.* (1947). A suggested critical potash level in leaf-punch samples. Hawaii Plrs' Rec., 51: 139-142.

Bould, C. (1964). Leaf analysis as a guide to the nutrition of fruit crops: V. Sand culture N, P, K, Mg experiments in the strawberry (Fragraria spp.). J. Sci. Fd. Agric., 15: 474-487.

Champion, J.*(1966). Nutrition and fertilising of banana. Bull. Doc. Assoc. int. Fabr. Superphos., 44: 21-22.

Chapman, H.D. and Brown, S.M. (1950). Analysis of orange leaves for diagnosing nutrient status with reference to K. Hilgardia, 19(7): 501-549.

Chubb, W.O. and Atkinson, H.J. (1948). Plant tissue testing. II. Study of the method of foliar diagnosis. Sci. Agric., 28: 49-60.

Cibes, H. and Samuels, G.* (1958). Mineral deficiency symptoms displayed by 'Red Spanish' pineapple plants grown under controlled conditions. Univ. Puerto Rico Agr. Expt. Stn. Tech. Paper, pp. 25.

Clements, A.F. (1947). Potassium and sugarcane. Hawaii Agric. Expt. Stn. Biennial Rept., 108-111.

DeWaard, P.W.F. (1969). Foliar Diagnosis, Nutrition and Yield Stability of Black Pepper (Piper nigrum L.) in Sarawak. Dept. of Agricultural Research of the Royal Tropical Institute, Amsterdam, The Netherlands, 58: pp. 149.

Emmert, S. (1946). Preliminary report on the periods of critical need of potatoes for nitrogen and phosphorus. Am. Potato J., 23: 267-271.

Evans, J. (1979). The effects of leaf position and leaf age in foliar analysis of Gomelina arborea. Pl. Soil, 52: 547-552.

Forde, C.M. (1976). Effect of applied N, P and K fertilizers on the chemical composition of earleaf of maize in field trials in the Eastern Caribbean. Trop. Agric., 53: 273-279.

Forestier, J. (1968). Potassium and the robusta coffee tree. Fertilite, 30: 3-65.

Fox, R.L., Aydeniz, A. and Kacar, B.* (1964). Soil and tissue tests for predicting olive yield in Turkey E xp. J. exp. Agric., 32: 84-91.

Friis-Nelson, B. (1966). An approach towards interpreting and controlling the nutrient status of growing plants by means of chemical plant analysis. Pl. Soil, 24: 63-80.

Gachon, L.* (1952). Application of foliar diagnosis to apple: Comparison of the N, P and K nutrition of mature and of old trees. C.R. Acad. Agric., 38: 477-479.

Gallo, J.R., Coelho, F.A.S. and Nobrega, S.A.* (1965). Analysis of leaves and petioles for determining the nutrient status of potatoes. Bragantia, 24: 385-401.

Goodall, D.W. (1949). Studies in the diagnosis of mineral deficiency: The mineral content of barley plants in relation to potassium deficiency. Ann. appl. Biol., 35: 605-623.

Gugeon, G.* (1947). Diagnosis of nitrogen deficiency in the apple tree by analysis of the leaf, experimental verification. C.R. Acad. Agric., 34: 287-309.

Halais, P.* (1952). Fertilising and irrigation of industrial sugarcane cultures according to foliar indices. Rep. Congr. Int. Industr. Agr., Rome, pp. 15.

Halais, P. (1963). The detection of NPK deficiency trends in sugarcane crop by means of foliar diagnosis from year to year on a follow up basis. Int. Soc. Sugarcane Tech. 11th Congr., pp. 214-221.

Handreck, K.A.* (1972). Variation in nutrient contents between upper and lower rank leaflets of oil palm. Papua NewGuinea Agric. J., 23: 53-57.

Hewitt, C.W. (1955). Leaf analysis as a guide to the nutrition of bananas. Emp. J. exp. Agric., 23: 11-16.

Jackson, M.L. (1958). Soil Chemical Analysis. Prentice-Hall Inc., U.S.A.

Johnson, P.T. (1978). Foliar Diagnosis, yield and Quality of Ginger (Zingiber officinale Roscoe) in Relation to Nitrogen, Phosphorus and Potassium. M.Sc. Thesis submitted to the Kerala Agricultural University, Trichur, Kerala.

Jones, L.S. * (1963). Leaf composition in apple, raspberry and black currant as related to nutrient elements in the soil. Meld. Norg. Landbr Hogsk., 42(5): 1-90.

Jones, L.S.* (1966). Ranges of the nutrient status of fruit trees and small fruits as evaluated by leaf analysis and yield records. Meld. Norg. Landbr Hogsk. 45(6): 85-146.

Kanapathy, K.* (1973). Evaluation of soil fertility and fertiliser requirement. Proc. Conf. Chem. Fert. Trop. Soils, Kualalumpur, Malaysia.

Krishnamurthy, N., Mathew, A.G., Nambudiri, E.S. and Lewis, Y.S. (1972). Essential oils and oleoresins from major spices of India. Proc. First Natn. Symp. Pln. Crops, pp. 181-183.

Krishnamurthy, N., Mathew, A.G., Nambudiri, E.S., Shivasankar, S., Lewis, Y.S. and Natarajan, C.P. (1976). Oil and oleoresin of turmeric. Trop. Sci. 18(4): 37-45.

Lagatu, H. and Maume, L.* (1926). Diagnostic de l'ailementation d'unve ge tal par l' evolution ch'n' que d'une feuille convenablement choisie. C.R. Acad. Sci., Paris, 18(2): 653-655.

Lagatu, H. and Maume, L.* (1934). Ann. ecole. natn. agric., montpellier, 22: 257-306.

Lefevre, F. (1965). A study of the effects of soil and stock on the mineral content of leaves of Cox's orange apple in deep loam soils. Sci. Sol., 2: 135-148.

Leonard, O.A., Anderson, W.S. and Geiger, M. (1949). Field studies on the mineral nutrition of sweet potato. Proc. Amer. Soc. hort. Sci., 53: 387-392.

LePoidevin, N. and Robinson, L.A. (1964). Foliar analysis procedures as employed in the Booker group of sugar estates in British Guiana. Fertilite, 21: 3-17.

Leverington, K.C., Sedl, J.M. and Burge, J.R. (1962). Some problems in predicting potassium requirement of sugarcane. Proc. 11th Congr. int. Soc. Sugarcane. Tech. Mauritius, pp. 123-129.

Lewis, Y.S., Krishnamurthy, N. and Nambudiri, E.S. (1974). Spice oil and oleoresins. Proc. symp. develpt. prospects spice industry, India, pp. 60-62.

Lin, C.F.* (1963). Leaf analysis as a guide to nitrogen fertilisation of tea bushes. J. Agric. Ass. China, 41: 27-42.

Lin, C.F. (1966). The development of laboratory analysis as a guide to fertilisation of tea bushes. Soils Fertil. Taiwan, 7-13.

Ling, P.* (1965). The nutrient status of citrus nurseries in Taiwan. Mem. Coll. Agric. natn. Taiwan University. 8(2): 216-234.

Malavolta, E., Graner, E.A. and Haag, H.P.* (1964). Studies on the mineral nutrition of coffee. xii. Effect of fertilisers on the mineral composition of leaves. Anais. esc. sup. Agric. Luiz Queiroz, 21: 74-78.

Malavolta, E., Pimentel, G.E. and Couzy, T. (1965). Foliar diagnosis applied to the sugarcane. Fertilite, 25: 5-32.

Mathai, C.K. (1975). Quality studies in spices and cashew. Ann. Rep. Central Pln. Crops Res. Inst. Kasargod, pp. 147.

McDonald, J.A. (1934). The relationship between nutrient supply and the chemical composition of the cacao tree. Cacao Res. Trinidad A. Rep., 3: 50-62

Miller, G.G.* (1962). Foliar diagnosis of N in sugarcane. Acta Agron. Palmira, 12: 141-170.

Muralidharan, A. and Balakrishnan, S. (1972). Studies on the performance of some varieties of turmeric (Curcuma sp.) and its fertiliser requirements. Agric. Res. J. Kerala, 10(2): 112-115.

Nadir, M.* (1967). Sampling methods for foliar diagnosis of citrus in Morocco. Awamia, 23: 101-123.

Nair, P.K.C. (1964). Investigations on Turmeric in Relation to NPK Fertilisation and Rhizosphere Bacterial Population. M.Sc.(Ag.) Thesis submitted to the University of Kerala.

Nicholas, D.J.D.* (1947) Use of chemical tissue tests in diagnosis of the mineral status of plants. Int. Congr. Pin. ppe. Chem., 11: 1-27.

Ochs, R. *(1965). Potassium fertilising of oil palm II. Oleagineux, 20: 365-368.

Oke, O.L. * (1966). The use of plant tissue analysis for diagnosing nitrogen deficiency symptoms. W. Afr. J. Biol. appl. Chem., 9:1-3.

Ollagnier, M. and Giller, P.* (1965). Comparison between foliar diagnosis and soil analysis in determining the fertiliser requirements of groundnut in Senegal (Phosphorus and Potassium). Oleagineux, 20: 513-516.

Omar, M.A. and Kobbia, T. (1965). Leaf analysis as a guide to the nutritional status of plants. J. Soil Sci. Un. Arab Republic, 5: 65-73.

Opanasenkova, I.N., Strelnikova, M.M. and Pillipets, G.V. (1977). Diagnosis of N nutrition of winter wheat in relation to the effectiveness of nitrogen fertilisers and grain quality. Agrokhimiya, 5: 144-149.

Pankov, V.V.* (1965). On the dates of taking leaf samples for chemical diagnosis of nitrogen and phosphorus nutrition in tomatoes. Himija V. Sil' Hoz., 3(10): 15-19.

Panse, V. G. and Sukhatme, P.V. (1967). Statistical Methods for Agricultural Workers. Indian Council of Agricultural Research, New Delhi, pp. 341.

Philip, J. (1978). Morphological Studies and Quality Evaluation of Turmeric (Curcuma longa L.) Types. M.Sc.(Hort.) Thesis submitted to the Kerala Agricultural University.

Prevot, T. * (1953). The fundamentals of foliar diagnosis application to groundnuts. Oleogineux, 8: 67-71.

Prevot, P. and Ollagnier, M. (1957). Directions for use of foliar diagnosis. Fertilite, 2: 3-12.

Pushpadas, M.V., Vijayan, M.R. and Aiyer, R.S. (1975). Nutritional studies on cassava (Manihot esculenta Crantz) 1. Sampling technique for foliar diagnosis. J. Root Crops, 1: 63-69.

Rao, R.D.V. * (1973). Studies on the nutrition of turmeric. Thesis submitted to the Andhra Pradesh Agricultural University for award of M.Sc.(Ag.).

Rao, M.R. and Reddy, V.R. (1977). Effect of different levels of N, P and K on the yield of turmeric. J. Pln. Crops, 5(1): 60-62.

Rao, R.M., Reddy, P.K. and Subbarayudu, M. (1975). Promising turmeric types of Andhra Pradesh. Indian Spices, 12(2): 2-5.

Roche, P., Velly, J. and Celton, J. (1966). Some agronomic problems in the reclamation of upland ferrallitic soils in Madagascar. Agron. trop. Paris, 21: 191-237.

Rogers, B.L., Batjer, L.P. and Thompson, A.H. (1955). Fertilizer application as related to nitrogen, phosphorus, potassium, calcium and magnesium utilization by peach trees. Proc. Am. Soc. hort. Sci., 66: 7-12.

Ruer, P. (1966). Induced mineral deficiencies in young container-cultivated plants. Agron. trop. Paris, 21: 5-8.

Samuels, G., Landrau, P.J.R. and Olivencia, R.* (1955). Response of pineapples to the application of fertilizers. Univ. Puerto Rico J. Agric., 39: 1-11.

Sen, D.K., Roy, F.K. and De, B.N. (1947). Hunger signs in mango. Indian J. Hort., 5: 34-44.

Shorrocks, V.M. (1961). Some effects of fertilizer application on the nutrient composition of leaves and latex of Hevea brasiliensis. Proc. Natural Rubber Res. Conf., 2: 118-141.

Simmonds, N.W. (1959). Bananas. Longman's Green and Co. Ltd, London.

Singh, M.M., Chick, W.H., Gusha, M.M., Hsia, R.C.H. and Kanapathy, K. (1973). Report of 1972 Cross-checks on foliar analysis of the laboratories. Chem. fertility trop. Soils, Nov. 1973: 117-127.

Smilde, K.W. and Chapas, L.C. (1963). The determination of nutritional status of oil palms by leaf sampling. J. W. Agric. Inst. Oil palm Res., 4: 8-29.

Steenbjerg, F. (1954). Manuring, plant production and the chemical composition of plants. Pl. Soil, 5: 226-242.

Subramanian, T.R., Chadha, K.L., Srinivasamurthy, H.K., Rao, M.H.P. and Melanta, K.R. (1978). Critical levels of NPK in pineapple variety Queen Vatika. 1(1): 51-55.

Thomas, V. (1937). Foliar diagnosis, principles and practices. Pl. Physiol., 12. 571-599.

Thomas, W., Mack, W.B. and Smith, C.B.* (1953). Leaf concentration of five elements in relation to optimum nutrition of a number of horticultural crops. Pennsylvania State Coll. Agr. Expt. Stn. Bull., 7:17.

Tyler, K.B. and Lorenz, O.A. (1964). Diagnosing nutrient needs of melons through plant tissue analysis. Proc. Am. soc. hort. Sci., 85: 393-398.

Tyner, E.H. (1946). The relation of corn yields to leaf nitrogen, phosphorus and potassium content. Proc. Soil Sci. Soc. Am., 11: 317-323.

Ulrich, A. (1946). Plant analysis as a guide to the fertilization of sugarbeets. Proc. Amer. Soc. Sugarbeet Tech., pp. 88-95.

Ulrich, A. (1952). Physiological bases for assessing the nutritional requirements of plants. Rev. Pl. Physiol., 3: 207-223.

Velasco, J.R. and Novero, R.P.* (1953). Studies on foliar diagnosis: I. Nitrogen relations. Phillipp. Agricst., 35: 223-230.

Vomel, A. and Ulrich, A.* (1963). Leaf analysis for the determination of Mn deficiency in sugarbeet. Z. Pfl ernachr. Dueng. Bodenk., 102: 28-45.

Wadleigh, C.H. (1949). Mineral nutritions of plants. A. Rev. Biochem., 18: 655-677.

Ward, G.M. (1963). The application of tissue analysis to greenhouse tomato nutrition. Proc. Am. Soc. hort. Sci., 83: 695-699.

Weir, C.C. (1966). Leaf sampling for foliar analysis of citrus in Trinidad. Trop. Agric. Trin., 43: 153-154.

Yates, F. (1937). The design and analysis of factorial experiments. Tech. Commun. Bur. Soil Sci., Harpenden, 35: 95.

Ziller, R. and Prevot, P. (1963). Le diagnostic foliare: Methode d'etude de la nutrition mineraleson application au cocotier. FAO Tech. Working Party on Coconut Production. Papers presented at first meeting, Trivandrum, pp. 211-242.

*Originals not seen

Appendices

APPENDIX I

Weather data (May 1979 to January 1980)

Month	Rainfall, mm	Temperature, °C		Humidity, %	
		Maximum	Minimum	Morning	Evening
May	162.1	33.33	25.79	90.12	61.68
June	722.7	30.68	23.70	93.47	76.10
July	929.7	37.86	23.81	98.23	85.77
August	472.4	29.16	23.16	94.90	76.87
September	203.7	30.58	23.65	94.30	75.97
October	134.3	31.80	24.46	88.65	63.94
November	316.4	30.82	23.92	88.72	73.48
December	-	30.14	22.82	80.00	57.83
January	-	32.00	22.31	79.90	51.81

APPENDIX II

Effect of NPK treatments on the number of tillers per clump of turmeric

Analysis of variance

Source	df	Mean squares				
		Periods				
		1	2	3	4	5
Block	8	0.38	0.35	0.57	0.53	1.10**
N	2	0.15	0.29	0.40	1.39	1.60*
P	2	0.08	0.14	0.13	0.55	0.26
NP	4	0.10	0.10	0.84	0.36	0.26
K	2	0.06	0.07	1.25	4.97**	0.69
NK	4	0.15	0.16	1.04	1.33	0.24
PK	4	0.34	0.43	0.47	0.91	0.51
NPK	2	0.52	0.03	0.03	2.00	0.31
NPK^2	2	0.13	0.46	0.02	0.42	0.42
NP^2K	2	0.27	0.06	0.40	0.55	2.02
Error	48	0.33	0.44	0.65	0.86	0.36

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

(Appendix II continued)

A. Comparison of levels of N, P and K

Treatment groups	Periods					
	1	2	3	4	5	6
n_0	1.89	1.67	1.57	2.14	2.30	1.78
n_1	2.06	1.79	1.71	2.20	2.72	1.90
n_2	2.09	1.65	1.51	2.37	2.65	2.25
p_0	1.96	1.69	1.58	2.25	2.39	1.90
p_1	2.00	1.65	1.53	2.30	2.60	1.94
p_2	2.07	1.76	1.67	2.16	2.67	2.09
k_0	1.85	1.65	1.54	1.99	2.18	1.88
k_1	2.17	1.71	1.64	2.33	3.03	2.16
k_2	2.02	1.74	1.61	2.38	2.46	1.89
C.D. (0.05)		N.S.	N.S.	N.S.	0.51	0.33

<u>Conclusion</u>

1. Levels of K during 4th period k_1 $\overline{k_2 \ k_0}$

2. Levels of K during 5th period n_2 $\overline{n_1 \ n_0}$

APPENDIX III

Effect of NPK treatments on the number of leaves per tiller of turmeric

Analysis of variance

Source	df	Mean squares Periods 1	2	3	4	5
Block	8	1.65	2.22*	2.27	1.55	0.78
N	2	2.15	0.59	1.37	1.26	7.19**
P	2	0.74	0.04	2.10	5.29	3.13
NP	4	0.78	1.29	2.10	2.42	2.10
K	2	1.64	0.78	1.25	1.49	0.09
NK	4	0.91	0.28	0.33	2.01	0.99
PK	4	1.03	0.49	1.50	0.99	0.30
NPK	2	2.65	0.02	3.26	1.60	0.83
NPK^2	2	0.09	0.19	0.14	0.09	1.95
NP^2K	2	1.20	1.19	0.08	8.62*	1.80
Error	48	1.49	0.82	1.92	1.97	1.05

**Significant at 1% level

*Significant at 5% level

(Appendix III continued)

A. Comparison of levels of N, P and K

Treat-ment groups	Periods				
	1	2	3	4	5
n_0	5.71	5.32	6.87	6.81	7.41
n_1	5.35	5.14	6.78	6.48	6.82
n_2	5.16	5.02	6.44	6.40	6.39
p_0	5.28	5.13	6.73	7.07	7.05
p_1	5.35	5.15	6.40	6.26	7.09
p_2	5.60	5.20	6.95	6.35	6.48
k_0	5.15	5.12	6.94	6.62	6.88
k_1	5.64	5.35	6.60	6.50	6.93
k_2	5.44	5.01	6.54	6.37	6.82
C.D. (0.05)	N.S.	N.S.	N.S.	N.S.	0.56

Conclusion

Number of leaves per tiller at 6th period n_0 $\overline{n_1 \quad n_2}$

APPENDIX IV

Effect of NPK treatments on the height of tiller of turmeric

Analysis of variance

Source	df	Mean squares				
		Periods				
		1	2	3	4	5
Block	8	103.48	168.25	304.31	265.07	236.59
N	2	56.27	450.25	193.17	823.99	25.82
P	2	170.13	221.65	13.95	569.05	12.61
NP	4	350.91	332.70	233.01	563.16	633.62*
K	2	102.52	35.00	76.64	219.67	233.69
NK	4	435.44	409.34	348.77	482.24	751.58*
PK	4	294.00	235.04	302.57	345.96	361.92
NPK	2	146.50	63.71	402.32	1194.78*	3.19
NPK^2	2	179.39	200.11	222.87	615.55	267.37
NP^2K	2	295.62	805.67	789.78*	258.25	313.75
Error	48	220.89	335.40	220.56	346.89	239.77

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

(Appendix IV continued)

A. Comparison of levels of N, P and K

Treatment groups	Periods				
	1	2	3	4	5
n_0	58.68	65.81	91.11	93.73	104.79
n_1	61.15	73.08	89.29	91.46	104.44
n_2	58.62	66.23	85.84	99.17	106.28
p_0	57.99	70.82	89.52	91.61	104.40
p_1	62.38	67.28	88.62	98.19	105.68
p_2	58.07	67.02	88.10	89.57	105.44
k_0	60.61	68.43	90.68	97.60	104.61
k_1	60.60	69.48	87.60	94.86	106.36
k_2	57.23	67.21	87.96	91.90	102.56
C.D. (0.05)	N.S.	N.S.	N.S.	N.S.	N.S.

B. Comparison of NP and NK interactions at fifth period

	p_0	p_1	p_2	k_0	k_1	k_2
n_0	105.85	106.15	102.37	112.78	105.85	95.74
n_1	97.45	113.89	102.00	92.41	112.04	108.89
n_2	109.89	97.00	111.96	108.63	107.19	103.04

C.D. (0.05) = 14.68

APPENDIX V

Effect of NPK treatments and period of growth on the fresh and dry weights of rhizome and total dry matter production of turmeric

Analysis of variance

Source	df	Mean squares		
		Fresh weight of rhizome	Dry weight of rhizome	Total dry matter
Block	2	9.508	0.002	0.042
periods	4	39.114**	0.360**	3.008**
N	2	0.077	0.005	0.034
P	2	1.853	0.009	0.033
NP	4	1.485	0.022*	0.137
K	2	0.568	0.017	0.280*
NK	4	1.558	0.028**	0.294**
PK	4	1.886	0.013	0.108
Error	110	0.851	0.008	0.071

**Significant at 1% level

*Significant at 5% level

(Appendix V continued)

A. Comparison of periods

Periods	Fresh weight of rhizome	Dry weight of rhizome	Total dry matter
2	0.414	0.020	0.234
3	0.783	0.069	0.625
4	1.286	0.153	0.717
5	2.418	0.253	0.974
6	3.326	0.287	1.090
C.D. (0.05)	0.497	0.048	0.144

<u>Conclusion</u>

Fresh weight of rhizome   6 5 4 $\overline{3\ \ 2}$

Dry weight of rhizome $\overline{6\ \ 5}$ 4 3 2

Total dry matter   6 5 $\overline{4\ \ 3}$ 2

B. Comparison of NP and NK interactions

Dry weight of rhizome

	p_0	p_1	p_2	k_0	k_1	k_2
n_0	0.142	0.221	0.142	0.209	0.177	0.118
n_1	0.188	0.144	0.125	0.099	0.196	0.161
n_2	0.125	0.152	0.169	0.167	0.151	0.128

C.D. (0.05) = 0.065

(Appendix V continued)

C. Comparison of levels of potassium for total dry matter

	k_1	k_0	k_2	C.D. (0.05)
Mean	0.815	0.707	0.661	0.111

<u>Conclusion</u> $\overline{k_1 \quad k_0} \quad k_2$ (with a second overline joining k_0 and k_2)

D. Comparison of NK interaction

Total dry matter

	k_0	k_1	k_2
n_0	0.842	0.816	0.614
n_1	0.501	0.889	0.720
n_2	0.779	0.740	0.650

C.D. (0.05) = 0.193

APPENDIX VI

Rhizome yield of turmeric at harvest

Analysis of variance

Source	df	Mean square	
Block	8	0.714	N.S.
N	2	0.061	N.S.
P	2	0.237	N.S.
NP	4	1.115	N.S.
K	2	0.368	N.S.
NK	4	0.146	N.S.
PK	4	0.036	N.S.
NPK	2	0.477	N.S.
NPK^2	2	0.221	N.S.
NP^2K	2	1.586	N.S.
Error	48	0.527	

APPENDIX VII

Effect of NPK treatments and period of growth on nitrogen content of turmeric

Analysis of variance

Source	df	Mean squares						
		N content of leaf	N content of pseudostem	N content of rhizome	Uptake of N in leaf	Uptake of N in pseudo-stem	Uptake of N in rhizome	Total uptake of N
Block	2	0.037	0.082	0.049	9.690	8.008	0.331	62.824
N	2	0.375**	1.035**	0.160	26.891	1.971	5.133	91.663
P	2	0.089	0.195	0.213*	15.413	4.383	7.520	26.266
N x P	4	0.073	0.055	0.150	17.181	3.481	21.400*	105.473
K	2	0.015	0.002	0.151	28.330	9.922	20.279	192.451*
N x K	4	0.026	0.065	0.128	28.776	17.028*	23.954*	202.083*
P x K	4	0.091	0.041	0.021	11.729	8.446	9.761	78.342
Period (T)	5	20.366**	4.784**	18.101**	941.338**	222.057**	376.212**	3315.698**
T x N	10	0.324**	0.254**	0.014	11.174	9.468	6.302	58.968
T x P	10	0.080	0.089	0.086	22.304	5.330	13.795	112.248
T x K	10	0.028	0.021	0.093	5.630	4.301	11.142	41.232
Error	106	0.058	0.078	0.064	15.991	5.312	6.830	59.990

**Significant at 1% level

*Significant at 5% level

(Appendix VII continued)

A. Comparison of periods (Mean values are furnished in Table 15)

<u>Conclusion</u>

N content of leaf	$4\;\;3\;\;6\;\;5\;\;\overline{2\;\;1}$
N content of pseudostem	$\overline{4\;\;1}\,\overline{\;\;5\;\;6}\;\;3\;\;2$
N content of rhizome	$\overline{3\;\;4\;\;6}\;\;5\;\;2$
N uptake of leaf	$\overline{6\;\;5}\,\overline{\;\;3\;\;4}\;\;2\;\;1$
N uptake of pseudostem	$\overline{6\;\;5}\;\;4\;\;3\;\;\overline{1\;\;2}$
N uptake of rhizome	$6\;\;5\;\;4\;\;3\;\;2$
N uptake total	$\overline{6\;\;5}\;\;\overline{4\;\;3}\;\;2$

B. Comparison of levels of nitrogen (Mean values are furnished in Table 15)

<u>Conclusion</u>

N content of leaf	$\overline{n_0\;\;n_2}\;\;n_1$
N content of pseudostem	$\overline{n_2\;\;n_1}\;\;n_0$

C. Comparison of levels of phosphorus (Mean values are furnished in Table 15)

<u>Conclusion</u>

N content of rhizome	$\overline{p_2\;\;p_1}\;\;p_0$

(Appendix VII continued)

D. Comparison of NP interaction

Uptake of N in rhizome

	n_0	n_1	n_2
p_0	4.18	6.08	3.37
p_1	6.82	4.47	4.82
p_2	4.78	4.06	4.97

C.D.(0.05) = 1.693

E. Comparison of levels of K

Total uptake of N (Mean values are furnished in Table 15)

<u>Conclusion</u> $k_1 \quad \overline{k_0 \quad k_2}$

(Appendix VII continued)

F. Comparison of NK interaction

(a) Uptake of N in pseudostem

	n_0	n_1	n_2
k_0	5.14	3.30	5.39
k_1	5.43	6.25	4.62
k_2	4.94	4.89	4.61

C.D. (0.05) = 1.493

(b) Uptake of N in rhizome

	n_0	n_1	n_2
k_0	6.27	3.14	4.82
k_1	5.78	6.25	4.90
k_2	3.73	5.22	4.04

C.D. (0.05) = 1.693

(c) Total uptake of N

	n_0	n_1	n_2
k_0	24.30	14.16	22.40
k_1	24.08	25.37	21.79
k_2	20.34	20.74	19.09

C.D. (0.05) = 5.018

(Appendix VII continued)

G. Comparison of period x N combination

(a) N content of leaf

Periods	1	2	3	4	5	6
n_0	1.32	1.49	3.34	3.86	2.74	2.94
n_1	1.43	1.56	3.27	2.99	2.66	2.85
n_2	1.60	1.49	3.25	3.37	2.74	2.92

C.D. (0.05) = 0.221

(b) N content of pseudostem

Periods	1	2	3	4	5	6
n_0	2.63	1.66	2.16	2.89	2.76	2.63
n_1	2.86	1.82	2.86	2.89	2.71	2.76
n_2	2.94	1.82	3.02	2.96	2.76	2.83

C.D. (0.05) = 0.256

APPENDIX VIII

Effect of NPK treatments and period of growth on phosphorus content of turmeric

Analysis of variance

Source	df	Mean squares						
		P content of leaf	P content of pseudo-stem	P content of rhizome	Uptake of P in leaf	Uptake of P in pseudo-stem	Uptake of P in rhizome	Total uptake of P
Block	2	0.000005	0.0005	0.003	0.053	0.035	0.053	0.214
N	2	0.002**	0.005	0.002	0.041	0.059	0.018	0.266
P	2	0.00003	0.002	0.001	0.034	0.0013	0.113	0.064
N x P	4	0.00006	0.001	0.001	0.055	0.014	0.096	0.398
K	2	0.0002	0.0003	0.0003	0.179**	0.075	0.104	1.133*
N x K	4	0.0001	0.001	0.0007	0.138*	0.103**	0.294*	1.400**
P x K	4	0.0002	0.001	0.0005	0.024	0.053	0.104	0.302
Period (T)	5	0.019**	0.163**	0.019**	1.532**	0.722**	3.738**	11.483**
T x N	10	0.002**	0.003	0.002	0.060	0.034	0.060	0.399
T x P	10	0.0002*	0.003	0.001	0.041	0.030	0.134	0.466
T x K	10	0.0002*	0.0011	0.0005	0.025	0.016	0.070	0.263
Error	106	0.0001	0.002	0.001	0.049	0.025	0.085	0.344

**Significant at 1% level

*Significant at 5% level

(Appendix VIII continued)

A. Comparison of periods
(Mean values are furnished in Table 23)

<u>Conclusion</u>

P content of leaf	$1\ \ 2\ \ \overline{3\ \ 4}\ \ \overline{6\ \ 5}$
P content of pseudostem	$2\ \ 3\ \ \overline{6\ \ 5\ \ 4}\ \ 1$
P content of rhizome	$2\ \ \overline{6\ \ 5\ \ 4}\ \ 3$
P uptake leaf	$6\ \ \overline{5\ \ 3\ \ 4}\ \ \overline{2\ \ 1}$
P uptake, pseudostem	$\overline{6\ \ 5\ \ 3\ \ 4}\ \ 2\ \ 1$
P uptake, rhizome	$\overline{6\ \ 5}\ \ 4\ \ \overline{3\ \ 2}$
P uptake, total	$\overline{6\ \ 5}\ \ \overline{4\ \ 3}\ \ 2$

B. Comparison of levels of nitrogen
P content of leaf (Mean values are furnished in Table 23)

<u>Conclusion</u> $\overline{n_2\ \ n_0}\ \ n_1$

C. Comparison of levels of potassium
(Mean values are furnished in Table 23)

<u>Conclusion</u>

P uptake in leaf	$k_1\ \ \overline{k_0\ \ k_2}$
P uptake, total	$\overline{k_1\ \ k_0\ \ k_2}$

(Appendix VIII continued)

D. Comparison of NK interaction

(a) P uptake in leaf

	n_0	n_1	n_2
k_0	0.622	0.420	0.647
k_1	0.616	0.682	0.659
k_2	0.516	0.578	0.539

C.D. (0.05) = 0.143

(b) P uptake in pseudostem

	n_0	n_1	n_2
k_0	0.453	0.241	0.386
k_1	0.424	0.459	0.361
k_2	0.352	0.349	0.326

C.D. (0.05) = 0.102

(Appendix VIII continued)

(c) P uptake in rhizome

	n_0	n_1	n_2
k_0	0.642	0.306	0.453
k_1	0.534	0.601	0.479
k_2	0.341	0.493	0.505

C.D. (0.05) = 0.189

(d) P uptake, total

	n_0	n_1	n_2
k_0	1.861	1.034	1.601
k_1	1.706	1.869	1.638
k_2	1.319	1.525	1.469

C.D. (0.05) = 0.380

(Appendix VIII continued)

E. Comparison of period x N combination
P content of leaf

Periods	1	2	3	4	5	6
n_0	0.211	0.241	0.191	0.188	0.164	0.164
n_1	0.221	0.202	0.185	0.188	0.152	0.151
n_2	0.248	0.203	0.187	0.188	0.167	0.178

C.D. (0.05) = 0.009

F. Comparison of period x P combination
P content of leaf

Periods	1	2	3	4	5	6
p_0	0.230	0.223	0.187	0.188	0.160	0.160
p_1	0.220	0.218	0.190	0.188	0.157	0.166
p_2	0.230	0.208	0.186	0.188	0.166	0.167

C.D. (0.05) = 0.009

G. Comparison of period x K combination
P content of leaf

Periods	1	2	3	4	5	6
k_0	0.231	0.219	0.190	0.187	0.166	0.163
k_1	0.217	0.219	0.185	0.188	0.162	0.163
k_2	0.232	0.209	0.188	0.189	0.155	0.168

C.D. (0.05) = 0.009

APPENDIX IX

Effect of NPK treatments and period of growth on potassium content of turmeric

Analysis of variance

Source	df	Mean squares						
		K content of leaf	K content of pseu-stem	K content of rhi-zome	Uptake of K in leaf	Uptake of K in pseudo-stem	Uptake of K in rhizome	Total uptake of K
Block	2	0.221	0.170	0.292	54.944	15.195	2.814	140.533
N	2	0.296	1.161	0.058	11.211	45.931	37.665	186.400
P	2	0.034	0.618	0.244	17.006	1.608	62.066	132.866
N x P	4	0.059	1.494	0.921*	29.449	29.872	56.091	315.294
K	2	0.946**	3.964*	0.597	178.758*	89.181**	115.074*	1189.771**
N x K	4	0.197	0.422	0.633	116.916*	60.049**	83.516	754.996**
P x K	4	0.128	2.020	0.117	91.636	50.828*	60.743	476.497
Period (T)	5	58.206**	20.266**	47.843**	3844.406**	690.867**	1764.646**	15293.972**
T x N	10	0.567**	0.675	0.420	25.338	32.676*	26.559	150.670
T x P	10	0.163	0.624	0.172	52.969	12.440	73.809*	365.524
T x K	10	0.127	1.317	0.283	50.494	19.375	57.548	311.615
Error	106	0.127	0.918	0.282	41.063	15.066	34.989	206.335

** Significant at 1% level

* Significant at 5% level

(Appendix IX continued)

A. Comparison of periods
(Mean values are furnished in Table 31)

<u>Conclusion</u>

K content of leaf	$\overline{6\ 5}\ \overline{2\ 1\ 3}\ 4$
K content of pseudostem	$\overline{5\ 6\ 4}\,\overline{\ 2\ 3}\ 1$
K content of rhizome	$\overline{5\ 6}\ 4\ \overline{2\ 3\ \ \ }$
K uptake in leaf	$6\ 5\ \overline{3\ 4}\ \overline{2\ 1}$
K uptake in pseudostem	$\overline{6\ 5}\ 4\ 3\ \overline{2\ 1}$
K uptake in rhizome	$\overline{6\ 5}\ 4\ 3\ 2$
K uptake, total	$\overline{6\ 5}\ \overline{4\ 3}\ 2$

B. Comparison of levels of potassium
(Mean values are furnished in Table 31)

<u>Conclusion</u>

K content of leaf	$\overline{k_2\ k_1}\ k_0$
K content of pseudostem	$\overline{k_1\ k_2}\ k_0$
K uptake in leaf	$k_1\ \overline{k_0\ k_2}$
K uptake in pseudostem	$k_1\ \overline{k_2\ k_0}$
K uptake in rhizome	$\overline{k_1\ k_0}\,\overline{\ k_2}$
K uptake, total	$k_1\ \overline{k_0\ k_2}$

(Appendix IX continued)

C. Comparison of NP interaction

K content of rhizome

	n_0	n_1	n_2
p_0	5.43	5.40	5.77
p_1	5.45	5.73	5.54
p_2	5.87	5.77	5.39

C.D.(0.05) = 0.34

D. Comparison of NK interaction

(a) Uptake of K in leaf

	n_0	n_1	n_2
k_0	16.86	10.95	16.59
k_1	17.01	18.93	17.76
k_2	13.67	16.09	14.34

C.D. (0.05) = 4.15

(Appendix IX continued)

(b) Uptake of K in pseudostem

	n_0	n_1	n_2
k_0	9.51	4.98	8.05
k_1	10.16	11.53	7.95
k_2	8.71	7.55	7.23

C.D. (0.05) = 2.52

(c) Total uptake of K

	n_0	n_1	n_2
k_0	43.47	25.00	37.46
k_1	42.90	48.37	40.06
k_2	34.23	37.16	32.07

C.D. (0.05) = 9.31

E. Comparison of PK interaction

Uptake of K in pseudostem

	k_0	k_1	k_2
p_0	7.46	11.45	6.58
p_1	6.40	9.66	9.51
p_2	8.69	8.54	7.40

C.D. (0.05) = 2.52

(Appendix IX continued)

F. Comparison of period x N combination

(a) K content of leaf

Periods	1	2	3	4	5	6
n_0	3.33	3.78	3.37	3.57	6.04	6.38
n_1	3.56	3.78	3.70	3.01	6.34	6.19
n_2	3.65	3.68	3.28	2.60	6.23	6.32

C.D. (0.05) = 0.33

(b) Uptake of K in pseudostem

Periods	1	2	3	4	5	6
n_0	1.89	3.11	8.25	9.04	16.37	16.10
n_1	2.20	3.63	6.80	11.36	12.83	11.29
n_2	1.86	2.77	8.04	10.48	10.88	12.43

C.D. (0.05) = 3.56

G. Comparison of period x P combination

Uptake of K in rhizome

Periods	2	3	4	5	6
p_0	0.846	3.19	8.81	17.19	17.75
p_1	0.668	5.19	10.01	22.81	18.26
p_2	0.794	3.53	8.12	11.49	22.07

C.D. (0.05) = 5.42

APPENDIX X

Effect of NPK treatments on nutrient content of leaf in relation to leaf positions

Analysis of variance

Source	df	Mean squares: N content of leaf positions	Mean squares: P content of leaf positions	Mean squares: K content of leaf positions
Block	2	0.15	0.0023**	0.05
Position	5	3.21**	0.1290**	1.93**
N	2	0.12	0.0234**	0.17*
P	2	0.03	0.0033**	0.03
NP	4	0.33	0.0019**	0.27**
K	2	0.24	0.0008	0.15*
NK	4	0.48	0.0015**	0.04
PK	4	0.59	0.0012**	0.06
Error	136	0.28	0.0003	0.04

**Significant at 1% level

*Significant at 5% level

A. Comparison of leaf positions

	Leaf positions: 1	2	3	4	5	6	C.D.(0.05)
N content	1.93	1.78	1.59	1.41	1.24	1.00	0.28
P content	0.339	0.249	0.210	0.185	0.165	0.151	0.009
K content	4.28	3.64	3.58	3.64	3.70	3.62	0.107

Conclusion

N content of leaf positions 1 2 3 4 5 6

P content of leaf positions 1 2 3 4 5 6

K content of leaf positions 1 5 2 4 6 3

(Appendix X continued)

B. Comparison of levels of nitrogen, phosphorus and potassium

Treatment groups	N content	P content	K content
n_0	1.48	0.240	3.77
n_1	1.54	0.205	3.78
n_2	1.45	0.204	3.68
p_0	1.46	0.224	3.72
p_1	1.50	0.216	3.76
p_2	1.51	0.209	3.75
k_0	1.54	0.219	3.69
k_1	1.51	0.219	3.79
k_2	1.41	0.212	3.75
S.D. (0.05)	N.S.	0.007	0.075

Conclusion

P content of positions $n_0 \quad \overline{n_1 \quad n_2}$

$p_0 \quad p_1 \quad p_2$

K content of positions $\overline{n_1 \quad n_0} \quad n_2$

$\overline{k_1 \quad k_2} \quad \overline{k_2 \quad k_0}$

(Appendix X continued)

C. Comparison of NP and NK interactions
P content of leaf positions

	p_0	p_1	p_2	k_0	k_1	k_2
n_0	0.252	0.241	0.229	0.252	0.240	0.229
n_1	0.217	0.209	0.188	0.205	0.212	0.197
n_2	0.205	0.197	0.210	0.199	0.204	0.209

C.D.(0.05) = 0.011

D. Comparison of PK interaction
P content of leaf positions

	k_0	k_1	k_2
p_0	0.223	0.232	0.218
p_1	0.227	0.208	0.213
p_2	0.206	0.216	0.206

C.D. (0.05) = 0.011

E. Comparison of NP interaction
K content of leaf positions

	p_0	p_1	p_2
n_0	3.77	3.69	3.86
n_1	3.76	3.75	3.82
n_2	3.61	3.85	3.57

C.D. (0.05) = 0.13

APPENDIX XI

Effect of NPK treatments on oleoresin content of turmeric

Analysis of variance

Source	df	Mean square
Block	2	3.22
N	2	12.39
P	2	3.58
NP	4	3.46
K	2	0.52
NK	4	2.95
PK	4	0.73
Error	6	4.33
C.D.(0.05)		N.S.

APPENDIX XII

Effect of NPK treatments on the nutrient contents of third leaf in relation to period of growth.

Analysis of variance

Source	df	Mean squares		
		Nitrogen, %	Phosphorus, %	Potassium, %
Block	2	0.46*	0.0004	0.06
N	2	0.75**	0.0006	0.09
P	2	0.03	0.00007	0.03
NP	4	0.06	0.00007	0.09
K	2	0.18	0.00006	0.16*
NK	4	0.33	0.00006	0.08
PK	4	0.28	0.00009	0.10
Period	3	23.38**	0.01**	0.72**
Error	84	0.141	0.0003	0.049

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

(Appendix XII continued)

A. Comparison of period of growth

	Period				
	1	2	3	4	C.D.(0.05)
Nitrogen %	1.97	1.59	2.93	3.65	0.20
Phosphorus %	0.242	0.210	0.217	0.182	0.009
Potassium %	3.51	3.60	3.53	3.20	0.118

<u>Conclusion</u>

Nitrogen % $4 \quad 3 \quad 1 \quad 2$

Phosphorus % $1 \quad \overline{3 \quad 2} \quad 4$

Potassium % $\overline{2 \quad 3 \quad 1} \quad 4$

B. Comparison of levels of nitrogen

Nitrogen percentage of third leaf

	n_0	n_1	n_2	C.D.(0.05)
Mean	2.37	2.59	2.64	0.17

<u>Conclusion</u>

$\overline{n_2 \quad n_1} \quad n_0$

C. Comparison of levels of potassium

Potassium percentage of third leaf

	k_0	k_1	k_2	C.D.(0.05)
Mean	3.41	3.44	3.53	0.10

<u>Conclusion</u>

$\overline{k_2 \quad k_1}\,\overline{\quad k_0}$

APPENDIX XIII

Effect of NPK treatments and crop growth on NPK content of soil

	Organic carbon, %	Total nitrogen, %	Available phosphorus, %	Available potassium, %	pH
Pre-treatment soil	1.844	0.252	0.0042	0.0415	5.3
Post harvest soil					
n_0	1.679	0.212	0.0051	0.0401	
n_1	1.801	0.225	0.0042	0.0389	
n_2	1.825	0.224	0.0048	0.0411	
p_0	1.725	0.241	0.0052	0.0395	
p_1	1.852	0.255	0.0051	0.0381	
p_2	1.835	0.261	0.0049	0.0386	
k_0	1.829	0.272	0.0048	0.0395	
k_1	1.872	0.265	0.0053	0.0399	
k_2	1.855	0.272	0.0052	0.0408	

Results of mechanical analysis of pretreatment soil

Coarse sand - 26%   Silt - 21.2%

Fine sand - 22.1%   Clay - 29.75%

FOLIAR DIAGNOSIS, YIELD AND QUALITY OF TURMERIC (*Curcuma longa* L.) IN RELATION TO NITROGEN, PHOSPHORUS AND POTASSIUM

BY

SAIFUDEEN N.

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the
requirements for the Degree of

Master of Science in Agriculture

Faculty of Agriculture
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1981

ABSTRACT

A field experiment was carried out at the Instructional Farm of the College of Horticulture, Vellanikkara during 1979-80 to study the effect of graded doses of nitrogen, phosphorus and potassium on the growth, nutrient uptake, yield and quality of turmeric and also to develope suitable foliar diagnosis techniques in relation to these nutrient elements. The treatments comprised of three levels each of nitrogen (0, 20 and 40 kg N/ha), phosphorus (0, 20 and 40 kg P_2O_5/ha) and potassium (0, 40 and 80 kg K_2O/ha). The experiment was laid out in a 3^3 factorial experiment in randomised block design, confounding the effect of interaction NP^2K^2 totally.

Results revealed that among the morphological characters studied, the number of tillers per clump responded to the increasing levels of nitrogen whereas number of leaves per tiller decreased with increasing levels of nitrogen. The height of tiller was not influenced by any of the fertiliser treatment. The fresh and dry weights of rhizome and total dry matter yield remained unaffected by the levels of nitrogen and phosphorus. The total dry matter production was influenced by the levels of potassium and NK interaction. Maximum production of dry matter took place at k_1 level which was superior to those at k_0 and k_2 levels.

Levels of nitrogen, phosphorus and potassium and their

interaction failed to influence the yield of turmeric at harvest.

The uptake of nitrogen, phosphorus and potassium was not found influenced by the levels of nitrogen and phosphorus employed. But levels of potassium significantly influenced the uptake of these nutrient elements, the k_1 level being superior to k_2 and k_0.

There was a continuous increase in the number of tillers per clump, number of leaves per tiller and height of tiller with advancing period of growth. A period of pronounced and active vegetative growth was observed during the period between 120th and 150th day.

Fresh and dry weights of rhizome increased with increasing age of the crop and attained maximum at harvest.

Uptake of nitrogen, phosphorus and potassium steadily progressed with advancing age of the crop. Maximum uptake of nitrogen and phosphorus took place during the period from 120th day to 150th day whereas the uptake of potassium was maximum during 180th day to 210th day after planting.

The contents of nitrogen, phosphorus and potassium were highest in the top most leaf and continuously decreased with increasing number of the leaf position when the leaves are numbered from top to bottom of the tiller. In considera- tion of the stability of the nutrient level with leaf positions and correlation with uptake of nutrients, the third leaf appeared to be the best suited for foliar diagnosis of nitrogen, phosphorus and potassium status of the crop. The period between 90th to 120th day after planting was recommended as optimum period for the detection and amendment of the nutrient status of the crop.

The graded doses of nitrogen, phosphorus and potassium and their interactions failed to influence the percentage of oleoresin content of turmeric.