THE EFFECT OF SOIL APPLICATION OF N, P AND K ON THE YIELD AND LEAF COMPOSITION IN CHIKU (*Achras sapota* L.) CV. KALIPTTI

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By
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September - 1978

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C E R T I F I C A T E

This is to certify that this Thesis entitled "The Effect of Soil Application of N, P and K on the yield and leaf composition in Chiku (Achras sapota L.) cv. Kalipatti" submitted for the degree of Master of Science (Agri.) in the subject of Horticulture to the Gujarat Agricultural University, Dantiwada, is a bonafide research work carried out by Shri B.T.Kachhadia under my supervision and guidance and that no part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of the investigations have been acknowledged by him.

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L I S T O F T A B L E S

LIST OF APPENDICES

CHAPTER I

INTRODUCTION

Chiku (Achras sapota L.) commonly known as sapodilla or sapota is an important fruit of the tropical and sub-tropical regions of the world. This relatively slow growing ever-green, owing to its comparative freedom from problems because of its suitability to a wide range of soil and climatic conditions, low cost of production, high nutritive value and processing quality of the fruits, covers a large acreage in the country.

During the last three decades, nutrition of trees has occupied a place of considerable importance in commercial orcharding. Intensive investigations have been conducted in several fruit trees, especially Citrus and deciduous fruits and leaf analysis has been developed (Childers, 1976) for formulation of scientific fertilizer recommendations. The fundamental idea behind the use of leaf analysis as the means of determining the nutritional requirements of trees has been clearly stated by Lundegard (1943), and he has pointed out that 'leaf analysis is based on the functioning, assimilating leaves as the central "laboratories" of nutrition'.

For this purpose, analysis of the leaf, based on appropriate sampling method and interpretation of data can be extremely useful. It has been well recognised in different fruit crops that the age of leaf (Koo and Young, 1972); position of leaf on shoot (Furata et al., 1963); height of leaf from ground level and distance from the center (Koo and Sites, 1956); fruiting performance of shoots (Harding et al., 1962); time of leaf sampling (Lieu, 1971); the root stock used (Amin et al., 1976; Cline, 1966-67) etc. may contribute to the variation in nutrition content of the leaves.

In addition to these, soil type (Young and Koo, 1969); season (EL-nagger and Gaffer, 1973); soil temperature (Yusof et al., 1969) and exposure to light (Inoue et al., 1974), also affect the nutrient content of leaves.

The sampling technique in chiku has not been standardised yet. This emphasises the need for studying the leaf composition and its relation to yield in chiku.

Kalipatti is the most commercially grown cultivar of chiku. Therefore, the present investigation was undertaken to study the seasonal changes in mineral composition of young leaf samples in chiku cv. kalipatti with the following objectives:

1. To determine the leaf levels of N, P and K under different levels of soil application of these elements;

2. To study the seasonal variation in leaf content of N, P and K and its possible relation to the biological processes in the trees;

3. The relationship between the soil application and leaf levels of the nutrients to the total yield and

4. To determine the most suitable period for leaf analysis in chiku.

CHAPTER II

REVIEW OF LITERATURE

Assessment of the nutritional status of fruit trees is of great importance for determining the quantity, method and time of application of mineral nutrients for improvement of yield and quality of fruits. It is also helpful in prediction of the yields to reasonable approximation. In fruit trees in which the layout of statistical field trials presents several difficulties, leaf analysis may form a more reliable guide for fertilization.

Ulrich (1952) reviewed the work elucidating the physiological basis for the development of the concept of critical nutrient concentration. Several plant parts have been studied for their utility as indicators of the nutritional status of the trees.

Burr (1955) used the 8th to 10th internodes of stalk as a suitable part to serve as an index.

Ulrich (1942) found that in grape, the petiole was a better index of the potash status than the leaf blade.

Lincoln and Bennett (1927) recorded that total N content as percentage of fresh weight of the whole tree of pear, leaves included, was quite constant throughout the year. If the amount of N in the leaves was excluded, then the percentage composition of the tree was very much lowered during the summer months, reaching nearly one-half of the winter values. They found that during mid-summer, over half of the N of the tree was in its foliage. Roughly two-thirds of the tree's N was above ground. The bark of the tree, above and below ground, contained about one-third of the tree's N. The unpruned trees had more of their weight and more of their N above ground.

Butijn (1957) discussing the leaf and soil analysis as a guide to the nitrogen nutrition of apple and pear concluded that the analysis of leaf samples was a good guide. Leaf being the seat of maximum metabolism in plants, most workers have finally fixed on the leaf as an index of the nutrient status in most fruit trees.

However, the composition of the leaf varies with its position. Koto and Takeshita (1955) found that in satsuma orange, N content of leaves was highest in the upper part of the crown, lowest in the middle part and intermediate in the lower part.

Tok et al. (1963) studied the leaves collected in June and August from trees of Magnolia grandiflora, to

determine the influence of the leaf position in regard to height from the ground, position on the shoot and compass direction on the content of N, P, K, Ca, Mg. They reported that all positions influenced leaf composition of one or more elements at both sampling dates. Changes in composition from June to August were also influenced by leaf position.

Mochizuki and Handa (1958) found that the 9th and 17th leaves on an apple shoot had the highest nitrogen content and that the leaves below the 13th leaf, which was the smallest, represented the nitrogen status of the tree and those above it, the response to current application of nitrogen. On the other hand, Uriu and Crane (1977) reported that in pistachio, the composition of leaflets did not differ significantly with their position, leading them to conclude that the leaflets may be used instead of whole leaves for sampling. Chadha et al. (1973) found significant differences between the composition of leaves of guava taken from ten successive positions.

Age is an important factor affecting leaf composition. Gopalakrishna and Gotmare (1963) showed that in 12 year old sapodillas, the age of leaf and date of sampling had a pronounced effect on leaf composition. They came to the conclusion that 3 to 5 month old leaves from winter flush could be a reliable index.

Sen (1973) studied the spring flush of two mango varieties which showed a decline in the percentage of leaf nitrogen during the four weeks from the commencement of flush. Chadha et al. (1973) found in the guava cultivar, Allahabad Safeda, the N, P and K contents decreased and the Mg, Ca and Fe contents increased with advance of leaf age.

Randhawa and Kar (1967) found that the N content remained high at the initial stage and thereafter decreased with the age of the shoots of Mandarin. They also pointed out that both the dry matter and ash exhibited an increasing trend with the maturity of shoots. P and K declined in their concentration with the increase in age of the shoots. Jones and Parker (1950) found a decline in the N, P and K content of the leaves with age in orange. Young and Koo (1971); Koo and Young (1972) and Pathak and Pandey (1976) found that the K content of leaves decreased with increase in age of mango leaves.

However, leaves of the same age also show a wide variation in the nutrient content. Wallace et al. (1952, a) found that 8 months old leaves collected from a single Valencia orange tree showed wide variations in nutrient content ranging from 1.61 to 2.65 in the case of nitrogen, 0.089 to 0.145 in phosphorus and so on. They conclude that the maximum number of leaves to be sampled has to be

determined in order to utilize the data on leaf analysis. Chadha et al. (1973) found that the sample size varying from 20 to 50 leaves did not affect leaf composition data. Lilleland and Brown (1942) found that the variations in the P content of the leaf were found between adjacent peach trees and a greater variability was associated with the trees having the higher analysis. The average of 100 trees showed satisfactory agreements.

There is generally a difference in the nutrient content of leaves on fruited and non fruited shoots. Wallace and Zidan (1954) reported that non fruited shoots of citrus trees had 16% more N in the leaves than the fruited shoots. Harding et al. (1962) also found significantly more amounts of N, P and K in leaves on non-fruited shoots of orange than on the fruited ones. Gupta (1972) reported significantly higher levels of N, P and K in the leaves of non-fruited shoots than those of fruited shoots in mango.

Chadha et al. (1973) found that the leaves from non-fruiting shoots of guava contained more of N, P and K than leaves from fruiting shoots.

Aiyappa et al. (1967) found that in order to establish the nutrient status in healthy, high performing and high yielding Coorg mandarin seedling trees and to

guide the fertilization programme, leaf samples were collected from three different zones in Coorg, selecting two age group orchards of 15 and 10 years in each of the trees. They found a trend of comparatively higher content of P_2O_5, K_2O and N was noticed in all the zones in the leaves of non-fruit bearing terminals than in fruit bearing ones in 15 year old orchards. The same trend was observed in the case of 10 year old orchards except for K_2O in Murnad and P_2O_5 in Somwarpet zones.

Singh and Rajput (1976) reported that in guava the potassium contents in leaves were on peak before flush growth commenced and declined gradually with advancement of growth. January-February and July-August were reported to be the most suitable period for potassium study.

Changes in the dry weight, ash and macro-nutrient status (N, P, K, Mg, and Ca) of leaves from four different growth cycles of young bearing valencia orange trees was followed over a two year period in Florida by Smith and Reuther (1950), selecting non-fruiting terminals of growth when they were quite young, marking them with tags, and sampling them at frequent intervals thereafter. In general, the broad trends in leaf composition were in agreement with those found by previous workers, but they were shown with greater precision and detail than here to fore, and additional

ramifications were indicated. The dry weight of leaves increased rapidly at first as enlargement proceeds, and thenceforth increase or decrease somewhat depended on the growth activity of the tree and other factors. All constituents measured, when expressed on the basis of milligram per leaf, showed the same rapid influx into the leaf as it expanded to mature size. Some constituents then began to migrate out of the leaf, others remained fairly constant. When expressed as percentage of dry matter, each showed characteristic trends in relation to age and tree growth factors. In order to secure representative leaf samples from non-fruiting branches they felt that leaves 3 to 6 months old would be the best. Since plateaus exist for each of the measured elements, matured more rapidly than spring leaves.

Randhawa and Kar (1967) found that different flushes in mandarin showed variations in respect of their composition. Phosphorus and potassium were rich in September flush followed by June, July and March flushes.

Saini and Singh (1975) reported that the nutrient concentration in the leaves of young vines varied at different stages of growth. Nutrients like N, P and K were at higher level in April, decreased gradually upto June, then increased again in July-August and remained nearly at same level of September. Application of N, P and K fertilizers increased

the level of those nutrients in the leaves. Levels of N and K were higher than that noticed for P. Application of higher doses of N and K had a tendancy to decrease the level of P in the leaves.

The leaf composition is influenced by the root stock. Castle and Krezdorn (1975) studied the mineral content of 'Orlando' tangelos on eleven root stocks. The level of leaf N, P and Ca, Mg but not P was related to root stock, suggesting a differential absorption of mineral nutrients by root stock. The level of N appeared to be influenced by root distribution. Trees with deep extensive root systems or with a large number of feeder roots near the surface had high leaf N, leaf K was significantly correlated with depth of rooting.

Samiullah and Narasimham (1977) reported significant differences in the leaf composition of Sathgudi orange on six different root stocks. Gupta (1972) observed appreciable differences in the leaf composition of two varieties of mango on three pdy embyonic root stocks. The relationship between the nutrition applied to the tree and its effect on leaf composition was studied by several workers. Kumar et al. (1974) found that many mango trees could meet their nutritional requirements from deep alluvial soil of Punjab even when never manured. Mineral composition of leaves of trees, which were given regular but light doses of farm yard manures and nitrogenous fertilizers, was not much

different than those of never fertilized trees.

After standardising the leaves to be sampled and the time of sampling, the leaf composition is related to the yield.

Poulsen (1971) showed that the relationship between the yield of apple trees and leaf N content allows a convex curve with two clearly different zones, deficiency at 1.6 - 2.1 percent and optimum at 2.1 - 2.8 percent of nitrogen.

Singh and Rajput (1976) reported that yield of guava fruit was increased upto 4 percent concentration of muriate of potash and beyond this it declined. Positive and highly significant correlation coefficients were found for yield with leaf K content. They further pointed out that quadratic regression equations were fitted between yield of guava fruits and rate of potassium applications. The most productive range for K value was 1.25 to 1.47 percent on dry weight basis.

Seasonal changes in leaf nutrient levels were recorded by many workers and hopes were raised about studying continuous nutrient metabolism in the tree.

Analysis of leaves of mango cv. Kent by Avilan (1971) showed that N, P and K levels were highest before flowering fell during flowering and fruit formation.

The effect of one applied nutrient on the uptake of another applied nutrient has been studied by interpreting the leaf composition as an index of uptake.

Cline (1966) studied the effect of N additions with and without added K, on the early growth and nutrient composition of young apple trees on a sandy soil. The growth of trees was depressed when K was applied with N. Leaf N and leaf K reflected fertilizer treatments. However, levels of both N and K were adequate even without fertilizer applications. Mg uptake was depressed to deficient levels by K fertilization. Both scion variety and root stock had important influence on leaf composition. High rate of fertilizer depressed growth.

Singh and Rajput (1976) reported that application of muriate of Potash appreciably increased K content and decreased the N content in guava leaves.

Reese and Koo (1975) found that higher N rates increased fruit production and yield of soluble solids in oranges. High K application decreased soluble solids. Increase in tree canopy area between 1968 to 1974 was related to N but not to K applications. Maximum yield response with N in three cultivars was attained at 202 kg/ha/yr. They further pointed out that the 'Hamlin' orange gave maximum yield response to K at 167 kg/ha/yr.,

whereas Pineapple and Valencia orange gave maximum yield at 112 kg/ha/yr. Leaf analysis showed that increased application resulted in higher leaf N but lower P and K levels. Increased K application showed higher P and K levels.

Saini and Singh (1975) found that in young vines, application of N, P and K fertilizers increased the level of these nutrients in leaves. Leaf levels of N and K were higher than that noticed for P. Application of higher doses of N and K had a tendency to decrease the level of P in leaves.

Jones and Parker (1950) found that the application of triple super phosphate slightly increased the P content of the leaves of orange, and the application of K fertilizer markedly increased the potassium content of the leaves. The application of triple super phosphate also increased the calcium and magnesium contents and decreased the potassium content of the leaves.

According to Nathan and Shoemaker (1963), peach leaves in late May or early June in peninsular Florida contained approximately 3% N and 1% K. Higher percentage of N was associated with delayed ripening and lower levels were associated with reduced yields. Lower percentage of K was also associated with reduced yields and higher

percentage may be indirectly associated with poor quality because of consequent low calcium levels. Minimum desirable amounts of leaf calcium, magnesium and potassium were set at 1.0%, 0.3% and 0.1% respectively; larger amounts of these three elements have not been determined. They further pointed out that in the soils limed to a pH of 5.9 to 6.4 the desired levels of nutrient in the leaves can be controlled by adjusting the quantity of N applied on the basis of tree size and by keeping the $N:K_2O$ ratio between 2:1 and 3:1.

Jones et al. (1957) found that fruit yields from individual plots were much more variable than leaf composition of certain fruit quality factors. The data emphasize that in the planning of orchard experiments, the probable variability of the factors to be measured should be known. On the basis of their experience with orange, lemons and avocados, they have presented a series of curves which should be helpful in designing field experiments with these and other tree crops.

Sahay and Ram (1970) reported that leaf N content of the order of about 1.35% and below was an indicator of a demand for N on the part of mango trees. They observed that leaf P content of 0.30% and above and leaf K content of 1.20% and above perhaps represented levels of luxury consumption for these elements in mango.

Khera and Chundavat (1976) studied the seasonal variation in macro nutrient levels of leaves of guava under one or two crop intensities. They noted that the N content was more in new leaves than fully expanded ones. There was not much difference in total N uptake during the flush and variation within the month between two treatments. P and K contents were also higher in new leaves than fully expanded leaves. The leaf P and K contents were low during development (November) and at the maturity (January). Their content was also low where two crops were allowed.

Amin et al. (1976) showed that chiku plants grafted on Rayan have given yield higher than the same propogated by layering. The data compiled of the cumulative yield indicate that the application of yearly increasing dose of 68 g. of nitrogen, phosphorus and potassium and thereby giving 2.500 kg of N, P and K in the 32nd year of chiku grafted on rayan and application of 2.500 kg of N and K in the case of Gooty plants have given higher yield compared to all treatments.

Patel, Majmudar and Barevadia (1976) revealed that the results of the trees indicated the treatment giving 6 kg of N, 12 kg of P_2O_5 and 6 kg of K_2O was significantly beneficial for maximum fruit production of chiku when compared with other fertilizer treatments to get maximum net returns.

Patil and Naswadker (1974) presented the data on the flowering, fruit set and fruit drop of 15 year old sapodilla trees, cv. Kalipatti. The time from flower-bud emergence to anthesis was 33-34 days. Fruit set was high (22%) with natural pollination and there was no parthanocarpic fruit development. About 94% of the flower-buds developed into flowers, but of these only 53% set fruits, of the latter only 11% developed and were retained on the tree until maturity. Fruit drop attained a maximum immediately after fruit set.

The above review brings out the paucity of information needed for the standardisation of the leaf analysis technique for assessment of nutrient status and its relation to performance of chiku trees. The present study endeavours to obtain this information.

CHAPTER III

MATERIALS AND METHODS

Experimental Site:

The studies were undertaken at the experimental orchard of the Regional Fruit Research Station, N.M.College of Agriculture, Navsari, in Gujarat State. Navsari is situated on the coast of the Arabian Sea at an altitude of about 12 metres above mean sea level, latitude 20°-57' North and longitude 72°-54' East. It has an equable climate, with an average maximum temperature ranging from 37.8°C to 29.6°C and minimum temperature ranging from 23.8°C to 10.0°C in summer and winter respectively. Meteorological data tabulated for the period 1977-78 (January 1977 to April 1978) are given in Appendix 1.

The soil (0 to 25, 25 to 105, 105 to 131 and 131 to 140 cm. depth) of the experimental site was classified as Jalalpur Vertic ustochrepts with the clay texture. The N, P and K nutrient content of the soil ranges from 0.033% to 0.045%; 0.0008% to 0.002% and 0.010% to 0.0312% respectively (Desai and Patel, 1970), which represents the chiku growing area of the region.

Experimental design:

The experiment was laid out in randomised block design with factorial concept. There were two replications having two trees per plot. Chiku grafts of variety Kalipatti on rayan (Manilkara hexandra Rexb) rootstock were planted in the year 1970. The distance between plants was 9.0 x 9.0 metres. The experimental trees for the study were of uniform growth and vigour.

The three levels of nitrogen, phosphorus and potash were planned to increase in graded doses with age, starting with 0, 45 and 90 g. each of N, P and K per tree in the first year with the same quantity of increment each year upto the 10th year. In the 8th year (the year of the present study), the levels were 0, 360 and 720 g. Nitrogen was applied in the form of urea, phosphorus in the form of super phosphate and potash in the form of muriate of potash. These fertilizers were applied in two splits, half of these doses on 18th May 1977 and the remaining half on 24th October 1977.

Treatments.

The details of treatment combinations are given in Table 1. The experimental plots were irrigated on the following dates during the study period:

1. 21-5-77 to 27-5-77
2. 26-10-77 to 29-10-77
3. 20-11-77 to 24-11-77
4. 21-12-77 to 24-12-77
5. 21-2-78 to 26-2-78

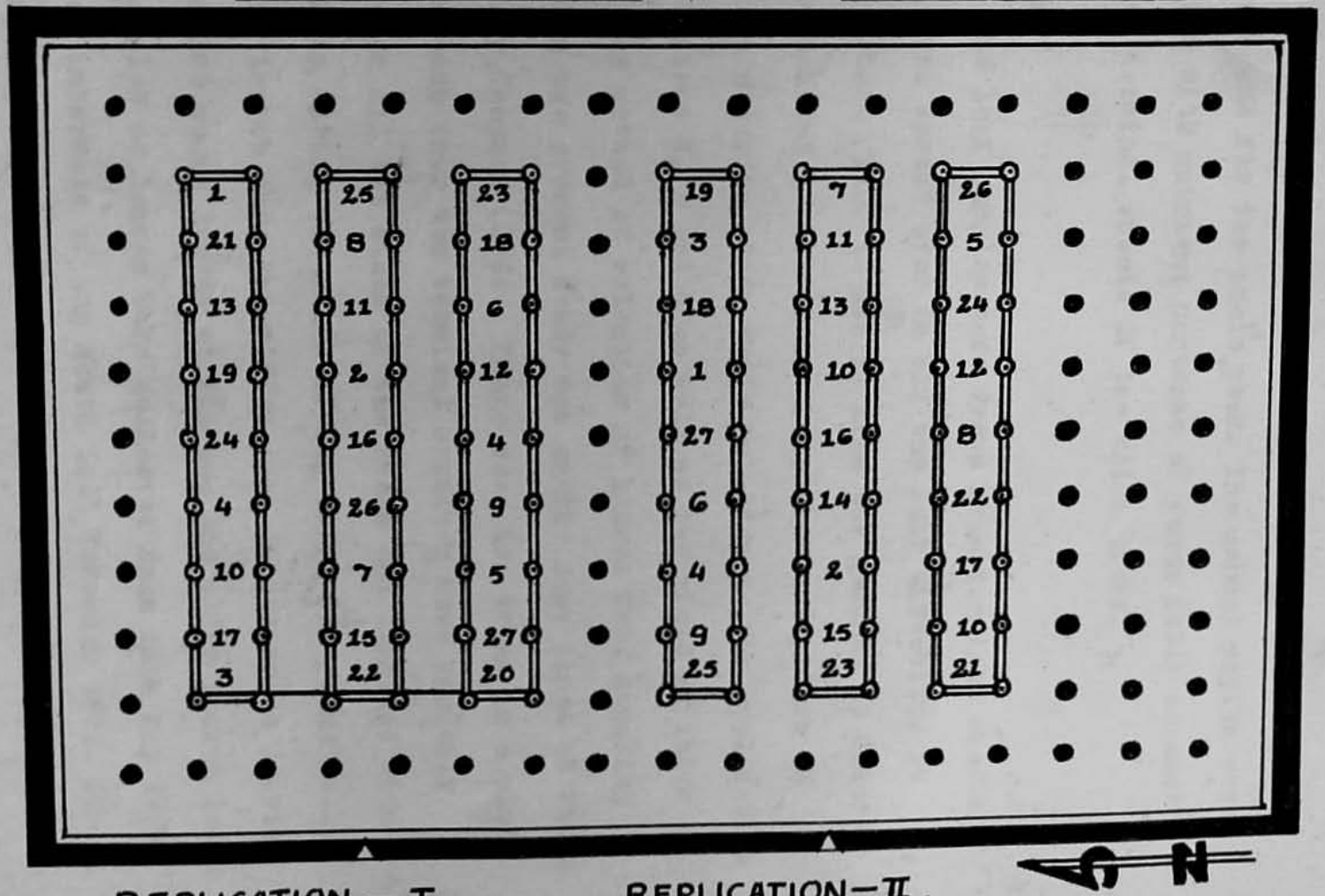
Table 1. Details of the treatment combinations

Sl. No.	Treatment combination	Details N	P	K in g/treat.
1	N_0 P_0 K_0	0.000	0.000	0.000
2	N_0 P_0 K_1	0.000	0.000	0.360
3	N_0 P_0 K_2	0.000	0.000	0.720
4	N_0 P_1 K_0	0.000	0.360	0.000
5	N_0 P_1 K_1	0.000	0.360	0.360
6	N_0 P_1 K_2	0.000	0.360	0.720
7	N_0 P_2 K_0	0.000	0.720	0.000
8	N_0 P_2 K_1	0.000	0.720	0.360
9	N_0 P_2 K_2	0.000	0.720	0.720
10	N_1 P_0 K_0	0.360	0.000	0.000
11	N_1 P_0 K_1	0.360	0.000	0.360
12	N_1 P_0 K_2	0.360	0.000	0.720
13	N_1 P_1 K_0	0.360	0.360	0.000
14	N_1 P_1 K_1	0.360	0.360	0.360
15	N_1 P_1 K_2	0.360	0.360	0.720
16	N_1 P_2 K_0	0.360	0.720	0.000
17	N_1 P_2 K_1	0.360	0.720	0.360
18	N_1 P_2 K_2	0.360	0.720	0.720
19	N_2 P_0 K_0	0.720	0.000	0.000
20	N_2 P_0 K_1	0.720	0.000	0.360
21	N_2 P_0 K_2	0.720	0.000	0.720
22	N_2 P_1 K_0	0.720	0.360	0.000
23	N_2 P_1 K_1	0.720	0.360	0.360
24	N_2 P_1 K_2	0.720	0.360	0.720
25	N_2 P_2 K_0	0.720	0.720	0.000
26	N_2 P_2 K_1	0.720	0.720	0.360
27	N_2 P_2 K_2	0.720	0.720	0.720

FIGURE :- A PLAN OF THE EXPERMENT.

REGIONAL FRUIT RESEARCH STATION — NAVSARI.

● :→ GUARD LINE TREES, ⊖ :- TREATMENT LINE TREES.



REPLICATION — I REPLICATION — II.

DISTANCE BETWEEN TREES :→ 9.0 x 9.0 METRES.

Fruit Yield Data.

Mature fruits were harvested as and when ready for harvest. The fruit yields were recorded on each picking date from 27th July 1977 to March 1978 and totalled up for each month and for the whole year. The annual yields were correlated with nutrient contents of young fully expanded leaves of terminal shoots of the chiku trees.

Sampling

The leaf samples were drawn from terminal shoots of each tree spread over in all the four directions at uniform height (1.00 to 1.5 m) from the ground; to determine the content of nitrogen, phosphorus and potash in leaves, in order to study their relation to the application of fertilizers N, P and K as well as the yield of chiku fruits. The method of selection of leaves for sampling adopted in the present study was on the same lines as those adopted by Chapman (1964). There were two trees in a plot and from each tree ten terminal branches were randomly selected on all the sides of the trees and labelled with zinc labels during the month of May 1977. Two young fully developed leaves were drawn from each tagged shoot leaving the immature young leaves at the top and older leaves lower down. Samples of leaves were collected from 18th May 1977 onward at intervals of one month till November 1977. On each sampling date leaves from each replication of treatment

were drawn for the purpose of chemical analysis. They were immediately placed in brown paper bags and taken to the laboratory. The samples were washed under tap water and dried at 65°C to 70°C for 36 hours, ground in an electric Multiplex Mill and were sieved through 40 mesh sieve.

Method of Chemical Analysis.

a) Nitrogen: From the leaves prepared as above, a 100 mg sample was taken and digested in Kjeldahl flask of 100 ml capacity by adding 2 ml concentrated sulphuric acid and heating on an electric heater for 30 minutes. Then 0.2 ml H_2O_2 was added and heated till the contents became colourless. After complete digestion the contents of the flask were transferred into a 100 ml volumetric flask and made up to 100 ml with distilled water. An aliquot of 5 ml was pipetted out into a 50 ml volumetric flask, 0.2 ml of Nesseler's reagent, 2 ml of sodium tartrate solution (10%) and distilled water were added to make up to 50 ml. The colour was developed in 10 minutes. The colour was measured in Klett Summerson Photo electric calorimeter with a blue filter, 420 nm (Snell and Snell, 1955). Nitrogen was calculated from the standard curve drawn using a series of known concentrations of ammoniacal nitrogen solution.

b) Phosphorus: From leaves prepared as above, one gram of leaf sample was taken in a 100 ml conical flask. Then 15 ml of the tri-acid mixture (10:1:4 HNO_3:H_2SO_4:$HClO_4$) was added.

The conical flasks were kept overnight, then heated on electric hot plate upto 200°C. They were cooled and contents were transferred to 50 ml volumetric flasks and volume was made up with distilled water. Phosphorus was estimated using Vanado molybdo phosphoric yellow colour method as described by Jackson (1967).

An aliquot of 10 ml was pipetted out into a 50 ml volumetric flask. Then 10 ml of vanadomolybdate reagent was added, and the solution was diluted to 50 ml with distilled water and mixed well. The colour developed rapidly but it was usually read after 10 minutes to assure full strength. The colour was read in the Klett Summerson photo electric colorimeter with a blue filter, 420 nm.

Phosphorus was calculated from the standard curve drawn using a series of known concentrations of phosphate standard solution.

c) Potassium: From the extract prepared by digesting the samples with ternary acid above, an aliquot of 5 ml was pipetted out into a 50 ml volumetric flask and it was diluted to 50 ml with distilled water. The concentration of potassium was measured with the help of Systronic electric flame photo meter. The concentration of potassium was calculated from the standard curve drawn using a series of known

concentration of potassium chloride.

Statistical Analysis

The yield data and the data on the leaf content of nutrients obtained during the course of experimentation were used as a factorial experiment and analysed by the method shown by Fisher and Yates (1938). The correlation between yield and content of nutrients N, P and K were also analysed by this method. The critical difference at 5% level of probability was also worked out.

Economy

Incremental cost benefit ratio was calculated for the different treatments, as per the method suggested by Patel (1976). The fertilizer response was in comparison with the production with no fertilizer, keeping other conditions constant and it represents the return on investment in fertilizers only and not on total investment towards cost of labour and other resources used.

CHAPTER IV

EXPERIMENTAL RESULTS

A fertilizer trial on chiku is in progress in the orchard of the Regional Fruit Research Station, N. M. College of Agriculture, Navsari, District Bulsar, Gujarat State, on kalipatti cv. of chiku (*Achras sapota* L.) grafted on rayan (*Manilkara hexandra* Rexb) rootstock. Three levels of N, P and K were applied in all combinations, constituting twentyseven treatments. The details of treatments are given in Materials and Methods Chapter.

The levels of fertilizer applied to these trees in May 1977 (the year of the experiment) were 0, 360 and 720 g. of N; 0, 360 and 720 g. of P and 0, 360 and 720 g. of K as the three levels of fertilizations with each element. Fruits were harvested on different dates in the months of July '77, August '77, November '77, December '77, January '78 and March '78 as and when fruits were at the right stage of maturity. Yield was recorded in each picking and total yield from July 77 to March 78 under each treatment is presented in Tables 1a and 1b. The analysis of variance is furnished in Appendix-II.

The difference in yield between the treatments was statistically significant. On partitioning the effects,

Table 1a:- Total Yield of Chiku Fruits from July 1977 to March 1978

Kg/plot of two trees.

	Ko				K1				K2				
	Po	P1	P2	Total	Po	P1	P2	Total	Po	P1	P2	Total	Total
No	46.550	33.800	56.075	136.425	62.400	49.950	68.550	180.900	37.625	35.150	32.300	105.075	422.400
N1	87.600	72.650	73.000	233.250	67.900	80.600	70.600	219.100	95.650	121.900	74.900	292.450	744.800
N2	52.500	121.850	105.900	280.250	103.500	116.700	55.650	275.850	86.300	97.450	85.150	268.900	825.000
To-tal	186.650	228.300	234.975	649.925	233.800	247.250	194.800	675.850	219.575	254.500	192.350	666.425	1992.20

Table 1b:-

	NP Table				NK Table				PK Table			
	Po	P1	P2	Total	Ko	K1	K2	Total	Ko	K1	K2	Total
No	146.575	118.900	156.925	422.400	136.425	180.900	105.075	422.400	Po	186.650	233.800	219.575	640.025
N1	251.150	275.150	218.500	744.800	233.250	219.100	292.450	744.800	P1	228.300	247.250	254.500	730.050
N2	242.300	336.000	246.700	825.000	280.250	275.850	268.900	825.00	P2	234.975	194.800	192.350	622.125
	640.025	730.050	622.550	1992.200	649.925	675.850	666.425	1992.200		649.925	675.850	666.425	1992.200

	Main Effect			Sub Effect			
	N.	P.	K.	NP.	PK.	NK.	NPK
'F' test result.	Sign.	NS	NS	NS	NS	Sign.	NS
C.D. at 5% level.	6.48	—	—	—	—	11.22	—
C.D. at 1% level.	-	—	—	—	—		
C.V.				25.63			

it was noted that the effect of nitrogen was significant but not that of phosphorus and potassium.

Mean yields with N_1 and N_2 levels of fertilization were significantly higher than those with N_0 level. N_2 level gave higher yields than N_1 level. Phosphorus did not significantly affect the yield but in combination with N_1 at N_1K_2 level of nitrogen and potash; P_1 level tended to improve the yield.

Potassium alone also did not significantly affect the yield. However, interaction N2K2 was significant.

Mature fruits were harvested in the months of July 77, August 77, November 77, December 77, January 78 and March 78. Out of these significant differences in yield due to treatment were observed in the month of August and November 77 (Appendix III a, b, c, d, e, f and g).

The yield of mature fruits tended to increase upto December. The peak period for harvest was observed in the month of November and December. It was found that after December there was a steeper fall in the yield which reached to minimum in the month of March 78.

In order to assess the effect of the nutrients on the earliness of yield, the mean percentage of the cumulative yield upto each month has been calculated and presented in Table 2.

It is revealed from the result that at the end of July 77 N_0 level of nitrogen yielded only 4.71% of the total yield, while with N_1 it was 11.87% and with N_2 level 14.27%.

Table 2 . Mean percentage of cumulative yield after each month (kg per treatment) under the three levels of Nitrogen, Phosphorus and Potassium application.

Treatments	July 77	August 77	November 77	December 77	January 78	Mean
No	4.71	20.78	39.34	87.22	97.79	49.97
N1	11.87	23.58	47.25	90.39	97.23	54.06
N2	14.27	26.13	56.45	91.16	96.98	56.99
Mean	10.28	23.50	47.68	89.59	97.33	53.68
Po	10.11	23.70	49.25	88.38	97.00	53.68
P1	9.66	22.22	46.47	90.61	97.47	53.35
P2	10.78	24.57	47.32	89.78	97.53	53.99
Mean	10.28	23.50	47.68	89.59	97.33	53.68
Ko	12.26	26.00	47.76	91.27	97.64	54.99
K1	9.66	22.95	47.38	88.56	96.72	53.05
K2	8.92	21.53	47.91	88.94	97.65	52.99
Mean	10.28	23.50	47.68	89.59	97.33	53.68

No such trend was observed with phosphorus or potassium. It was further observed that there was a tendency to reducing the percentage of yield in the month of July 77 and August 77. Though the trees were apparently uniform in behaviour with respect to yield, the coefficient of variability of the overall yield was 25.63. It was 92.69 in July when the yield was low and 35.73 in December when the yield was higher.

In order to assess the influence of the applied nutrition on the nutrient status of the tree, young fully developed leaves of the terminal shoots were sampled for analysis of nitrogen, phosphorus and potassium content.

Nitrogen

The nitrogen content in leaves under different treatments in the months of May 77 to November 77 are presented in Tables 3,a,b, c, d, e, f and g. The average N content of the leaves in the month of May was 1.160 per cent in N_0 treatment, while it was 1.438 and 1.643 in the N_1 and N_2 treatments respectively. It revealed that there is significant increase in the N content of leaves with higher levels of nitrogen fertilization.

It was also observed that the N content of the leaf increased with the levels of phosphorus and potassium application to the soil (Fig. 1.1a).

Table 3:- Nitrogen Content of Chiku Leaves (per cent dry weight) sampled in Different Months From Trees Under Different Treatments.

Sr. No.	Treatments			Sampling dates						
				18-5-77	18-6-77	18-7-77	18-8-77	18-9-77	18-10-77	18-11-77
1	No	Po	Ko	1.022	0.665	1.029	0.724	0.805	0.826	1.092
2	No	Po	K1	1.036	0.728	1.036	0.721	0.854	0.882	1.106
3	No	Po	K2	1.057	0.700	1.022	0.812	0.903	0.954	1.155
4	No	P1	Ko	1.120	0.749	1.067	0.868	0.923	1.064	1.225
5	No	P1	K1	1.141	0.770	1.120	0.910	0.903	1.120	1.253
6	No	P1	K2	1.218	0.784	1.144	1.029	0.992	1.162	1.267
7	No	P2	Ko	1.267	0.840	1.106	1.001	1.029	1.218	1.302
8	No	P2	K1	1.281	0.917	1.232	1.064	1.099	1.202	1.358
9	No	P2	K2	1.302	0.994	1.253	1.134	1.169	1.295	1.435
10	N1	Po	Ko	1.344	1.050	1.281	1.183	1.225	1.281	1.526
11	N1	Po	K1	1.358	1.106	1.256	1.211	1.246	1.316	1.526
12	N1	Po	K2	1.372	1.134	1.295	1.176	1.275	1.316	1.498
13	N1	P1	Ko	1.442	1.148	1.302	1.232	1.309	1.337	1.561
14	N1	P1	K1	1.463	1.225	1.361	1.372	1.337	1.330	1.539
15	N1	P1	K2	1.463	1.253	1.361	1.428	1.344	1.351	1.131
16	N1	P2	Ko	1.477	1.246	1.369	1.442	1.365	1.372	1.131
17	N1	P2	K1	1.505	1.302	1.386	1.463	1.337	1.351	1.163
18	N1	P2	K2	1.519	1.309	1.400	1.518	1.351	1.449	1.187
19	N2	Po	Ko	1.540	1.323	1.431	1.512	1.373	1.456	1.701
20	N2	Po	K1	1.568	1.274	1.484	1.582	1.337	1.414	1.750
21	N2	Po	K2	1.610	1.295	1.463	1.512	1.400	1.407	1.757
22	N2	P1	Ko	1.617	1.365	1.477	1.603	1.463	1.393	1.771
23	N2	P1	K1	1.652	1.414	1.408	1.568	1.379	1.400	1.806
24	N2	P1	K2	1.673	1.428	1.540	1.645	1.393	1.414	1.820
25	N2	P2	Ko	1.701	1.464	1.540	1.611	1.484	1.463	1.848
26	N2	P2	K1	1.708	1.554	1.498	1.589	1.533	1.624	1.867
27	N2	P2	K2	1.715	1.568	1.561	1.666	1.561	1.624	1.967
	Mean			1.414	1.133	1.315	1.281	1.236	1.298	1.548
'F' test result.				Sign.	Sign.	Sign.	Sign.	Sign.	Sign.	Sign.
S.Em ± :				0.0510	0.0436	0.0424	0.0707	0.0380	0.0339	0.0412
C.D. at 5% level.				0.1483	0.1267	0.1234	0.2056	0.1107	0.0986	0.1199
C.D. at 1% level.				0.2004	0.1714	0.1666	0.2779	0.1493	0.1332	0.1619
C.V. :				5.10	5.44	4.56	7.81	4.36	3.69	3.77

Table 3a. N Content of the Leaf in the Month of May 1977.

	Ko				K1				K2				
	P_o	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
N_o	1.022	1.120	1.267	1.136	1.036	1.141	1.281	1.153	1.057	1.218	1.302	1.192	1.160
N_1	1.344	1.442	1.477	1.421	1.358	1.463	1.509	1.442	1.372	1.463	1.519	1.451	1.438
N_2	1.540	1.617	1.701	1.619	1.568	1.652	1.708	1.643	1.610	1.673	1.715	1.666	1.643
Mean	1.302	1.393	1.482	1.392	1.326	1.419	1.498	1.412	1.346	1.451	1.512	1.436	1.414

	N.	P.	K.	N.P.	N.K.	PK	N.P.K.
S.Em. ±	0.0170	0.0170	0.0170	0.0294	0.0294	0.0294	0.0510
C.D. at 5% level.	0.0494	0.0494	0.0494	0.0856	0.0856	0.0856	0.1483

Table 3b:- N Content of the Leaf in the month of June 1977.

	Ko				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	0.665	0.749	0.840	0.751	0.728	0.770	0.917	0.805	0.700	0.784	0.994	0.826	0.794
N1	1.050	1.148	1.246	1.148	1.106	1.225	1.302	1.211	1.134	1.253	1.309	1.232	1.194
N2	1.323	1.365	1.464	1.384	1.274	1.414	1.554	1.414	1.295	1.428	1.568	1.430	1.409
Mean	1.013	1.087	1.183	1.094	1.036	1.136	1.258	1.143	1.043	1.155	1.290	1.163	1.133

	N.	P.	K.	N.P.	N.K.	P.K.	NPK
S.Em ±	0.0145	0.0145	0.0145	0.0252	0.0252	0.0252	0.0436
C.D. at 5%.	0.0422	0.0422	0.0422	0.0732	0.0732	0.0732	0.1267

Table 3c:- N Content of the Leaf in the month of July 1977.

	Ko				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	1.027	1.067	1.106	1.067	1.036	1.120	1.234	1.129	1.022	1.144	1.253	1.140	1.112
N1	1.281	1.302	1.369	1.317	1.256	1.361	1.386	1.334	1.295	1.361	1.400	1.353	1.335
N2	1.431	1.477	1.540	1.482	1.484	1.498	1.498	1.493	1.963	1.540	1.561	1.521	1.499
Mean	1.247	1.282	1.338	1.289	1.259	1.326	1.372	1.319	1.260	1.348	1.405	1.338	1.315

	N.	P.	K.	NP.	NK.	PK.	NPK.
S.Em. ±	0.0141	0.0141	0.0141	0.0245	0.0245	0.0245	0.0424
C.D. at 5%.	0.0411	0.0411	0.0411	0.0712	0.0712	0.0712	0.1234

Table 3d:- N Content of the Leaf in the Month of August 1977.

	K0				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	0.724	0.868	1.001	0.864	0.721	0.910	1.064	0.898	0.812	1.029	1.134	0.992	0.918
N1	1.183	1.232	1.442	1.286	1.211	1.372	1.463	1.349	1.176	1.428	1.519	1.374	1.336
N2	1.512	1.603	1.610	1.575	1.582	1.568	1.589	1.580	1.512	1.645	1.666	1.608	1.588
Mean	1.140	1.234	1.351	1.242	1.171	1.283	1.372	1.276	1.666	1.367	1.440	1.325	1.281

	N.	P.	K.	NP.	NK.	PK.	NPK.
S.Em. ±	0.0236	0.0236	0.0236	0.0408	0.0408	0.0408	0.0707
C.D. at 5%.	0.0685	0.0685	0.0685	0.1187	0.1187	0.1187	0.2056

Table 3e:- N Content of the Leaf in the Month of September 1977.

	Ko				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	0.805	0.924	1.029	0.919	0.854	0.903	1.099	0.952	0.903	0.992	1.169	1.021	0.964
N1	1.225	1.309	1.365	1.300	1.246	1.337	1.337	1.307	1.275	1.344	1.351	1.324	1.310
N2	1.373	1.436	1.484	1.431	1.337	1.379	1.533	1.416	1.400	1.393	1.561	1.451	1.433
Mean	1.134	1.223	1.293	1.217	1.146	1.206	1.323	1.225	1.192	1.243	1.360	1.265	1.236

	N.	P.	K.	NP.	NK.	PK.	NPK.
S.Em. ±	0.0127	0.0127	0.0127	0.0220	0.0220	0.0220	0.0381
C.D. at 5%.	0.0369	0.0369	0.0369	0.0639	0.0639	0.0639	0.1107

Table 3f:- N Content of the Leaf in the Month of October 1977.

	Ko				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	0.826	1.064	1.218	1.036	0.882	1.120	1.232	1.078	0.959	1.162	1.295	1.139	1.084
N1	1.257	1.337	1.472	1.330	1.316	1.330	1.301	1.332	1.316	1.351	1.449	1.372	1.345
N2	1.456	1.393	1.463	1.437	1.414	1.400	1.624	1.478	1.407	1.414	1.624	1.482	1.466
Mean	1.188	1.265	1.351	1.268	1.206	1.293	1.402	1.297	1.227	1.309	1.456	1.331	1.298

	N.	P.	K.	NP.	NK.	PK.	NPK.
S.Em. ±	0.0113	0.0113	0.0113	0.0196	0.0196	0.0196	0.0339
C.D. at 5%.	0.0329	0.0329	0.0329	0.0569	0.0569	0.0569	0.0986

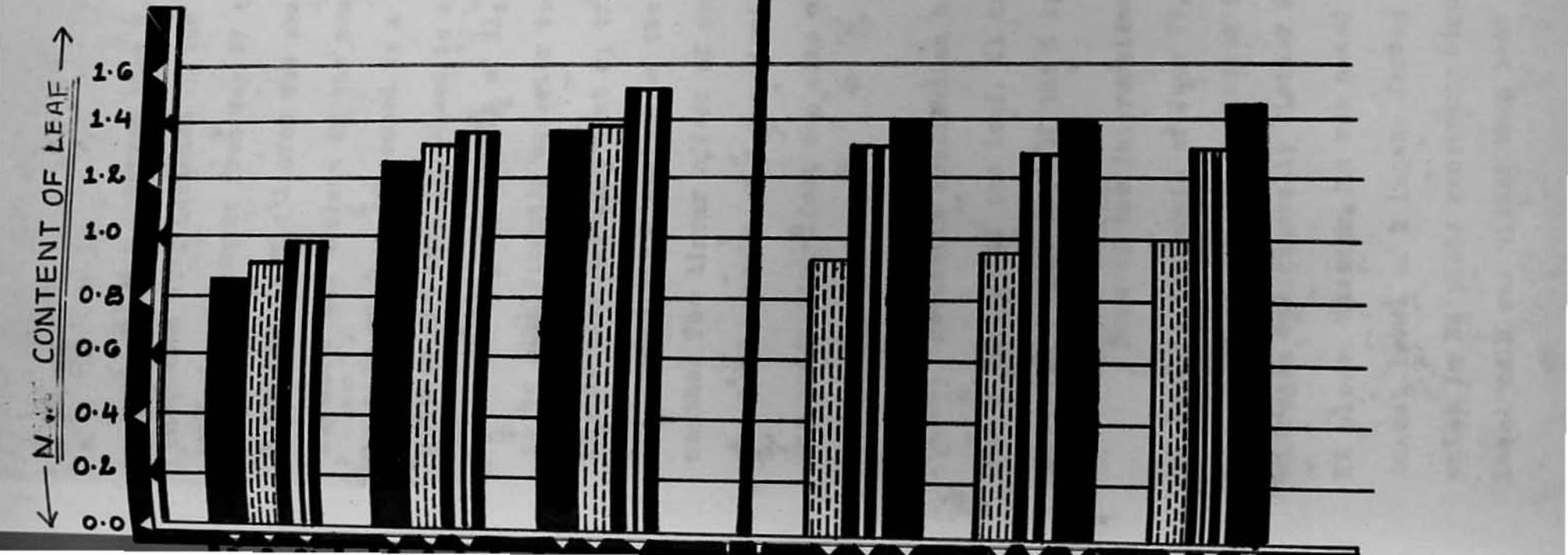
Table 3g:- N Content of the Leaf in the Month of November 1977.

	Ko				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	1.092	1.225	1.302	1.206	1.106	1.253	1.358	1.239	1.155	1.267	1.435	1.286	1.244
N1	1.526	1.561	1.631	1.573	1.526	1.589	1.673	1.596	1.498	1.631	1.687	1.605	1.592
N2	1.701	1.771	1.848	1.773	1.750	1.806	1.869	1.808	1.757	1.820	1.967	1.848	1.810
Mean	1.440	1.519	1.594	1.518	1.461	1.549	1.633	1.548	1.470	1.573	1.696	1.580	1.548

	N.	P.	K.	NP.	NK.	PK.	NPK.
S.Em. ±	0.0137	0.0137	0.0137	0.0238	0.0238	0.0238	0.0412
C.D. at 5%.	0.0400	0.0400	0.0400	0.0692	0.0692	0.0692	0.1199

FIGURE :- 1. NITROGEN CONTENT OF LEAF IN SEPTEMBER UNDER DIFFERENT P. AND N APPLICATION TO THE SOIL.

FIGURE :- 1a NITROGEN CONTENT OF LEAF IN SEPTEMBER UNDER THE DIFFERENT K. AND N. APPLICATION TO THE SOIL.



It was observed that N content of the leaves increased with increase in the level of soil application in all the months from May 77 to November 77. The maximum N content in the leaves was observed in the month of November and minimum in the month of June 77. It increased in July 77 then decreased to a fairly constant level upto October and then increased to a maximum in the month of November 77. Leaf levels of N1, N2 treatment were found to be significantly superior to those in N_0 treatment. It was also observed that P_1 treatment had significantly influenced the N content of the leaves during all the months. The linear effect of soil application of N over the leaf content of N was significant in all the months. The quadratic effect was also significant in all the months except May and July.

Potassium application has significantly influenced the N content of the leaf. K1 treatment was significantly superior to the rest of the K treatments.

None of the interactions influenced the N content of leaf in the month of June 77, July 77 and November 77. The trend of monthly variation in the leaf content of nitrogen was generally similar in the N_0 as well as N_1 and N2 plots. However, it was noted that in N_0 plots the August level of N in the leaves was lower than that of July while in N_2 plots receiving high nitrogen, the August level of N was higher than that of July.

Table 4:- Phosphorus Content of Chiku Leaves (Percentage of Dry Weight) Sampled in Different Months from Trees Under Different Treatments.

Sr. No.	Treatments	Sampling dates 18-5-77	18-6-77	18-7-77	18-8-77	18-9-77	18-10-77	18-11-77
1	No Po Ko	0.621	0.411	0.443	0.625	0.642	0.631	0.506
2	No Po K1	0.557	0.396	0.412	0.599	0.532	0.560	0.393
3	No Po K2	0.464	0.336	0.362	0.529	0.454	0.479	0.358
4	No P1 Ko	0.603	0.479	0.462	0.668	0.674	0.617	0.464
5	No P1 K1	0.585	0.454	0.411	0.599	0.624	0.564	0.412
6	No P1 K2	0.493	0.415	0.382	0.507	0.397	0.511	0.355
7	No P2 Ko	0.560	0.532	0.511	0.674	0.767	0.660	0.458
8	No P2 K1	0.532	0.468	0.432	0.642	0.695	0.614	0.411
9	No P2 K2	0.522	0.411	0.393	0.521	0.678	0.582	0.386
10	N1 Po Ko	0.489	0.419	0.347	0.622	0.628	0.578	0.458
11	N1 Po K1	0.444	0.397	0.348	0.557	0.507	0.564	0.416
12	N1 Po K2	0.411	0.369	0.319	0.404	0.458	0.511	0.374
13	N1 P1 Ko	0.503	0.454	0.386	0.462	0.667	0.621	0.483
14	N1 P1 K1	0.450	0.440	0.323	0.404	0.617	0.606	0.447
15	N1 P1 K2	0.436	0.418	0.287	0.376	0.603	0.593	0.405
16	N1 P2 Ko	0.504	0.447	0.454	0.638	0.614	0.594	0.529
17	N1 P2 K1	0.482	0.414	0.333	0.617	0.543	0.543	0.479
18	N1 P2 K2	0.408	0.347	0.295	0.411	0.538	0.514	0.447
19	N2 Po Ko	0.528	0.493	0.408	0.362	0.564	0.646	0.547
20	N2 Po K1	0.525	0.465	0.337	0.326	0.528	0.568	0.414
21	N2 Po K2	0.511	0.426	0.329	0.269	0.401	0.478	0.388
22	N2 P1 Ko	0.565	0.411	0.418	0.564	0.674	0.643	0.495
23	N2 P1 K1	0.539	0.369	0.394	0.518	0.607	0.624	0.453
24	N2 P1 K2	0.483	0.354	0.369	0.429	0.589	0.620	0.432
25	N2 P2 Ko	0.574	0.450	0.522	0.507	0.564	0.561	0.537
26	N2 P2 K1	0.472	0.433	0.418	0.479	0.514	0.535	0.464
27	N2 P2 K2	0.397	0.390	0.348	0.397	0.333	0.501	0.439
Mean		0.506	0.422	0.387	0.508	0.571	0.574	0.442
'F' test result.		Sign.	Sign.	Sign.	Sign.	Sign.	Sign.	Sign.
S.Em ±		0.0394	0.0264	0.0300	0.0264	0.0332	0.0212	0.0235
C.D. at 5% level.		0.1145	0.0769	0.0872	0.0769	0.0964	0.0617	0.0682
C.D. at 1% level.		0.1548	0.1038	0.1179	0.1040	0.1305	0.0833	0.0924
C.V. %		11.00	8.86	10.97	7.37	8.22	5.22	7.50

Phosphorus

In the month of May, (Table 4a) the mean leaf P content of all Po plots was 0.549, all the P1 plots 0.459 and P2 plots 0.510 percent.

The P content of the leaf was not increased with higher doses of applied phosphate. The differences in the mean leaf level of P among the three levels of P fertilization were not statistically significant.

The mean leaf P content was highest in the N_0 plots, less in N2 plots and least in the N1 plots. It was also observed that the mean leaf P values were highest in K_0 plots, lower in K_1 and least in K_2 plots, showing that with increasing potassium fertilization there is a tendency for reduction of phosphate content of leaf.

In the month of June, (Table 4b) the average leaf content of P was less than that of May 77.

There was no significant difference in the leaf level of P with the three levels of P fertilization. There was reduction in the leaf level of P with increasing K application to the soil. The leaf level of P tended to increase with level of soil application in N_0 plots, but not in plots receiving higher levels of soil application of nitrogen. On the other hand, in Po plots, the leaf P content was raised by soil application of nitrogen which was not the case in May.

In the month of July, (Table 4c) there was a further decrease in the average leaf content of phosphorus. With increasing soil application of K, the leaf level of P tended to fall as in previous months.

N_o plot tended to have higher leaf content of P than N1 and N2 plots. There were no significant differences between the mean leaf content of Po, P1 and P2 plots.

In the month of August (Table 4d), the average leaf P content rose higher to the same level as in May. There was an increase in the leaf P content with higher levels of soil application. The reduction in leaf content of P with increased soil application of K was noticeable in the month of August also. Similarly, with higher level of N also, there was a tendency for reduction in the leaf content of phosphorus.

During the month of September (Table 4e), there were no significant difference in the mean leaf content of P, with the three levels of soil application of P. The leaf content of P tended to fall with increasing soil application of K. Leaf content of P also tended to fall with application of higher levels of N to the soil in K_o and K_1 combinations.

In the month of October (Table 4f) the average leaf content of P was maintained at the same levels as in September. There were no significant differences in leaf P content with increased level of soil application. The leaf content of P

Table 4a:- P Content of the Leaf in the Month of May 1977.

	Ko				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	0.621	0.603	0.560	0.594	0.557	0.585	0.532	0.558	0.464	0.493	0.522	0.493	0.549
N1	0.489	0.503	0.504	0.499	0.444	0.450	0.482	0.459	0.411	0.436	0.408	0.418	0.459
N2	0.528	0.565	0.574	0.556	0.525	0.539	0.472	0.512	0.511	0.483	0.397	0.464	0.510
Mean	0.546	0.557	0.546	0.550	0.509	0.525	0.495	0.510	0.462	0.471	0.442	0.458	0.506

	N.	P.	K.	N.P.	N.K.	P.K.	N.P.K.
S.Em ±	0.0131	0.0131	0.0131	0.0227	0.0227	0.0227	0.0394
C.D. at 5%.	0.0382	0.0382	0.0382	0.0661	0.0661	0.0661	0.1145

Table 4b:- P Content of the Leaf in the Month of June 1977.

	K0				K1				K2				Mean
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	
No	0.411	0.419	0.493	0.441	0.396	0.398	0.465	0.420	0.337	0.368	0.426	0.377	0.412
N1	0.479	0.454	0.412	0.448	0.454	0.440	0.368	0.421	0.415	0.419	0.355	0.396	0.422
N2	0.532	0.447	0.451	0.477	0.468	0.415	0.433	0.439	0.412	0.347	0.390	0.383	0.431
Mean	0.474	0.440	0.452	0.455	0.439	0.418	0.422	0.426	0.388	0.378	0.39	0.385	0.422

	N.	P.	K.	N.P.	N.K.	P.K.	N.P.K.
S.Em ±	0.0088	0.0088	0.0088	0.0153	0.0153	0.0153	0.0265
C.D. at 5%.	0.0256	0.0256	0.0256	0.0444	0.0444	0.0444	0.0769

Table 4c:- P Content of the Leaf in the Month of July 1977

	Ko				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	0.443	0.462	0.511	0.472	0.412	0.411	0.432	0.418	0.362	0.382	0.393	0.379	0.423
N1	0.347	0.386	0.454	0.396	0.348	0.323	0.333	0.335	0.319	0.287	0.295	0.300	0.344
N2	0.408	0.418	0.522	0.449	0.337	0.394	0.418	0.383	0.329	0.369	0.348	0.349	0.394
Mean	0.399	0.422	0.496	0.439	0.366	0.376	0.394	0.379	0.337	0.346	0.345	0.343	0.387

	N.	P.	K.	N.P.	N.K.	P.K.	N.P.K.
S.Em ±	0.0100	0.0100	0.0100	0.0173	0.0173	0.0173	0.0300
C.D. at 5%.	0.0291	0.0291	0.0291	0.0504	0.0504	0.0504	0.0872

Table 4d:- P Content of the Leaf in the Month of August 1977.

	Ko				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	0.625	0.668	0.674	0.656	0.599	0.599	0.642	0.613	0.529	0.507	0.521	0.519	0.596
N1	0.622	0.462	0.638	0.574	0.557	0.404	0.617	0.526	0.404	0.376	0.411	0.397	0.499
N2	0.362	0.564	0.507	0.478	0.326	0.578	0.479	0.441	0.269	0.429	0.397	0.365	0.428
Mean	0.536	0.565	0.606	0.569	0.494	0.507	0.579	0.527	0.401	0.437	0.443	0.427	0.508

	N.	P.	K.	N.P.	N.K.	P.K.	N.P.K.
S.Em ±	0.0088	0.0088	0.0088	0.0153	0.0153	0.0153	0.0265
C.D. at 5%.	0.0256	0.0256	0.0256	0.0444	0.0444	0.0444	0.0769

Table 4e:- P Content of the Leaf in the Month of September 1977.

	Ko				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	0.642	0.674	0.767	0.694	0.532	0.624	0.694	.617	0.454	0.397	0.678	0.510	0.607
N1	0.628	0.667	0.614	0.636	0.507	0.617	0.543	0.556	0.458	0.603	0.538	0.533	0.575
N2	0.564	0.674	0.564	0.601	0.528	0.607	0.514	0.550	0.401	0.589	0.333	0.444	0.531
Mean	0.611	0.672	0.648	0.644	0.522	0.616	0.584	0.574	0.438	0.530	0.516	0.495	0.571

	N.	P.	K.	N.P.	N.K.	P.K.	N.P.K.
S.Em ±	0.0111	0.0111	0.0111	0.0191	0.0191	0.0191	0.0332
C.D. at 5%.	0.0321	0.0321	0.0321	0.0557	0.0557	0.0557	0.0964

Table 4f:- P Content of the Leaf in the Month of October 1977.

	Ko				Kb				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	0.631	0.617	0.660	0.636	0.560	0.564	0.614	0.579	0.479	0.511	0.562	0.524	0.580
N1	0.578	0.621	0.594	0.598	0.564	0.606	0.543	0.571	0.511	0.593	0.514	0.539	0.569
N2	0.646	0.643	0.561	0.617	0.568	0.624	0.535	0.576	0.478	0.620	0.501	0.533	0.575
Mean	0.618	0.627	0.605	0.617	0.564	0.598	0.564	0.575	0.489	0.575	0.532	0.532	0.574

	N.	P.	K.	N.P.	N.K.	P.K.	N.P.K.
S.Em ±	0.0071	0.0071	0.0071	0.0122	0.0122	0.0122	0.0212
C.D. at 5%.	0.0206	0.0206	0.0206	0.0356	0.0356	0.0356	0.0617

Table 4g:- P Content of the Leaf in the Month of November 1977.

	K0				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	0.506	0.464	0.458	0.476	0.393	0.412	0.411	0.405	0.358	0.355	0.386	0.366	0.416
N1	0.458	0.483	0.529	0.490	0.416	0.447	0.479	0.447	0.574	0.405	0.447	0.409	0.449
N2	0.547	0.495	0.537	0.526	0.414	0.453	0.454	0.440	0.388	0.432	0.439	0.420	0.462
Mean	0.504	0.481	0.508	0.497	0.408	0.437	0.448	0.431	0.373	0.397	0.424	0.398	0.442

	N.	P.	K.	N.P.	N.K.	P.K.	N.P.K.
S.Em ±	0.0078	0.0078	0.0078	0.0135	0.0135	0.0135	0.0235
C.D. at 5%.	0.0227	0.0227	0.0227	0.0396	0.0394	0.0394	0.0682

tended to fall with higher levels of soil application of potassium.

In the month of November, (Table 4g) there was again a fall of leaf P content. There were no significant difference in leaf P content with higher levels of soil application. The leaf level of P tended to fall with increased soil application of K. With few exceptions there was a tendency of P level at the higher level of soil application of nitrogen.(Table 4).

Potash

In the month of May, (Table 5a) there were no significant differences in the average leaf content of K with different levels of soil application of K, P and N.

In the month of June (Table 5b) also there were no significant differences in the leaf level of K with the three levels of soil application of K, P and N. The leaf levels of K in June were similar to those of May.

In the month of July (Table 5c), the average leaf K content was slightly less than that of the previous two months. There were no significant differences in the leaf level of K with different levels of soil application of K, P and N. In the months of August, September and October (Tables 5d, e, f), the leaf level of K was similar.

Table 5:- Potassium Content of Chiku Leaves (Percentage of dry weight) sampled in Different Months From Trees Under Different Treatments.

Sr. No.	Treatments			Sampling dates 18-5-77	18-6-77	18-7-77	18-8-77	18-9-77	18-10-77	18-11-77
1	No	Po	Ko	1.0375	1.057	0.937	1.050	1.0185	0.981	0.737
2	No	Po	K1	1.100	0.9685	1.000	0.9185	0.7435	0.956	0.7875
3	No	Po	K2	1.1185	1.031	0.975	0.838	0.987	0.950	0.837
4	No	P1	Ko	1.1625	1.031	0.9685	1.1185	0.9935	0.987	0.675
5	No	P1	K1	1.1995	1.1245	1.037	1.125	0.8625	0.9185	0.725
6	No	P1	K2	1.106	1.156	0.9685	0.8795	0.937	1.094	0.799
7	No	P2	Ko	1.1935	1.0185	1.043	1.156	0.8870	1.425	0.725
8	No	P2	K1	1.156	0.975	1.062	1.0435	0.8625	0.956	0.7745
9	No	P2	K2	1.256	1.1245	1.081	1.000	0.8625	0.975	0.862
10	N1	Po	Ko	1.1625	0.975	0.806	0.899	1.106	0.894	0.731
11	N1	Po	K1	1.075	1.0685	0.8625	0.800	1.0435	1.037	0.744
12	N1	Po	K2	1.1315	1.0935	1.0185	1.031	1.062	1.0685	0.8185
13	N1	P1	Ko	0.981	0.900	0.9185	0.9625	1.075	1.0495	0.706
14	N1	P1	K1	1.1495	1.081	0.956	0.962	1.0995	1.031	0.756
15	N1	P1	K2	1.118	1.031	1.0185	1.131	1.0685	1.056	0.744
16	N1	P2	Ko	1.0685	1.1315	0.956	1.2685	1.1685	1.131	0.7185
17	N1	P2	K1	1.106	0.931	0.9685	0.906	1.050	0.912	0.675
18	N1	P2	K2	1.0685	1.0185	0.9495	0.9685	1.025	0.9685	0.7875
19	N2	Po	Ko	0.9625	0.919	0.9245	0.950	0.8685	0.981	0.737
20	N2	Po	K1	0.9560	1.0935	0.925	1.0185	1.0185	1.025	0.725
21	N2	Po	K2	1.225	1.006	1.100	0.956	1.106	0.931	0.750
22	N2	P1	Ko	1.075	0.875	0.975	0.913	0.9875	1.031	0.700
23	N2	P1	K1	0.987	1.256	0.925	1.025	1.037	1.025	0.762
24	N2	P1	K2	1.125	0.925	1.006	1.000	1.162	1.106	0.738
25	N2	P2	Ko	0.775	1.050	0.912	1.137	1.0125	1.0625	0.775
26	N2	P2	K1	0.9185	1.0435	0.9935	1.056	0.9935	1.0375	0.750
27	N2	P2	K2	1.1685	1.100	0.956	1.112	0.981	1.069	0.8185
	Mean			1.088	1.030	0.972	1.008	1.001	1.024	0.754
'F' test result.				NS	NS	NS	NS	NS	NS	NS
S.Em. ±				0.1122	0.0851	0.1290	0.0787	0.1082	0.0989	0.0458
C.D. at 5% level.				-	-	-	-	-	-	-
C.D. at 1% level.				-	-	-	-	-	-	-
C.V.				14.58	11.61	18.77	11.00	17.28	13.67	8.59

Table 5a:- K Content of the Leaf in the Month of May 1977.

	Ko				Ki				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
N o	1.037	1.162	1.193	1.13[illegible]	1.100	1.199	1.156	1.152	1.118	1.106	1.256	1.160	1.148
N1	1.162	0.981	[illegible].068	1.070	1.075	1.149	1.106	1.110	1.13[illegible]	1.118	1.068	1.106	1.095
N2	0.965	1.075	0.775	0.937	0.956	0.987	0.918	0.954	1.225	1.125	1.168	1.173	1.021
Mean	1.054	1.073	1.012	1.046	1.044	1.112	1.060	1.07[illegible]	1.158	1.116	1.164	1.146	1.088

	N.	P.	K.	N.P.	N.K.	P.K.	N.P.K
S.Em ±	0.0374	0.0374	0.0374	0.0648	0.0648	0.0648	0.1122
C.D. at 5 %.	—	—	—	—	—	—	—

Table 5b:- K Content of Leaf in the Month of June 1977.

	Ko				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	1.056	1.031	1.038	1.035	0.968	1.124	0.975	1.022	1.031	1.156	1.124	1.104	1.05
N1	0.975	0.900	1.131	1.002	1.068	0.931	1.018	1.006	1.093	1.018	0.919	1.010	1.00
N2	0.919	0.875	1.050	0.948	1.093	1.256	1.043	1.131	1.006	0.925	1.100	1.010	1.03
Mean	0.983	0.935	1.066	0.995	1.043	1.104	1.012	1.053	1.043	1.033	1.048	1.041	1.03

	N.	P.	K.	N.P.	N.K.	P.K.	N.P.K.
S.Em ±	0.0284	0.0284	0.0284	0.0492	0.0492	0.0492	0.0851
C.D. at 5%.	—	—	—	—	—	—	—

Table 5c:- K Content of Leaf in the Month of July 1977.

	K0				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mea
No	0.937	0.968	1.083	0.983	1.000	1.037	1.062	1.033	0.975	0.968	1.081	1.008	1.0
N1	0.806	0.918	0.856	0.893	0.868	0.956	0.968	0.928	0.918	0.918	0.949	0.995	0.9
N2	0.924	0.975	0.912	0.937	0.925	0.925	0.993	0.948	1.100	1.006	0.956	1.021	0.9
Mean	0.889	0.954	0.970	0.938	0.929	0.973	1.008	0.970	1.031	0.997	0.995	1.008	0.9

	N.	P.	K.	N.P.	N.K.	P.K.	N.P.K.
S.Em ±	0.0430	0.0430	0.0430	0.0745	0.0745	0.0745	0.1290
C.D. at 5%	—	—	—	—	—	—	—

Table 5d. K Content of Leaf in the Month of August 1977.

	K0				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	PO	P1	P2	Mean	Mean
No	1.050	1.118	1.156	1.108	0.918	1.125	1.043	1.029	0.838	0.874	1.000	0.904	1.014
N1	0.899	0.963	0.963	1.043	0.800	0.963	0.906	0.889	0.031	1.131	1.000	1.054	0.995
N2	0.968	0.956	0.956	1.020	0.950	0.913	1.056	0.973	1.018	1.025	1.112	1.052	1.015

	N.	P.	K.	N.P.	P.K.	N.K.	N.P.K.
S.Em ±	0.0262	0.0262	0.0262	0.0455	0.0455	0.0455	0.0787
C.D. at 5%.	—	—	—	—	—	—	—

Table 5e:- K Content of Leaf in the Month of September 1977.

	Ko				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	1.018	0.953	0.887	0.966	0.743	0.862	0.862	0.822	0.987	0.937	0.862	0.929	0.906
N1	1.106	1.075	1.168	1.116	1.043	1.099	1.050	1.064	1.062	1.068	1.050	1.060	1.080
N2	0.868	0.987	1.012	0.956	1.018	1.037	0.993	1.016	1.106	1.162	0.981	1.083	1.018
Mean	0.997	1.018	1.022	1.013	0.935	0.999	0.968	0.967	1.052	1.056	0.964	1.024	1.001

	N.	P.	K.	N.P.	N.K.	P.K.	N.P.K.
S.Em ±	0.0361	0.0361	0.0361	0.0624	0.0624	0.0624	0.1082
C.D. at 5%.	—	—	—	—	—	—	—

Table 5f. K Content of Leaf in the Month of October 1977.

	Ko				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean.
No	0.962	1.000	1.119	1.027	1.131	0.943	1.006	1.027	0.952	1.006	0.983	0.980	1.011
N1	1.000	1.045	1.004	1.016	1.025	0.993	1.031	1.016	1.022	0.991	1.065	1.033	1.022
N2	0.979	1.054	1.056	1.030	1.025	1.029	1.025	1.029	1.206	0.968	1.004	1.059	1.039

	N.	P.	K.	N.P.	N.K.	P.K.	N.P.K.
S.Em ±	0.0330	0.0330	0.0330	0.0571	0.0571	0.0571	0.0990
C.D. at 5%.	—	—	—	—	—	—	—

Table 5g:- K Content of Leaf in the Month of November 1977.

	Ko				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	0.737	0.675	0.725	0.712	0.737	0.725	0.774	0.762	0.837	0.799	0.862	0.833	0.769
N1	0.731	0.706	0.718	0.718	0.744	0.756	0.675	0.725	0.818	0.744	0.787	0.783	0.742
N2	0.737	0.700	0.775	0.737	0.725	0.762	0.750	0.746	0.750	0.738	0.818	0.769	0.751
Mean	0.735	0.694	0.739	0.723	0.752	0.748	0.733	0.744	0.802	0.760	0.822	0.795	0.754

	N.	P.	K.	N.P.	N.K.	P.K.	N.P.K.
S.Em ±	0.0153	0.0153	0.0153	0.0265	0.0265	0.0265	0.0458
C.D.at 5%.	—	—	—	—	—	—	—

In the month of November (Table 5g) there was an appreciable fall in leaf content of K in all treatments. There was a general tendency for increase in the leaf content of K with higher levels of soil application which was not statistically significant. There was no effect of the soil application of nitrogen and phosphorus on the leaf content of K.

Correlation of leaf content with yield:

Correlation was worked out for each month from May to November between leaf content of N, P and K and total annual yield of the trees (Table 6).

It is seen that tree yield is positively and significantly correlated with leaf content of N for all the months. The yield was negatively correlated with P in the content of May to September and positively in October and November but none of them statistically significant. Similarly, there was noticed a negative correlation between leaf content of K and yield in the months of May and July. However, the correlation was not significant. On the other hand the tree yield was correlated positively with the leaf content of K in the months of August to November and was significant at 5% level in August and September.

Table 6. Correlation between N, P and K Content of Chicku Leaves and Yields of the (Treatments)

Month	N	P	K
May 1977	0.6536**	-0.243	-0.3078
June 1977	0.5596**	-0.118	-0.0794
July 1977	0.7065**	-0.286	-0.1878
August 1977	0.6705**	-0.396	0.3828*
September 1977	0.6540**	-0.061	0.4278*
October 1977	0.5099**	0.1066	0.0823
November 1977	0.6669**	0.1694	0.0391

* Significant value of r at 5 Per cent level.

** Significant value of r at 1 Per cent level.

Economics

The present recommendations on the use of fertilizer N, P and K for chiku crop were based on old price of outputs and old rates of fertilizer nutrients. The yield of chiku is improved by fertilizer N, P and K. The yield data presented in Table 7 indicates that the application of $N_1P_0K_0$ level of fertilizer has given maximum return (1:16-11 I.C.B.R.) compared to the other levels and combinations. However, an addition of potassium with nitrogen also gave good response in levels of $N_1P_0K_2$, $N_1P_1K_2$ with incremental cost benefit ratio of 1:10.02 and 1:9.53 respectively. However, increased dose of nitrogen has proved profitable in the combinations of $N_2P_0K_1$ and $N_2P_1K_0$ with ICBR of 1:8.77 and 1:9.04 respectively.

At $N_0P_0K_1$ level of fertilization, however the ICBR works out the 1:14.42 partly because of the low cost of fertilizers.

Table 7:- Fertilizers (N, P & K) response and net Incremental Cost Benefit Ratio (ICBR) On Yield of Chiku Fruits, 1977-78.

Sr. No.	Treatment	Yield of Chiku kg/ha	Additional yield kg/ha	Incremental cost Rs.	Incremental benefit kg/ha	Profit	Net I.C.B.R.
1	N0P0K0	1436.53	-	-	-	-	-
2	N0P0K1	1925.66	489.13	31-72	489.13	457.41	1:14.42
3	N0P0K2	1161.11	-	63-44	-	-	-
4	N0P1K0	1043.07	-	83-33	-	-	-
5	N0P1K1	1541.46	104.93	115.05	104.93	-	-
6	N0P1K2	1084.73	-	146.77	-	-	-
7	N0P2K0	1730.63	294.10	166.65	294.10	127.45	1:0.76
8	N0P2K1	2115.45	678.92	198.37	678.92	480.55	1:2.42
9	N0P2K2	996.78	-	230.09	-	-	-
10	N1P0K0	2703.34	1266.81	74.05	1266.81	1192.76	1:16.11
11	N1P0K1	2095.39	658.86	105.77	658.86	553.09	1:5.23
12	N1P0K2	2951.76	1515.23	137.49	1515.23	1377.74	1:10.02
13	N1P1K0	2241.98	806.45	157.38	805.45	648.07	1:4.12
14	N1P1K1	2437.32	1050.79	189.10	1050.79	861.69	1:4.56
15	N1P1K2	3761.83	2325.30	220.82	2325.30	2104.48	1:9.53
16	N1P2K0	2252.78	816.25	240.70	816.25	575.55	1:2.39
17	N1P2K1	2178.72	742.19	272.42	742.19	469.77	1:1.72
18	N1P2K2	2311.41	874.88	304.14	874.88	57.74	1:1.88
19	N2P0K0	1820.15	183.62	148.10	183.62	35.52	1:0.24
20	N2P0K1	3194.01	1757.48	179.82	1757.48	1577.67	1:8.77
21	N2P0K2	2663.22	1226.69	211.54	1226.69	1015.15	1:4.80
22	N2P1K0	3760.29	2323.26	231.43	2323.26	2092.33	1:9.04
23	N2P1K1	3601.36	2164.83	263.15	2164.83	1901.68	1:7.23
24	N2P1K2	3007.30	1570.77	294.87	1570.77	1275.90	1:4.33
25	N2P2K0	3268.07	1831.54	314.75	1831.54	1516.79	1:4.82
26	N2P2K1	1717.36	280.83	346.47	280.83	-	-
27	N2P2K2	2627.73	1191.20	378.19	1191.20	813.01	1:2.15

Price of P fertilizer @ Rs. 60/- per 100 kg.

Price of Chiku @ Re.1/- per kg.

Price of (Urea) N fertilizer @ Rs.153.50 per 100 kg.

Price of K fertilizer @ Rs.82.80 per 100 kg.

CHAPTER V

DISCUSSION

Tissue analysis has been recommended as a useful guide for fertilization of fruit crops. The large volume of literature reviewed fully by a number of workers, Goodall and Gregory (1947), Ulrich (1948), Lundugardh (1951), Shanon (1954), Reuther, Embleton and Jones (1958), Smith (1962), Chapman (1966) and Kenworthy and Martin (1966), on various fruit trees, indicates the great need for standardisation of tissue for sampling as well as the time of sampling for all fruit trees.

Inspite of chiku being an important fruit in tropical India, much work has not been reported on the use of leaf analysis in chiku. Therefore, the present work was undertaken to determine the best season for sampling of leaves not only to obtain guidance on fertilizing the chiku, but also to get an insight into the seasonal variation in the leaf content of the major nutrients of nitrogen, phosphorus and potassium in relation to the developmental phases of the trees.

It is obvious from the yield data presented in Table 1 that there was a clear response of yield to

application of nitrogen. The response to phosphorus and potash was not significant. The phosphorus and potash levels of the soil must have been adequate for chiku. Sahay and Ram (1970) in mango; Reece and Koo (1975) in Valencia orange and Kunte et al. (1977) in Nagpur Santhra, have also noted that the yield responded only to applied N and not P and K.

The leaf level of N significantly increased with higher levels of soil application and the total annual yield was positively correlated to the leaf N content of each month, thus establishing the relationship between the applied nitrogen, its uptake into the leaf and the ultimate yield.

The nitrogen in leaf was high in May, declining sharply in June. There was again a rise in July and a slight decline in August. The value was more or less steady in September and October, there was again a rise in November. The dates of fertilization were 18th of May and 24th October. The high nitrogen level in November (which accounted for 25.55 percentage of the total annual yield) could be partly attributed to fertilization in October. However, the increase in the leaf level of N even in N_0 plots during this month points to the relatively low internal needs and use during this month, as also the increased root activity after the improvement of soil aeration with the cessation of rains.

In the month of July also there is an increase of leaf N even in N_0 plots.

Inspite of the manuring in May, June value was lower, but there was again a rise in July. This could be attributed to rainfall which could help mineralization of N and increase its availability. However, it should be noted that the irrigation given in the last week of May did not help in preventing the drop in the leaf level of nitrogen in June. It is thus seen that the leaf content of N was not only related to the quantity applied, but also to the soil moisture condition determining availability of nutrients. It also appears to be related to the biological processes in the tree. The nutrient content of the leaf at a given time is the result of not only the amounts taken up but also those that have been transported out of the leaf for metabolic needs of the developing flowers and fruits as well as new flush.

The analysis of leaf composition at the long intervals of one month have not fully reflected these rapid changes. This appears to be one of the limitations of the use of periodical leaf analysis for interpreting the continuous internal utilisation (Smith, 1966).

It was found that the leaf content of nitrogen was raised in the treatments having P1 and P2 levels of soil application of phosphorus. This effect was consistent

for all levels of N application and for the values of all months. Since with higher levels of application of P, its leaf content itself did not increase, it would appear that applied P has in someway helped a better uptake of nitrogen. For each level of soil application of nitrogen, the leaf content of nitrogen was increased with higher level of soil application of potassium also contrary to the finding of Singh and Rajput (1976) in guava. This has occurred even when the leaf levels of P and K themselves did not increase by the treatments. It is also interesting that though the yield was significantly correlated to the leaf N content, and some of the values utilised for establishing the correlation were the values raised by P and K application, the yield was not correlated to the level of P nor the levels of K (except in August, September in the case of K). Singh and Rajput (1976) found a highly significant correlation between leaf K and yield in guava. In the present study also there was a correlation with leaf content of K in August and September.

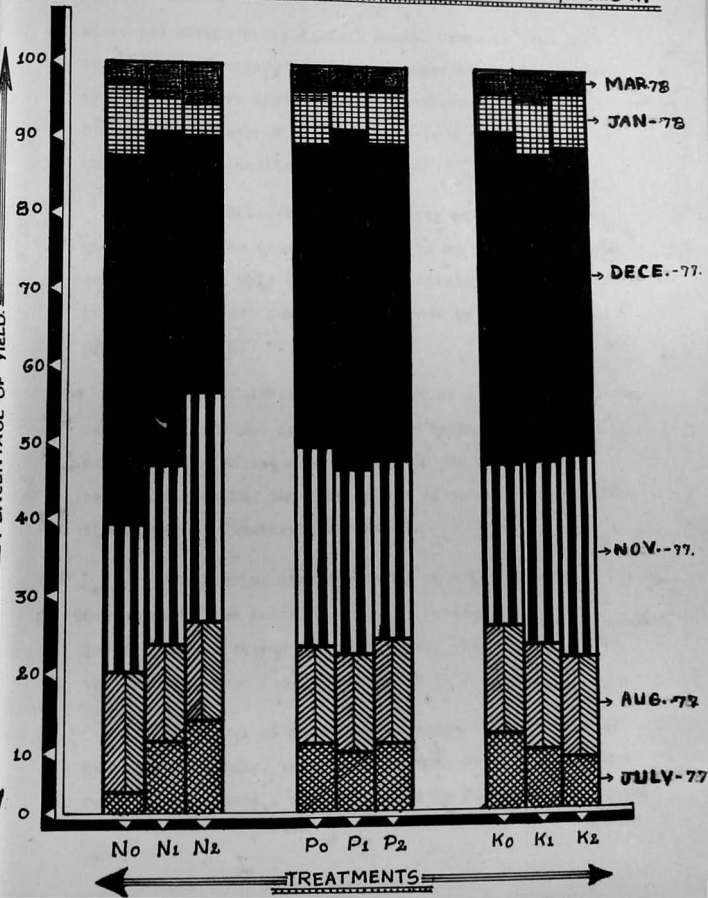
The higher level of soil application of P and K did not result in their better uptake as reflected by the leaf content of P and K. In respect of K the result is contrary to that of Singh and Rajput (1976) who report an increase in leaf K with higher soil application. This is apparently due to the presence of P and K in the soil (0.20% and 1.3 to 1.7 per cent respectively corresponding to 113.4 kg of P_2O_5 and 136.04 to 158.76 kg of K_2O/ha).

A consistent effect of K application was on the lowering of leaf content of P. Saini and Singh (1978) reported that application of higher doses of N and K had a tendency to decrease the leaf P content in grape vines. However, in the present study nitrogen did not appear to have such an effect consistently. On the other hand, Jones and Parker (1950) observed that application of phosphate to soil decreases the leaf content of potassium in Navel orange.

Thus the balance of nutrients as applied to the soil was not the same as the balance of nutrients in the leaves.

The average yield from N2 plots was higher than that from N1 plots. But when the yields with different levels of N in combination with each level of P and K are plotted separately (vide graph 1 and 2), it is noticed that the yield at N2 level was less than that with N1 level in combinations with P0K0, P0K2, P1K2 and P2K1, while it has increased in combination with P0K1, P1K1, P2K2, P1K0 and P2K0. The reduction in the case of N2P0K2 was not appreciable. From this it appears whenever the balance of the three nutrients was disturbed, the yield response to N2 level of nitrogen was depressed as in the case of N2P0K0 where N was higher but P and K were low;

FIGURE - MEAN PERCENTAGE OF TOTAL ANNUAL YIELD OF CHIKU FRUITS HARVESTED EACH MONTH UNDER DIFFERENT LEVELS OF APPLICATION OF N, P AND K.



N2P1K2 and N2P2K2, where N2 and K2 were higher but P fell short and N2P2K1 where K1 fell short. There is also some tendency for decrease in yield response to N2 when potash applications were high, if P applications were lower. Cline (1967) observed that response to N was depressed when K was also applied.

The coefficient of variability of yield is 23.65 and therefore the result will have to be repeated, before confirmation of this conclusion especially because P levels of the leaves were generally depressed by increasing soil application of K.

The leaf level of K was more or less steady between May and October and appreciably low during the month of November 77 with the commencement of the main harvest period, suggesting the utilization of potassium during the final stages of maturity of fruits.

Considering that the level of K in August and September 77 was correlated to the yield, and the leaf level of K was steady in this period, this appears to be the proper season for leaf sampling in respect of K.

The level of phosphorus declined in the month of May, June and July, then it was steady between August and October and showed a downward trend in November, suggesting

the utilisation of phosphorus during flowering and fruit set as well as for flush (Avilan, 1971; Nathan and Shoemaker, 1963). The leaf levels between August 77 to October 77 being steady, this period appears to be suitable for sampling leaf for analysis of this element. Considering that there were no significant differences in the leaf content of P with increase of soil application, and also the insignificant correlation with yield, it would appear that in this soil application of P would not be needed.

The nitrogen level of leaf was significantly affected by nitrogen application. There was depression of N content in June about 25 days after fertilization. The depression of N at the time of floral emergence has been reported in mango by Gupta and Narsimham (1977). This suggests the rapid utilisation of N in flowering and fruit set.

The level was more or less steady at a lower level in August and September during fruit development (Jones et al. 1967) presumably due to utilisation of N by the developing of fruits. The increase in N in November is attributable both to the application of fertilizers in October as well as the reduced demand for N owing to the conclusion of fruit development. The yields are correlated to N content of leaf in all the months.

Since the leaf levels of N are steady between August and October, and positively correlated to yield and as it also appears that N is in demand during this period by developing fruits, this period appears to be suitable for sampling leaves for N content.

Considering all the three nutrients, the month of September appears to be most suitable for sampling of leaves for providing guidance of fertilization. Gopalakrishna and Gotmare (1962) have, on the other hand, suggested sampling winter flush leaves.

The leaf level of N even in N_0 plots has shown the same trends of decline and increase as in the N fertilized plots. This suggests that not only the availability of the nutrient in the soil and the soil moisture conditions but also the internal needs of the tree seem to determine the leaf levels of nutrients at a given time.

It was seen from the leaf levels that N was utilised by the plant in the months of June to October, but not in November. It was also seen that November is the main harvesting season. Bearing these two factors in mind, it needs further consideration whether the second dose of fertilization should be applied earlier, preferably in September.

The yields were not correlated to the leaf P levels. They were correlated with leaf K levels in August and

September but the leaf levels of both P and K in the study did not show any appreciable response to soil application. It is therefore, not possible to suggest any critical levels for these two elements from the data of this study (vide graph 1 and 2). Further, the regression lines of yield over N and K levels in leaf are linear and it may be necessary to use high levels of fertilisation to get higher leaf content and a quadratic relationship with it before critical levels are arrived at.

Analysing the percentage of the total annual yield harvested upto the end of July, '77, August '77, November '77, December '77, January '78 and March '78, it was observed that nitrogen has shown a tendency to increase early yields in July 77 and August 77. (Fig.1&2.) This appears to be a combined effect of fertilization in previous October 76 which might have improved set and early retention of fruit, as also the fertilization in May 77 which might have helped by better development of fruits. This points to the need for precise timing of application for N fertilization by foliar appli - cation in order to alter the percentage of bearing in early and late harvest season.

Economics

The incremental cost benefit ratio presented in Table-7 shows that in general, nitrogen N1 level of fertilization is more beneficial than N2 level. A few combinations like NoPoK1 have given high values, but due to lack of consistancy of the effect of K1, the factor presumably responsible for

FIGURE :- MEAN YIELD PER TREAT. UNDER N_0, N_1 AND N_2 LEVELS OF APPLICATION OF NITROGEN IN COMBINATION WITH DIFFERENT LEVELS OF P AND K.

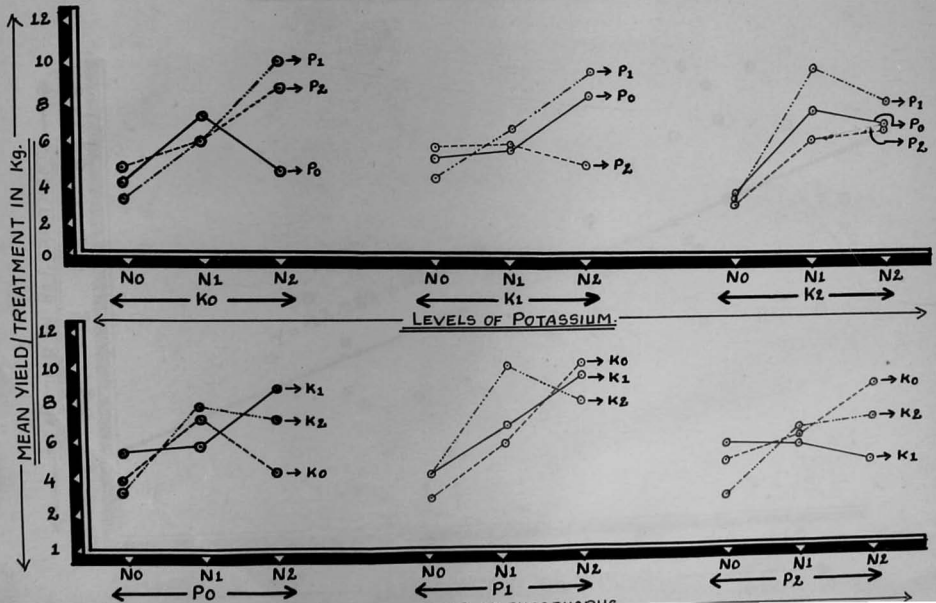
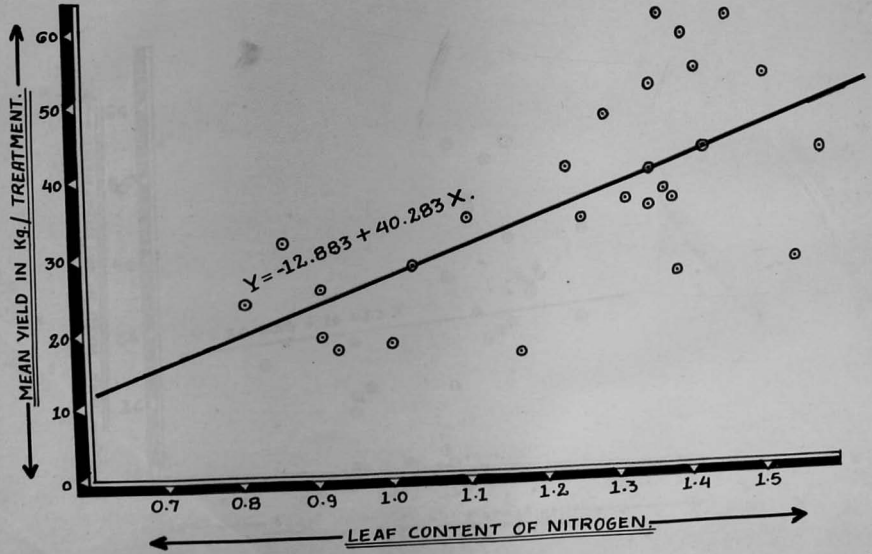


FIGURE :- 1 LINEAR REGRESSION OF MEAN YIELD ON THE NITROGEN CONTENT OF CHICKU LEAVES IN SEPTEMBER - 1977.



the yield, a firm recommendation may have to await further collection of data and a pooled analysis.

From the foregoing discussion it is seen that the yield of chi ku under these conditions responds well to nitrogen and to a little extent to potassium but not to phosphorus. Septmeber appears to be a suitable period for sampling leaves for assessing the nutrient status of the trees.

S U M M A R Y

A fertilizer trial with three levels of N, P and K is in progress on Chiku, cv. Kalipatti, at the Fruit Research Station, N. M. College of Agriculture, Navsari. The trees receiving graded doses according to their age are in their 8th year and have received in two split doses, 0, 360 and 720 g per treatment of N, P and K in all combinations in Randomised Replicated trial.

The yield of the trees and their leaf content of N, P and K each month from May 1977 to November 1977 were recorded.

The higher levels of nitrogen applied to the soil gave statistically significant higher yields. There was no significant response to P and K applications.

Leaf nitrogen content was moderate in May, reduced in June, increased in July 1977 then decreased again in August and remained at a fairly constant level upto October and then increased to a maximum in the month of November 1977.

It was also observed that application of phosphorus had consistently increased the N content of the leaves during

all the months. Potassium application had also improved the N content of the leaves.

The phosphorus content of the leaves was not affected significantly by the three levels of P fertilization. There was reduction in the leaf level of P with increasing K application to the soil.

The Potassium content of the leaves was also not affected significantly with different levels of soil application of K, P and N. There was a general tendency for increase in the leaf content of K with higher levels of soil application in the month of November only. There was no effect of the soil application of N and P on the leaf content of K.

Correlation was worked out for all the months between the leaf nutrient content and the total annual yields. The yields were positively and significantly correlated with leaf content of nitrogen. The yield was negatively correlated with P in the ~~constant~~ months of May to September 1977 and positively in October and November, but none of them statistically significant. Similarly, there was a negative correlation between leaf content of K and yield in the month of May, June and July, but not significant. The yield was correlated positively with the leaf content of K in the months of August to November, but the correlation was significant only

in August and September. It was concluded that the month of September would be most suitable for sampling leaves for the assessment of nutritional status of the trees.

The yields improved with application of nitrogen. There appeared to be no need to apply phosphorus as it did not affect levels or yield. Application of potash has shown same benefit.

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H.A. Horticultural Abstract.

Appendix I. Meteorological data 1977-78 (January 77 to April 78)

Weeks	Temperature		Humidity		Rainfall in cms.
	Avg. max. temp. in °C	Avg. minimum temp. in °C	Avg. max. humi. %	Avg. minimum humi. %	
1-1/7-1-77	31.0	13.0	73	43	0.0
8-1/14-1-77	31.4	11.4	70	43	0.0
15-1/21-1-77	29.2	11.4	79	41	0.0
22-1/28-1-77	29.2	11.5	79	54	0.0
29-1-77/4-2-77	30.6	11.1	72	32	0.0
5-2/11-2-77	32.0	10.0	59	22	0.0
12-/18-2-77	31.8	15.2	86	32	0.0
19-2/25-2-77	33.3	17.9	91	40	0.5
26-2/4-3-77	35.4	15.9	70	29	0.0
5-3/11-3-77	37.8	18.1	67	24	0.0
12-3/18-3-77	36.0	18.8	93	43	0.0
19-3/25-3-77	37.1	19.0	68	30	0.0
26-3/1-4-77	37.2	22.1	70	39	0.0
2-4/8-4-77	35.6	23.0	76	47	0.0
9-4/15-4-77	33.6	23.7	87	57	0.0
16-4/22-4-77	34.7	23.8	84	61	0.0
23-4/29-4-77	34.2	24.6	84	54	0.0
30-4/6-5-77	33.6	25.0	80	60	0.0
7-5/13-5-77	35.0	25.8	85	63	0.0
14-5/20-5-77	35.0	25.5	85	71	0.0
21-5/27-5-77	35.0	25.3	83	63	0.5
28-5/3-6-77	34.3	27.5	84	67	0.0
4-6/10-6-77	34.6	27.3	76	58	3.0
11-6/17-6-77	35.0	25.6	84	64	9.0
18-6/24-6-77	34.2	24.9	93	74	47.0
25-6/1-7-77	29.6	25.5	91	89	232.0
2-7/8-7-77	30.1	25.2	93	87	311.0
9-7/15-7-77	30.3	24.3	96	89	55.0
16-7/22-7-77	30.7	25.6	99	85	65.5
23-7/29-7-77	29.6	25.1	96	85	285.0
30-7/5-8-77	30.3	25.3	91	81	15.5
6-8/12-8-77	30.3	25.4	91	82	31.9
13-8/19-8-77	30.1	25.6	91	86	56.6
20-8/26-8-77	30.3	25.2	93	79	11.5
27-8/2-9-77	29.8	24.7	94	85	38.5

3-9/9-9-77	29.6	23.9	97	86	200.0
10-9/16-9-77	30.1	24.1	93	81	10.5
17-9/23-9-77	30.8	23.8	95	72	12.5
24-9/30-9-77	34.8	23.6	93	52	0.0
1-10/7-10-77	34.0	24.4	94	65	0.0
8-10/14-10-77	37.0	22.1	93	51	0.0
15-10/21-10-77	37.2	19.9	75	39	0.0
22-10/28-10-77	36.2	18.5	79	41	0.0
29-10/4-11-77	36.0	19.9	83	46	0.0
5-11/11-11-77	35.5	19.9	75	37	0.0
12-11/18-11-77	34.9	20.9	76	35	0.0
19-11/25-11-77	33.2	19.3	77	54	0.0
26-11/2-12-77	30.6	20.3	93	67	0.0
3-12-77/9-12-77	32.5	16.1	95	51	0.0
10-12/16-12-77	32.5	13.6	90	43	0.0
17-12/23-12-77	32.1	14.0	89	30	0.0
24-12/31-12-77	29.0	11.7	90	53	0.0
1-1/7-1-78	30.2	10.0	71	36	0.0
8-1/14-1-78	30.6	12.4	79	47	0.0
15-1/21-1-78	29.9	10.7	85	53	0.0
22-1/28-1-78	30.8	10.3	84	56	0.0
29-1/4-2-78	30.8	10.4	85	39	0.0
5-2-78/11-2-78	31.3	15.4	74	69	0.0
12-2/18-2-78	29.1	15.8	88	50	0.0
19-2/25-2-78	32.4	14.5	91	41	0.0
26-2/4-3-78	34.0	17.8	89	48	0.0
5-3/11-3-78	33.0	16.1	91	52	0.0
12-3/18-3-78	33.0	16.8	85	56	0.0
19-3/25-3-78	32.3	15.7	76	64	0.0
26-3/1-4-78	33.5	17.3	94	42	0.0
2-4-78/8-4-78	38.0	20.5	83	26	0.0
9-4/15-4-78	37.8	21.8	89	41	0.0
16-4/22-4-78	33.0	22.2	89	55	0.0
23-4/29-4-78	33.8	24.6	89	55	0.0
30-4/5-5-78	38.3	24.4	83	44	0.0

Appendix II. Analysis of Variance of the Data of Chiku yields.

Source	Df	S.S.	M.S.	Cal.'F'
Replication	1	112.3860	112.3860	1.257
Treatment	26	9336.4666	359.095	4.016**
NoPoKo				
N1	1	4502.4100	4502.4100	50.3490**
N2	1	543.1559	543.1559	6.0739*
P1	1	8.9002	0.0995	
P2	1	362.8166	362.8166	4.0573
K1	1	7.5626	7.5626	0.0846
K2	1	11.5706	11 .5706	0.1294
NP - N1P1	1	1.4750	1.4750	0.0165
N1P2	1	859.0512	859.0512	9.6065**
N2P1	1	89.0000	89.0000	0.9953
N2P2	1	8.3629	9.9629	0.1002
NK - N1K1	1	16.6666	1.6666	0.1864
N1K2	1	192.5703	192.5703	2.1535
N2K1	1	360.4612	360.4612	4.0309
N2K2	1	410.7158	410.7158	4.5929*
PK - P1K1	1	237.8251	237.8251	2.6592
P1K2	1	136.4001	136.4001	1.5253
P2K1	1	53.5612	53.5612	0.5990
P2K2	1	0.0003	0.0003	0.0000
NPK - N1P1K1	1	98.5056	98 .5056	1.1016
N1P1K2	1	507.3250	507.3250	5.6733*
N1P2K1	1	197.0325	197.0325	2.2034
N1P2K2	1	31.3600	31.3600	0.3507
N2P1K1	1	67.9252	67.9252	0.7596
N2P1K2	1	340.2487	340.2487	3.8049
N2P2K1	1	237.7264	237.7264	3.2176
N2P2K2	1	3.2378	3.2378	0.0362
rror	26	2325.0293	89.04240	
tal	53	9336.4666		

an	:	36.892
m ±	:	6.6867
D. 5%	:	19.442
D. 1%	:	26.279
V. %	:	25.63

Significant at 5% level
Significant at 1% level

Appendix IIIa:- Monthwise Mean Yield of Chiku Fruits per Treatment.

Sr. No.	Treatment	July 1977	August 1977	November 1977	December 1977	January 1978	March 1978	Total Mean	Mean
1	No Po Ko	1.750	4.625	4.600	9.250	2.300	0.750	23.275	3.879
2	No Po K1	1.500	4.750	7.375	13.500	2.750	1.325	31.200	5.200
3	No Po K2	0.450	2.950	3.400	8.125	3.800	0.086	18.813	3.136
4	No P1 Ko	0.950	3.000	2.050	9.500	1.100	0.200	16.900	2.817
5	No P1 K1	0.250	3.500	4.550	11.875	4.000	0.800	24.975	4.163
6	No P1 K2	0.200	2.375	3.600	10.250	0.600	0.550	17.575	2.929
7	No P2 Ko	3.750	5.775	3.275	12.375	2.500	0.362	28.037	4.673
8	No P2 K1	2.250	5.325	10.300	12.900	2.850	0.650	34.275	5.713
9	No P2 K2	-	2.000	2.100	9.750	2.100	0.250	16.150	2.692
10	N1 Po Ko	7.600	4.250	10.700	19.150	1.075	1.025	42.800	7.300
11	N1 Po K1	2.650	3.375	8.000	14.600	3.100	1.225	33.950	5.658
12	N1 Po K2	3.650	7.375	14.600	18.775	2.300	1.125	47.825	7.971
13	N1 P1 Ko	2.850	1.625	13.000	14.300	3.500	1.050	36.325	6.054
14	N1 P1 K1	4.750	4.800	8.250	18.550	2.900	1.050	40.300	6.717
15	N1 P1 K2	8.250	9.550	11.550	26.700	3.500	1.400	60.950	10.158
16	N1 P2 Ko	5.600	5.925	4.950	17.125	1.500	1.400	36.500	6.083
17	N1 P2 K1	5.750	4.250	5.150	16.875	2.100	1.175	35.300	5.883
18	N1 P2 K2	3.450	3.750	10.475	14.350	5.000	0.425	37.450	6.242
19	N2 Po Ko	1.600	2.625	7.575	11.825	2.300	0.325	26.250	4.375
20	N2 Po K1	9.500	8.000	14.650	15.200	2.200	2.200	51.750	8.625
21	N2 Po K2	8.200	4.750	12.800	11.100	4.050	2.250	43.150	7.192
22	N2 P1 Ko	11.750	5.900	14.275	24.750	2.750	1.550	60.925	10.154
23	N2 P1 K1	9.250	6.750	20.850	17.450	3.000	1.050	58.350	9.725
24	N2 P1 K2	6.600	5.750	16.075	16.925	2.050	1.325	48.725	8.121
25	N2 P2 Ko	9.500	8.125	13.850	18.650	1.750	1.075	52.950	8.825
26	N2 P2 K1	1.250	3.875	6.200	12.750	2.400	1.350	27.825	4.638
27	N2 P2 K2	8.900	3.400	19.350	11.050	1.775	1.100	42.575	7.096
	Mean	4.415	4.755	9.426	14.730	2.5648	1.001	996.100	6.149
'F' test result.		NS	Sign.	Sign.	NS	NS			
S.Em. ±		2.8935	1.6661	3.2218	2.6320	1.2369	5.041		
C.D. at 5% level.		-	4.8443	9.3680	-	-	-		
C.D. at 1% level.		-	6.5479	12.6630	-	-	-		
C.V.		92.69	47.08	48.34	35.73	68.20	100.73		

Appendix IIIb:- Mean Yield for the Month of July 1977.

	K0				K1				K2				
	P0	P1	P2	Mean	P0	P1	P2	Mean	P0	P1	P2	Mean	Mean
N0	1.750	0.950	3.750	2.150	1.500	0.250	2.250	1.333	0.450	0.200	-	0.217	1.233
N1	7.600	2.850	5.600	5.350	2.650	4.750	5.750	4.383	3.650	8.250	3.450	5.117	4.950
N2	1.600	11.750	9.500	7.617	9.500	9.250	1.250	6.666	8.200	6.600	5.900	6.900	7.061
Mean	3.650	5.180	6.28	5.039	4.550	4.750	3.083	4.128	4.100	5.017	3.117	4.018	4.415

	N.	P.	K.	NP.	NK.	PK.	NPK.
S.Em. ±	0.9645	0.9645	0.9645	1.6705	1.6705	1.6705	2.8935
C.D. at 5% level.	—	—	—	—	—	—	—

Appendix IIIc:- Mean Yield for the month of August 1977

	K0				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	4.625	3.000	5.775	4.467	4.750	3.500	5.325	4.525	2.950	2.375	2.000	2.442	3.811
N1	4.250	1.625	5.925	3.933	3.375	4.800	4.250	4.142	7.375	4.550	3.750	6.892	4.989
N2	2.625	5.900	8.125	5.550	8.000	6.750	3.875	6.208	4.750	5.750	3.400	4.633	5.464
Mean	3.833	3.508	6.608	4.649	5.375	5.017	4.483	4.958	5.025	5.891	3.050	4.656	4.755

	N.	P.	K.	NP.	NK.	PK.	NPK.
S.Em. ±	0.5554	0.5554	0.5554	0.9619	0.9619	0.9619	1.6661
C.D. at 5% level.	1.6148	1.6148	1.6148	2.7968	2.7968	2.7968	4.8443

Appendix IIId:- Mean Yield for the Month of November 1977

	K0				K1				K2				
	P0	P1	P2	Mean	P0	P1	P2	Mean	P0	P1	P2	Mean	Mean
N0	4.600	2.050	3.275	3.308	7.375	4.550	10.300	7.408	3.400	3.600	2.050	3.017	4.578
N1	10.700	13.000	4.950	9.550	9.000	8.250	5.150	7.467	14.600	11.550	10.475	12.208	9.742
N2	7.575	14.275	13.850	11.900	14.650	20.850	6.200	13.900	12.800	16.075	19.350	16.075	13.958
Mean	7.625	9.775	7.358	8.253	10.342	11.217	7.217	9.592	10.267	10.408	10.625	10.433	9.425

	N.	P.	K.	NP.	NK.	PK.	NPK.
S.Em. ±	1.0740	1.0740	1.0740	1.8602	1.8602	1.8602	3.2218
C.D. at 5% level.	3.1227	3.1227	3.1227	5.4086	5.4086	5.4086	9.3680

Appendix IIIe:- Mean Yield for the month of December 1977

	Ko				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	9.250	9.600	12.375	10.408	13.500	11.875	12.900	12.758	8.125	10.250	9.750	9.375	10.847
N1	19.150	14.300	17.125	16.858	14.600	18.550	16.875	16.675	18.775	26.700	14.350	19.942	17.825
N2	11.825	24.750	18.650	18.408	15.200	17.450	12.750	15.133	11.100	16.925	11.050	13.025	15.522
Mean	13.408	16.217	16.050	15.225	14.433	15.958	14.175	14.855	12.667	17.958	11.717	14.114	14.731

	N.	P.	K.	NP.	NK.	PK.	NPK.
S.Em. ±	1.2407	1.2407	1.2407	2.1490	2.1490	2.1490	3.7222
C.D. at 5% level.	—	—	—	—	—	—	—

Appendix IIIf:- Mean Yield for the Month of January 1978

	Ko				K1				K2				Mean
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	
No	2.300	1.100	2.500	1.967	2.750	4.000	2.850	3.200	3.800	0.600	2.100	2.166	2.444
N1	1.075	3.500	1.500	2.025	3.100	2.900	2.100	2.700	2.300	3.500	5.500	3.600	2.775
N2	2.300	2.750	1.750	2.267	2.2000	3.000	2.400	2.533	4.050	2.050	1.775	2.625	2.475
Mean	1.892	2.450	1.917	2.086	2.683	3.300	2.450	2.811	3.383	2.050	2.958	2.797	2.565

	N.	P.	K.	NP.	PK.	NK.	NPK.
S.Em. ±	0.4123	0.4123	0.4123	0.7141	0.7141	0.7141	1.2369
C.D. at 5% level.	—	—	—	—	—	—	—

Appendix III g:- Mean Yield for the Month of March 1978

	K0				K1				K2				
	Po	P1	P2	Mean	Po	P1	P2	Mean	Po	P1	P2	Mean	Mean
No	0.750	0.200	0.362	0.437	1.325	0.800	0.650	0.925	0.887	0.550	0.250	0.296	0.553
N1	1.025	1.050	1.400	1.158	1.225	1.050	1.175	1.150	1.125	1.400	0.425	0.983	1.097
N2	0.325	1.500	1.075	0.967	2.200	1.050	1.350	1.533	2.250	1.325	1.100	1.558	1.353
Mean	0.700	0.917	0.946	0.854	1.583	0.967	1.058	1.203	1.154	1.092	0.592	0.946	1.001

	N.	P.	K.	NP.	PK.	NK.	NPK.
S.Em. ±	0.2376	0.2376	0.2376	0.4116	0.4116	0.4116	0.7129
C.D. at 5% level.	—	—	—	—	—	—	—