EFFECT OF VARYING LEVELS OF NITROGEN, PHOSPHORUS AND POTASSIUM ON GROWTH, YIELD AND QUALITY OF CHIKU, Manilkara achras (Mill) VAR. 'KALIPATTI'

BY

Balasaheb Shriram Patil
B. Sc. (Agri.)

A Thesis Submitted to the

MAHATMA PHULE KRISHI VIDYAPEETH

(AGRICULTURAL UNIVERSITY)

RAHURI, Dist. Ahmednagar.

(MAHARASHTRA)

in partial fulfilment of the requirements for the degree

of

Master of Science (Agriculture)

in

Horticulture

DEPARTMENT OF HORTICULTURE

Post - Graduate School, M. P. K. V., Rahuri

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C E R T I F I C A T E

This is to certify that the thesis entitled "EFFECT OF VARYING LEVELS OF NITROGEN, PHOSPHORUS AND POTASSIUM ON GROWTH, YIELD AND QUALITY OF CHIKU, *Manilkara achras* (Mill) VAR. KALIPATTI", submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, District - Ahmednagar in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE (AGRICULTURE) in HORTICULTURE embodies a piece of *bona fide* research work carried out by SHRI BALASAHEB SHRIRAM PATIL under my guidance and supervision and that no part of the thesis has been submitted for any other degree or publication.

Rahuri,

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Rahuri,

Date : 26/9/80.

(K. S. Pharande)

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Patil

Rahuri,
Date : 26/9/80

(B. S. Patil)

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Chapter I

I N T R O D U C T I O N

CHAPTER I

INTRODUCTION

The chiku, *Manilkara achras* (Mill) is one of the important minor fruits of India. It is grown in Maharashtra, Gujrath, Kerala, Tamil Nadu, Karnataka, Andhra Pradesh, U.P., Punjab, Bihar and West Bengal. In Maharashtra chiku is mainly grown in ~~to~~ coastal areas of Thana, Kolaba and Ratnagiri districts. However, it is spreading to Deccan to eastern part of the State.

The area and production of this crop is increasing fast and the present area in India is reported to be 3500 hectares with an annual production of 75 to 80 thousand tonnes and a turn over of Rs.4 million (Phadnis, 1977).

The crop is of tropical nature and grows well under warm humid climatic conditions. However, it performs good under semi-arid conditions of the State also.

Chiku is one of the easiest crops to grow under a variety of soil and climatic conditions. It can tolerate a certain amount of salinity and alkalinity and is one of the few fruits which can tolerate irrigation with brackish water (Madhava Rao, 1975). It is one of the hardiest fruit trees and can tolerate drought to a considerable extent as compared to most other fruit plants.

The immature fruit contains tannin and latex and is astringent in taste. The flesh of ripe fruit has a good total sugar content (12-14 per cent) and some proteins and little acidity (Gandhi, 1956). It is quite rich in potassium also.

Chapter II

REVIEW OF LITERATURE

It contains other minerals like magnesium, calcium and phosphorus as well.

Manuring is an important cultural aspect which has great dealing on production of the fruit. However, in chiku no systematic research on manuring has been reported in India and also outside India. The manurial schedules for chiku have been reported by Cheema _et al_. (1954), Gandhi (1956) and Phadnis (1971), however, all these are on _ad hoc_ basis. Cheema _et al_. (1954) recommended annually, the application of 4-5 baskets of sheep manure and 10-15 lb of bone meal or sheep manure plus 10 to 15 lb of oil cake. Similarly, Gandhi (1956) recommended the application of 100 lb FYM + 15 lb of castor cake and 5 lb of bone meal for full grown tree of 10 years age. The above recommendations are mainly restricted to use of organic manures. Phadnis (1971) recommended along with organic manures the use of ammonium sulphate. Venkataratnam (1973) recommended superphosphate for chiku in South India.

All these manurial doses have been recommended on _ad hoc_ basis.

In view of the lack of information on nutrition of chiku it was considered essential to undertake a study on the effect of nitrogen, phosphorus and potassium on growth, yield and fruit quality with the following objectives.

i) To determine the optimum dose of nitrogen, phosphorus and potassium for chiku cv. Kalipatti.
ii) To study their effect on fruit quality.
iii) To study the leaf nutrient status in relation to various manurial treatments.

CHAPTER II

REVIEW OF LITERATURE

Nutritional supply is generally considered as the most important factor limiting growth and productiveness of the plants and no plant life would be conceivable without the nutrients. Voluminous information has been reported on nutritional studies of major fruit crops like grape, banana, mango, citrus and apple. However, the minor fruit crops like chiku, guava, pomegranate, fig, phalsa and anona have been neglected in this respect.

In view of crucially important part played by nutrients in fruit crops for proper growth and fruitfulness, an attempt is made to review the work done on nutritional aspects on chiku and other fruit crops as below.

There are only a few reports regarding nutritional requirements of chiku. Cheema et al. (1954) recommended application of 4-5 baskets of sheep manure and 20 lb of fish or 15 lb of bone meal or 15 lb of oil cake, twice a year, while Gandhi (1956) recommended the application of 100 lb of farm yard manure, 15 lb of castor cake and 5 lb of bone meal for 10 years old tree. Besides farm yard manure, the application of inorganic fertilizers has been advocated by Phadnis (1971), who recommended that the bearing tree should be manured with 100 kg of farm yard manure or compost, along with 2½ kg of ammonium sulphate in two doses in January and September each year. Venkataratnam (1973) recommended superphosphate for chiku under South Indian conditions. All these above manurial doses recommended were on *ad hoc* basis. No systematic experiments were laid out for studying the nutritional requirements of chiku crop so far.

The studies on chemical composition of leaf were carried out by Gotmare (1960). He studied the influences of propagational methods, seasonal flushes and age of leaf on chemical composition of chiku leaf. It was the first attempt done in systematic way for nutritional studies of chiku. He reported that with increase in age of chiku leaf the N, P, K content decreased while Ca, ash and Mg content increased. Further he reported that a minimum change or fair constancy was found when the leaf attains an age of four to five months. The average leaf nutrient values of 1.07% N, 0.35% P, 0.86% K, 3.65% Ca and 0.42% Mg were reported by him.

Narke (1969) carried out the leaf analysis studies to assess the nutritional status of healthy and declining chiku trees from Thana district. He reported that high nitrogen and low phosphorus coupled with optimum potassium were responsible for healthy development of chiku trees whereas the high phosphorus and low potassium content were responsible for the declining condition of trees.

The studies were carried out by Kamble (1980). As per studies of Kamble (1980) a dose of 1.5 kg N + 0.5 kg P_2O_5 + 0.5 kg K_2O per plant was found optimum for the chiku plant having an age of 5-6 years.

The attempt is made to review the work done on nutritional aspects of other fruit crops as below.

I <u>Nitrogen</u> :

Nitrogen is the basic constituent of plant life. Its deficiency results in heavy reduction in growth and yield.

Nitrogen plays a vital role in growth of plant. Singh <u>et al</u>. (1973) reported that the spread and volume of the mango tree were positively related to nitrogen levels. Arora (1969) found that an application of nitrogen was beneficial for significant improvement of terminal shoots, number of leaves and leaf area in guava. The linear response for growth characters with increasing levels of N was observed by Shende (1977) in pomegranate.

Nitrogen also plays a vital role in fruit production. The increase in yield with the application of nitrogen has been reported in guava by Tiwari <u>et al</u>. (1968). The increase in yield with nitrogen application has been reported by Shende (1977) in pomegranate while by Khandagale (1977) and Kalbhor (1979) in grapes.

A widespread impression prevails that high rates of nitrogen are detrimental to fruit quality. The results reported by number of workers are quite contradictory to each other. Deterioration in fruit quality due to N application has been reported by Chadha and Lakhbir singh (1971), and Chitkara <u>et al</u>. (1972) in grapes. The increase in acidity and decrease in T.S.S. and sugars were observed by Arutyunyan <u>et al</u>. (1964)

and Desai (1972) in grapes. Bhattacharya _et al_. (1973) observed that the number of seed per fruit was increased by N application and quality was deteriorated as compared with control in Kagzi lime. Improvement in fruit quality due to nitrogen application has been reported by Srivastava and Muthappa (1972) in Mandarins and Shende (1977) in pomegranate. They reported that percentage T.S.S. was increased with increased nitrogen fertilization. Similarly, increase in juice content, T.S.S. and acidity in Persian lime due to nitrogen application has been reported by Young and Koo (1968).

The leaf N content was directly related to the level of N fertilization according to Bansal and Motiramani (1968) in guava and Shende (1977) in pomegranate. Sadhu _et al_. (1975) reported that foliar P content increased with added P and N in phalsa plant. However, Christ and Ulrich (1954) observed that the addition of nitrogen to grapes not only resulted in better vine growth and higher production but actually increased potassium content of the vine. Neff _et al_. (1953) in tung and Mijjar (1972) in grapes reported that the leaf Ca content increased due to nitrogen application. Chapman (1952) reported that the higher nitrogen supply resulted in higher uptake of magnesium. Increased leaf Ca and Mg contents due to nitrogen application have been reported by Patil (1978) in guava.

II _Phosphorus_ :

Phosphorus is also an essential constituent of majority of enzymes which are of great importance in the transformation of energy, carbohydrate and fat metabolism and also in respiration in plants.

Singh and Rajput (1977) reported that the height of the guava plant was increased by P application. Singh (1973) reported that length of terminal shoots was increased with P application in Allahabad safeda guava. Fleming (1961) reported vigorous vine growth due to phosphorus application. However, Reuther *et al.* (1949) observed that large amount of phosphatic fertilisers have been used without beneficial effects on the growth of citrus. Shende (1977) observed adverse effect of higher phosphorus level on growth of pomegranate.

Increase in yield due to P application has been reported by Arora and Singh (1970), Teaotia *et al.* (1972) and Singh and Rajput (1976) in guava. Singh and Rajput (1976) observed a quadratic response between yield and rate of P fertilisation in guava. However, reduction in growth and yield was noticed by Shende (1977) in pomegranate and Shinde (1979) in fig.

Phosphorus helps to improve the fruit quality. In guava Arora and Singh (1970) and Teaotia *et al.* (1972), observed highest T.S.S., reducing sugars, total sugars, ascorbic acid and pectin content with the application of P. Similarly Singh (1975) observed improvement in sugars, total acidity, ascorbic acid and T.S.S. with P application in mango. Anderson (1966) reported that phosphorus increased the yield but deteriorated fruit quality in Valencia orange.

Kozma and Polyak (1964) observed increased P content of grape leaf petiole with the application of phosphorus. The increase in leaf P status with the application of phosphorus has been reported by Reese and Koo (1977) in orange, Shende

(1977) in pomegranate and Patil (1978) in guava. However, Abdalla and Sefick (1965) reported that the P content of leaf petiole was not altered with the application of phosphatic fertilizers. Bansal and Motiramani (1968) reported that there was no effect of P application on N and K content of guava leaves.

III Potassium :

The considerable increase in vegetative growth of plants with potassium was reported by Dornelles (1963) in citrus and Patil (1978) in guava. According to Singh (1973), the growth of plant was improved considerably by foliar application of muriate of potash, in guava. Khandagale (1977) reported that the K application helped to increase the stem girth and pruning weight in grape.

Martin (1973) and Reese and Koo (1975) reported increase in yields of citrus due to potassium application. The application of potassium has been found beneficial in increasing the yield of fruit crops as observed by Khandagale (1979) in grape, Chougule (1976) and Shende (1977) in pomegranate. Smith and Rasmussen (1961) reported that grapefruit trees on low K content, produced substantially large number of fruits than on high K content.

Gopalswamy and Rao (1972) reported that the application of K increased T.S.S., acidity and total sugars in grape. Khandagale (1977) reported that the quality of grape was improved with the application of potassium as compared with no application. He further pointed out that the potassium treated bunches were high in T.S.S., reducing sugars and T.S.S./acid ratio while low in acidity. According to Singh and Rajput (1977) the K application improved the fruit quality in guava.

The increase in leaf K content with the application of potassic fertilisers has been reported by Divate (1967), Desai (1972) and Khandagale (1977) in grapes, Reese and Koo (1977) in citrus, Shende (1977) in pomegranate.

IV <u>Combined effect of nitrogen, phosphorus and potassium</u> :

The balanced use of fertilizers is considered as a key to get maximum beneficial effect in terms of growth, yield and quality of fruit crops.

Merril and Greer (1946) reported that the interaction between N and P was more effective than when N and P were used separately in increasing the productiveness and growth of tung trees. Aso and Dantur (1970) in Valencia orange and Purohit (1972) in papaya, reported that the NP interaction was more effective than when N and P were used separately in increasing growth and productiveness.

Semochkina (1977) reported that when nitrogen was applied in combination with phosphorus the fruit sugar content was increased in fig. Thorne and Stark (1946) reported that in Uthah, the sweet cherries responded to commercial nitrogen fertilisers and produced largest yield when phosphorus was added to nitrogen. However, phosphorus alone was not effective in increasing the yield over unfertilized trees.

Partridge and Veatch (1937) reported that acid phosphate or potassium chloride added to nitrogen gave increased growth and productiveness in grape. Young and Koo (1968) in Persian lime observed an increase in growth and yield due to combined effect of N and K.

Khandagale (1977) in grape, Shende (1977) in pomegranate and Patil (1978) in guava, reported that combined application of P and K was more beneficial than individual application of P or K.

There is a general trend that the combined application of N, P and K increased the yield as compared to individual application of any element as reported by Prudente and Mendoza (1976) in coconut, Shende (1977) in pomegranate, Khandagale (1977) in grape. Desai (1972) obtained an increase total sugars, reducing sugars and T.S.S. with NPK over N or NP in grape.

A critical review of literature indicates that hardly any information is available on the mineral nutrition of "Kalipatti" cultivar of chiku. The need and urgency of finding out its impact on this cultivar under dry Western Maharashtra conditions is necessary. This promoted the author to undertake well planned nutritional experiment on this cultivar.

Chapter III

MATERIALS AND METHODS

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MATERIALS AND METHODS

The present manurial trial was laid out at the 'Instructional-cum-Research Orchard' of the Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri during the year 1979-80. The vegetatively propagated grafts of 'Kalipatti' variety of chiku were planted in July 1973 at a spacing of 9.5 x 9.5 metres.

The soil of the experimental plot is medium black with murum as sub-strata at about one metre depth and having pH of 8.5. It is low in nitrogen but slightly rich in phosphorus and potassium status (data of soil analysis is given in Appendix-I).

The basins of individual plant were dug during December, 1978 and fresh basins were prepared. A basal dose of FYM at the rate of 25 kg per plant was applied to all the plants and it was mixed well with the soil. The fertilizers were applied to experimental plants as per the treatments on 10-1-1979. Plant protection measures and intercultural operations such as irrigation and weeding were adopted as and when required.

Experimental details :

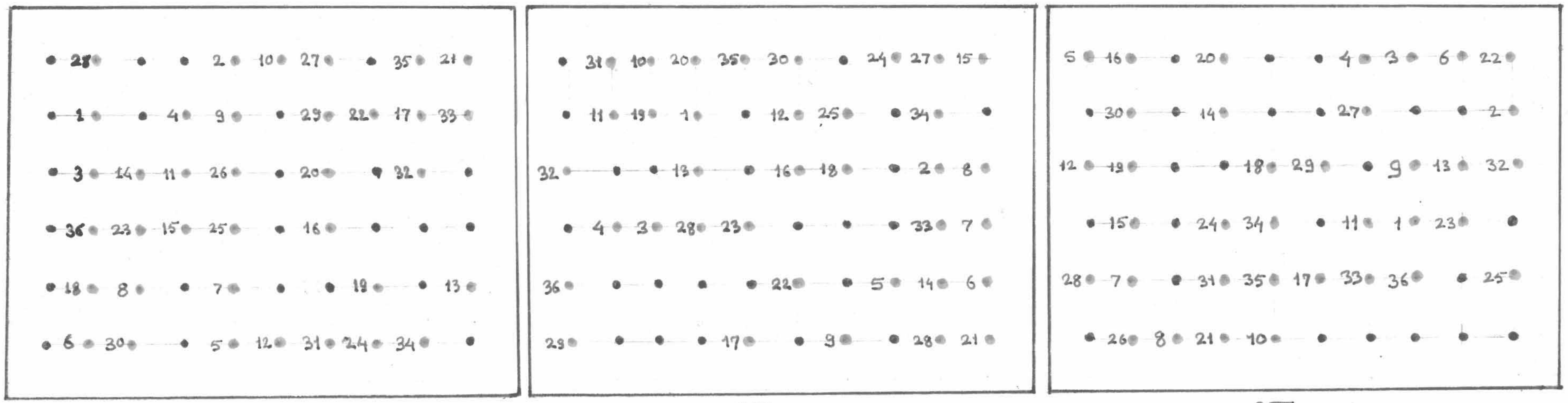
The experiment was laid out in 4 x 3 x 3 factorial randomised block design with the total 36 treatment combinations replicated thrice. Single plant was taken as an experimental plant in each treatment. The treatment combinations were formulated by taking four levels of nitrogen viz., 0, 0.6, 1.2 and 1.8 kg nitrogen per plant per year and three levels of each of phosphorus and potassium viz., 0, 0.6 and 1.2 kg P_2O_5

and K_2O per plant per year. The plan of layout of the experiment is given in Fig.1.

<u>Fertilizer application</u> :

Besides the basal dose of FYM, a half dose of phosphorus and potassium along with quarter dose of nitrogen was applied on 10-1-1979. The quarter dose of nitrogen was applied after one and half month from first dose i.e. on 25-2-1979. The remaining half dose of P and K and quarter dose of N was applied on 10th September, 1979. The remaining quarter dose of N was applied on 25-10-1979. Nitrogen was supplied in the form of urea, phosphorus through single superphosphate and potassium through muriate of potash. The fertilizers were applied in the ring below canopy of the plant and mixed well in the soil. The irrigation was given immediately after the fertilizer application.

PLAN OF LAYOUT



RI RII RIII

TREATMENT COMBINATIONS

VARIETY	– KALIPATTI
DATE OF PLANTING	– JULY 1973
SPACING	– 9.5 × 9.5 M
OBSERVATIONAL PLANTS	– 108
TOTAL PLANTS	– 180
OBSERVATIONAL PLANTS	– ●

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

Observations :

Observations in respect of growth, yield and physico-chemical characters of fruit for each treatment plant were recorded.

(A) Growth characters :

1. Stem girth :

The girth of the stem was measured in cm with the help of string at 15 cm. height from ground level at an interval of 3 months.

2. Height of plant :

The height of treatment plant was measured in metres with the help of bamboo stick from the ground level to the highest growing tip of the main stem at an interval of 3 months.

3. Spread of plant :

The East-West and North-South spread of the plant was recorded in metres with the help of bamboo stick at an interval of 3 months. The mean spread was worked out.

4. Volume of plant :

The volume of the plant was estimated in cubic metres by multiplying height x East-West spread x North-South spread.

5. Leaf area :

Fifty basal full sized leaves from shoots of moderate vigour were selected randomly on each plant on 10th May, 1979 (i.e. 120 days from first fertilizer application). The leaf area was estimated in square cm. With the help of automatic leaf area meter.

(B) Yield :

1. Number of fruits per plant :

Number of fruits harvested per treatment plant at each harvesting was counted and from this the total number of fruits harvested per plant during the year of observation was worked out.

2. Yield (kg) per plant :

At each harvesting, the weight of harvested fruits from each treatment plant was recorded and from this the total yield per plant in kg was worked out.

(C) Physico-chemical characters of fruit :

Large number of fruits were tagged at the time of fruit set, in order to get the fruits of uniform age and maturity. From each treatment plant fifteen matured fruits were selected randomly for studying the physico-chemical characters of fruit.

1. Diameter of fruit :

The diameter of each fruit was measured in cm at the maximum thickness by Vernier Calliper and average diameter of fruit was worked out.

2. Length of fruit :

Length of each fruit from stalk end to styler end was measured with the help of Vernier Calliper and average length of fruit was calculated.

3. Weight of fruit :

The weight of fifteen fruits was recorded for each treatment plant and from this average weight of fruit was worked out.

4. Volume of fruit :

The volume of each fruit in ml was recorded by water displacement method separately for fifteen fruits and average volume per fruit was calculated.

5. Percentage of fruit pulp :

The pulp of individual fruit was weighed for 15 fruits on balance and per cent weight of pulp was calculated.

The pulp of 15 fruits from single treatment plant was thoroughly mixed with mixer and it was further utilized for the chemical analysis.

6. Percentage of seed :

Seeds present in individual fruit were weighed and per cent weight of seed was calculated.

7. Percentage of skin :

The percentage of skin was worked out by substracting the percentage pulp + percentage of seed

8. Total soluble solids :

The percentage of total soluble solids of the pulp for each treatment was determined with hand refractometer (Erma, Tokyo, A 30°C).

9. Acidity :

The titratable acidity of the pulp was determined according to the method given in A.O.A.C. (1960) by titrating the pulp against N/10 NaOH solution using phenolphthalein as an indicator. The acidity was expressed in percentage as citric acid.

10. Reducing sugars :

Determination of reducing and total sugars was done volumetrically according to the methods standardized by Lane and Eynon (1960).

11. Non-reducing sugars :

The percentage of non-reducing sugars was worked out by deducting the percentage of reducing sugars from the percentage of total sugars.

(D) Leaf analysis :

a) Collection of samples :

The newly emerging leaves on twigs of plant from all sides were tagged during the application of first dose of fertilizers. At the age of four months, such fifty leaves were selected randomly. The leaves along with the petioles from all the sides of plants and at different positions were removed from each treatment plant. The leaf samples were collected between 7.30 to 11.30 a.m. A composite sample of fifty leaves was made for each treatment. The leaf sampling technique was adopted as per the procedure followed by Gotmare (1960).

b) Pre-treatment :

After collection, the leaves were brought to laboratory and washed with tap water and then with distilled water and wiped off with muslin cloth. The leaf samples were dried in hot air oven at 60°C temperature for 24 hours. The dried samples were powdered in procelin morter with pestle and kept in air tight amber coloured bottles.

c) Digestion :

Accurately weighed 0.1 g leaf powder was digested in digestion flask with 10 ml of 1:1 mixture of concentrated sulphuric acid and 30 per cent hydrogen peroxide as per the procedure laid out by Warncke and Barber (1974) till the content became colourless.

The cooled digested material was transferred to 10 ml volumetric flask and volume was made to 100 ml with repeated washings of the digestion flask. The filtered aliquot was used for the determination of nitrogen, phosphorus, potassium, calcium and magnesium.

d) Estimation of nutrients :

1. Nitrogen :

It was estimated by using 5 ml of aliquot with the micro-kjeldahl method as described by Jackson (1958).

2. Phosphorus :

Phosphorus content of the sample was estimated by Vanadomolybdate method as described by Chapman and Pratt (1961).

3. Potassium :

Potassium content of the leaf sample was determined with the help of flame-photometer as per the method described by Chapman and Pratt (1961).

4. Total calcium and magnesium :

Total calcium and magnesium were estimated with EDTA titration method as described by Chapman and Pratt (1961).

(E) Statistical analysis :

The data obtained was analysed statistically by analysis of variance method as described by Panse and Sukhatme (1967).

(F) Response curve and economics of fertilisation :

a) Response curve :

The response curves were fitted by using the following formulae (Snedecor and Cochran, 1967).

i) Linear response curve

$$y = a + bx$$

ii) Quadratic response curve

$$y = a + bx + cx^2$$

Where,

y = expected yield,
x = level of nutrients and
a, b and c = constant values.

b) Economics of fertilization :

By using following formula the economical optimum dose was calculated.

$$\text{Optimum dose} = \frac{1}{2c}\left(\frac{q}{p} - b\right)$$

Where,
q = cost of nutrients per g and
p = price of the fruit per kg.

Chapter IV

PRESENTATION OF DATA

CHAPTER IV

PRESENTATION OF DATA

The data regarding the effect of nitrogen, phosphorus and potassium on growth, yield, fruit quality and leaf nutrient status of "Kalipatti" cultivar of chiku are presented below :

I **Growth observations :**

1. **Stem girth :**

The data in respect of stem girth in cm are given in Tables 1.1, 1.2 and 1.3.

It is evident from the data presented in Table 1.1 that nitrogen application had significant effect on stem girth of the plant. The highest (N_3) level and medium (N_2) level were at par with each other, but significantly increased the stem girth over lower (N_1) level and control which were also at par with each other.

The stem girth of the plant was not significantly affected with the application of phosphorus and potassium.

The interaction effects of NP, NK, PK and NPK were found to be non-significant.

2. **Height of plant :**

The data in respect of height of the plant in metre as influenced by various levels of nitrogen, phosphorus and potassium are presented in Tables 2.1, 2.2, 2.3 and Fig.2.

On perusal of the data given in Table 2.1, it is seen that the nitrogen application resulted in significant linear increase in plant height.

Table 1 : Mean stem girth of the plant in cm as influenced by varying levels of N, P and K

Table 1.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	28.511	30.422	32.622	33.933	31.372
P_1	29.155	31.033	33.589	34.723	32.125
P_2	29.900	31.489	34.078	34.267	32.433
Mean	29.189	30.981	33.430	34.308	

Table 1.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	28.611	30.400	32.789	33.978	31.444
K_1	29.422	31.411	33.867	34.667	32.342
K_2	29.533	31.133	33.633	34.278	32.144
Mean	29.189	30.981	33.430	34.308	

Table 1.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	30.617	31.758	31.958	31.444
K_1	31.842	32.392	32.792	32.342
K_2	31.658	32.225	32.550	32.144
Mean	31.372	32.125	32.433	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.828	0.716	0.716	1.433	1.433	1.241	2.483
C.D. at 5%	2.293	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 2: Mean height of the plant in m as influenced by varying levels of N, P and K

Table 2.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	3.019	3.437	4.008	4.200	3.666
P_1	3.441	3.668	4.150	4.440	3.925
P_2	3.250	3.708	4.108	4.304	3.842
Mean	3.237	3.604	4.089	4.315	

Table 2.2 Nitrogen x Potassium

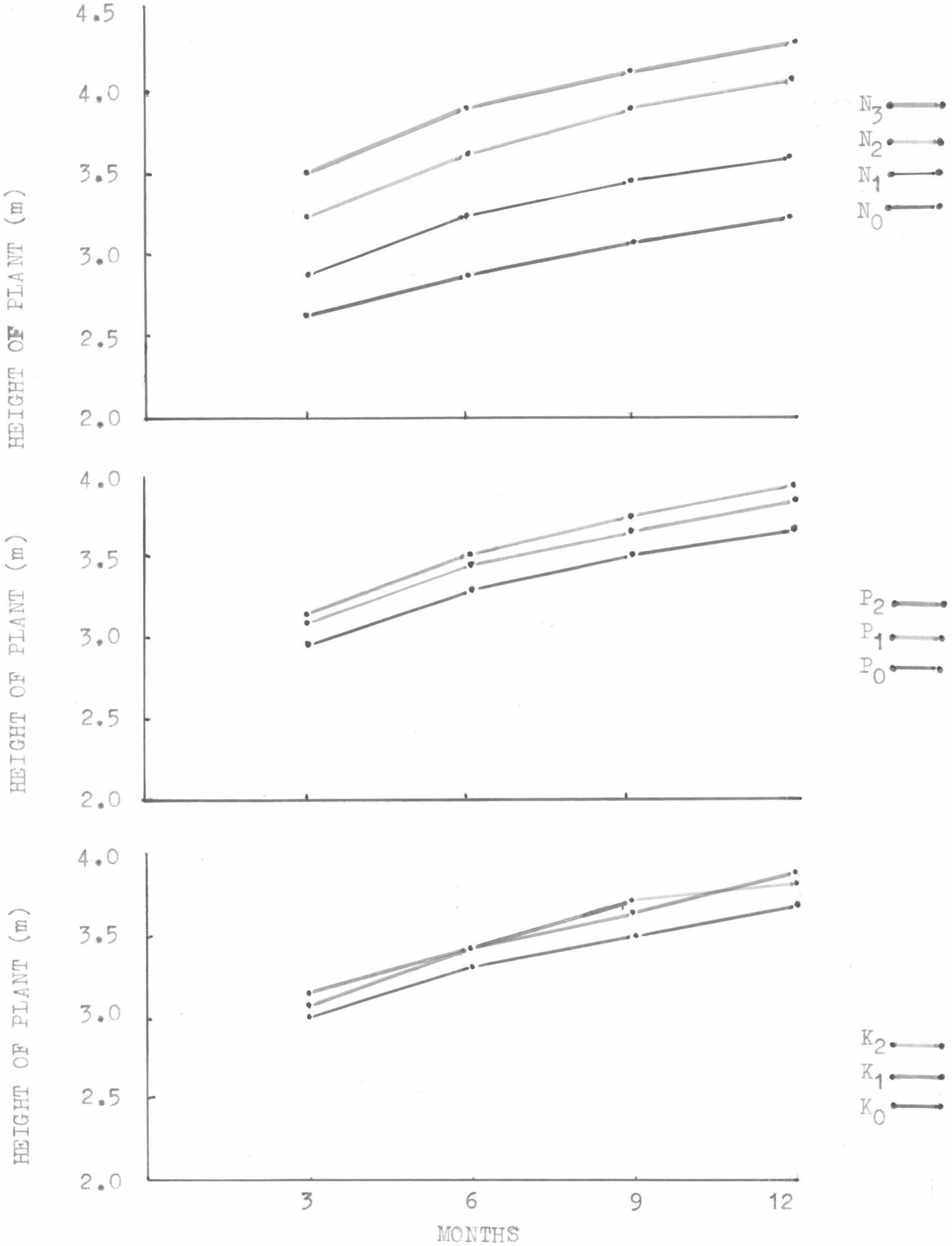
K/N	N_0	N_1	N_2	N_3	Mean
K_0	3.128	3.494	3.992	4.252	3.716
K_1	3.288	3.633	4.168	4.353	3.860
K_2	3.294	3.684	4.106	4.339	3.856
Mean	3.237	3.604	4.089	4.315	

Table 2.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	3.485	3.839	3.825	3.716
K_1	3.719	3.999	3.863	3.860
K_2	3.793	3.936	3.839	3.856
Mean	3.666	3.925	3.842	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.042	0.036	0.036	0.07	0.07	0.063	0.125
C.D. at 5%	0.116	0.099	0.099	N.S.	N.S.	N.S.	N.S.

Fig.2 : MEAN HEIGHT OF THE PLANT IN m AS INFLUENCED BY VARIOUS LEVELS OF NITROGEN, PHOSPHORUS AND POTASSIUM



The periodic observations recorded on height are depicted graphically in Fig.2.1. From the Fig.2.1 it is indicated that highest height was recorded by N_3 level. It was followed by N_2 and N_1 respectively. Lowest height was seen in N_0 level. It indicates that there was linear response of nitrogen throughout the growth period of one year.

It is observed from the data given in Table 2.1 that the application of phosphorus at both the levels significantly increased the plant height as compared with control. However, both the levels of phosphorus were at par with each other.

It is observed from Fig.2.2 that the height of plant was affected by various levels of phosphorus. Highest height was noticed at P_1 level, it was followed by P_2 level throughout the growth period of one year. Lowest height was seen at control.

It is seen from the data presented in Table 2.2 that the application of potassium also significantly increased the height of the plant. Both the levels of potassium (i.e. K_1 and K_2) significantly increased the plant height over control, however, they were at par with each other.

The curves drawn for height of plant and presented graphically in Fig.2.3 show that the curves for K_1 and K_2 were intermingling with each other. There was no much difference in height due to two levels of potassium, however, the curves for both the levels of potassium were above the curve drawn for control. The height in control was lower than that noticed in K_1 and K_2 levels.

The interaction effects of NP, NK, PK and NPK were observed to be non-significant.

3. Spread of plant :

The data regarding the mean spread of the plant are presented in Tables 3.1, 3.2 and 3.3.

The data given in Table 3.1 show that the nitrogen application resulted in significant linear increase in the spread of the plant.

It is seen from the data given in Table 3.1 that the application of phosphorus at both the levels significantly increased the spread of the plant as compared with control. However, both the levels of phosphorus were at par with each other.

The spread of plant was not significantly influenced with the application of potassium and the interaction effects between NP, NK, PK and NPK were found to be non-significant.

4. Volume of plant :

The data in respect of volume of the plant (m^3) are presented in Tables 4.1, 4.2, 4.3 and 4.4.

It is observed from the data given in Table 4.1 that the nitrogen application resulted in significant linear increase in plant volume.

The data presented in Table 4.1 show that the application of phosphorus at both the levels significantly increased the plant volume as compared with control. However, both the levels of phosphorus were at par with each other.

Table 3 : Mean spread of plant in m as influenced by varying levels of N, P and K

Table 3.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	3.470	3.744	4.072	4.244	3.883
P_1	3.630	3.832	4.253	4.460	4.044
P_2	3.674	3.829	4.185	4.337	4.006
Mean	3.591	3.803	4.170	4.347	

Table 3.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	3.443	3.777	4.065	4.299	3.896
K_1	3.663	3.805	4.223	4.393	4.021
K_2	3.668	3.826	4.222	4.349	4.016
Mean	3.591	3.803	4.170	4.347	

Table 3.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	3.677	4.036	3.976	3.896
K_1	3.987	4.043	4.033	4.021
K_2	3.986	4.053	4.010	4.016
Mean	3.883	4.044	4.006	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.051	0.044	0.044	0.088	0.088	0.076	0.153
C.D. at 5%	0.141	0.122	N.S.	N.S.	N.S.	N.S.	N.S.

Table 4 : Volume of the plant in m^3 as influenced by varying levels of N, P and K

Table 4.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	37.143	49.218	68.724	75.999	57.771
P_1	45.918	53.277	75.252	85.951	65.099
P_2	44.383	55.900	71.995	80.363	63.160
Mean	42.481	52.798	71.990	80.771	

Table 4.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	38.559	50.353	66.021	78.486	58.355
K_1	43.985	52.122	73.756	81.900	62.941
K_2	44.900	55.920	76.194	81.928	64.735
Mean	42.481	52.798	71.990	80.771	

Table 4.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	49.749	64.024	61.291	58.355
K_1	60.176	64.582	64.064	62.941
K_2	63.388	66.692	64.126	64.735
Mean	57.771	65.099	63.160	

	N	P	K	NP	NK	PK	NPK
S.E. ±	1.126	0.975	0.975	1.[illegible]	[illegible]	[illegible]689	3.379
C.D. at 5%	3.119	2.701	2.701	N.[illegible]	[illegible]	[illegible].678	9.360

Table 4.4 : Volume of the plant in m^3 as influenced by various treatments

Sr. No.	Treatments	Volume of the plant (m^3)	Sr. No.	Treatments	Volume of the plant (m^3)
1	$N_0P_0K_0$	23.96	19	$N_2P_0K_0$	59.44
2	$N_0P_0K_1$	42.62	20	$N_2P_0K_1$	70.77
3	$N_0P_0K_2$	44.85	21	$N_2P_0K_2$	75.97
4	$N_0P_1K_0$	44.26	22	$N_2P_1K_0$	74.34
5	$N_0P_1K_1$	45.87	23	$N_2P_1K_1$	72.50
6	$N_0P_1K_2$	47.63	24	$N_2P_1K_2$	78.92
7	$N_0P_2K_0$	47.45	25	$N_2P_2K_0$	64.28
8	$N_0P_2K_1$	43.47	26	$N_2P_2K_1$	78.00
9	$N_0P_2K_2$	42.23	27	$N_2P_2K_2$	73.70
10	$N_1P_0K_0$	47.86	28	$N_3P_0K_0$	67.73
11	$N_1P_0K_1$	49.13	29	$N_3P_0K_1$	78.19
12	$N_1P_0K_2$	50.66	30	$N_3P_0K_2$	82.08
13	$N_1P_1K_0$	53.89	31	$N_3P_1K_0$	83.61
14	$N_1P_1K_1$	53.03	32	$N_3P_1K_1$	86.93
15	$N_1P_1K_2$	52.91	33	$N_3P_1K_2$	87.31
16	$N_1P_2K_0$	49.31	34	$N_3P_2K_0$	84.12
17	$N_1P_2K_1$	54.20	35	$N_3P_2K_1$	80.58
18	$N_1P_2K_2$	64.19	36	$N_3P_2K_2$	76.39

S.E. $\pm$ 3.379

C.D. at 5% 9.360

It is seen from the data given in Table 4.2 that the application of potassium also significantly increased the volume of the plant. Both the levels of potassium (i.e. K_1 and K_2) significantly increased the plant volume over control, however, they were at par with each other.

It is observed from Table 4.3 that the P_1K_2 combination induced maximum volume of the plant but it was at par with P_1K_1, P_2K_2, P_2K_1, P_1K_0 and P_0K_2 combinations. The P_0K_0 combination recorded lowest volume of plant and it was significantly inferior to all other combinations.

The data given in Table 4.4 reveal that the $N_3P_1K_2$ combination produced maximum volume. It was significantly superior to all other combinations except $N_3P_1K_1$, $N_3P_2K_0$, $N_3P_1K_0$, $N_3P_0K_2$, $N_3P_2K_1$, $N_2P_1K_2$, $N_3P_0K_1$ and $N_2P_2K_1$. The $N_0P_0K_0$ combination produced minimum volume which was significantly inferior to all other NPK combinations.

The NP and NK interactions were non-significant.

5. <u>Leaf area</u> :

The data in respect of mean leaf area in cm^2 are given in Tables 5.1, 5.2 and 5.3.

From the data presented in Table 5.1, it is observed that the nitrogen application significantly increased leaf area. The highest (N_3) level and medium (N_2) level were at par with each other, but significantly increased the leaf area over lower (N_1) level and control. The N_1 level was also significantly superior to control.

Table 5 : Mean leaf area as influenced by varying levels of N, P and K

Table 5.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	20.991	22.639	25.330	25.974	23.733
P_1	21.142	24.101	25.687	26.563	24.373
P_2	21.502	24.422	25.760	26.141	24.456
Mean	21.212	23.721	25.592	26.226	

Table 5.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	20.650	22.838	25.462	26.004	23.738
K_1	21.297	23.942	25.860	26.658	24.439
K_2	21.689	24.382	25.454	26.017	24.385
Mean	21.212	23.721	25.592	26.226	

Table 5.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	23.314	23.865	24.036	23.738
K_1	23.853	24.706	24.758	24.439
K_2	24.033	24.549	24.574	24.385
Mean	23.733	24.373	24.456	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.240	0.208	0.208	0.416	0.416	0.360	0.721
C.D. at 5%	0.665	0.576	0.576	N.S.	N.S.	N.S.	N.S.

It is seen from the Table 5.1 that the application of phosphorus at both the levels significantly increased the leaf area as compared with control. However, both the levels of phosphorus were at par with each other.

The data presented in Table 5.2 show that the leaf area was significantly increased with the application of potassium in comparison with control but the two levels of potassium were at par with each other.

The NP, NK, PK and NPK interactions were non-significant.

II Yield :

1. Number of fruits per plant :

The data in respect of mean number of fruits harvested per plant are given in Tables 6.1, 6.2, 6.3 and Fig.3.

The data presented in Table 6.1 show that the nitrogen application resulted in significant linear increase in mean number of fruits.

The data presented in Table 6.1 reveal that the application of phosphorus at both the levels significantly increased mean number of fruits as compared with control. However, both the levels of phosphorus were at par with each other.

It is observed from the data given in Table 6.2 that the application of potassium also significantly increased mean number of fruits. The K_1 level produced significantly more number of fruits than K_2 and control. The K_2 level also produced significantly more number of fruits than control.

Table 6 : Mean total number of fruits per plant as influenced by varying levels of N, P and K

Table 6.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	50.889	62.333	79.555	96.555	72.333
P_1	57.111	73.111	87.778	115.111	83.278
P_2	61.777	74.444	80.778	108.111	81.277
Mean	56.592	69.963	82.704	106.592	

Table 6.2 Nitrogen x Potassium

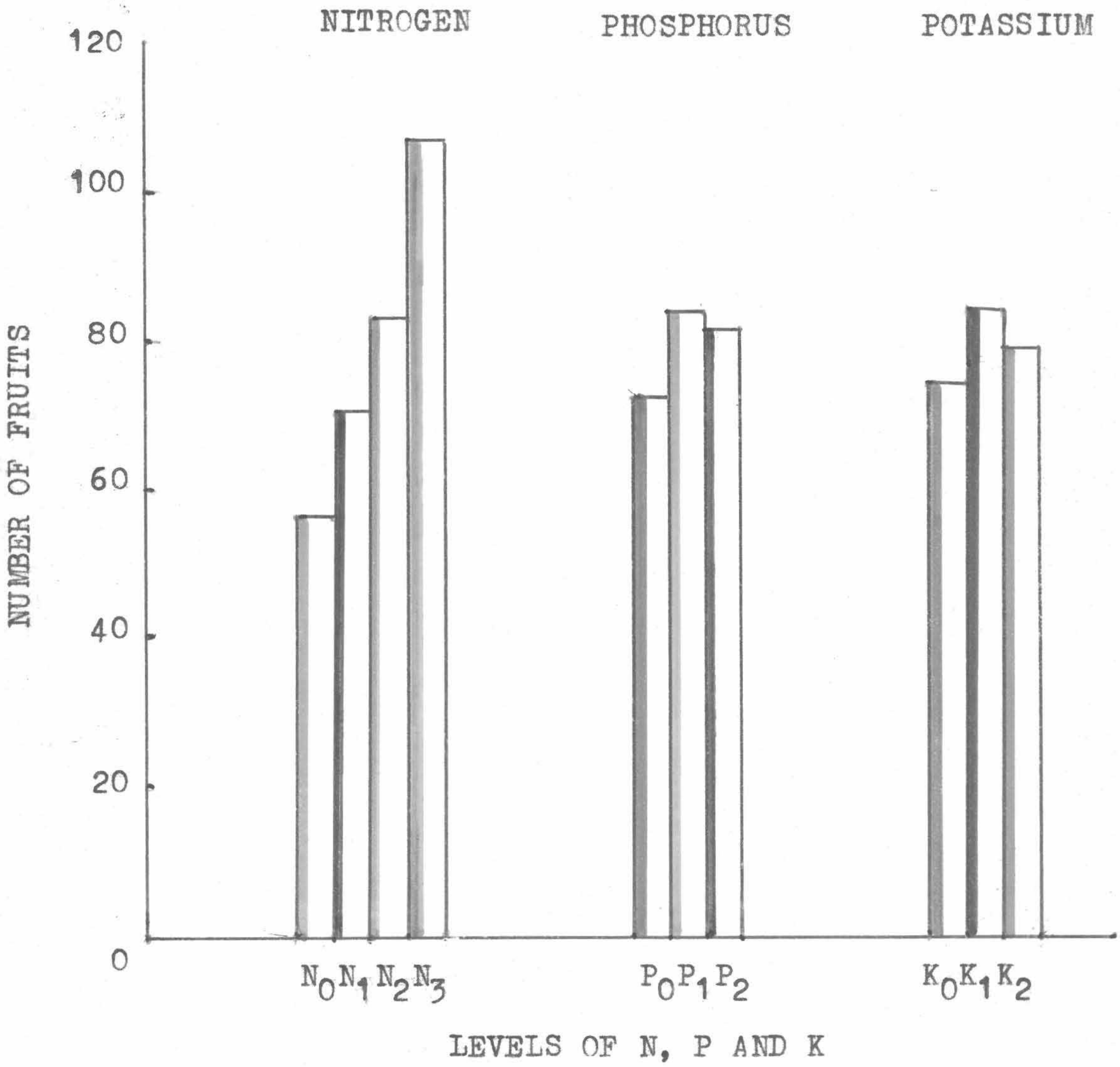
K/N	N_0	N_1	N_2	N_3	Mean
K_0	51.444	65.111	80.000	100.778	74.333
K_1	59.222	73.555	86.667	115.333	83.694
K_2	59.111	71.222	81.444	103.666	78.861
Mean	56.592	69.963	82.704	106.592	

Table 6.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	67.500	76.583	78.916	74.333
K_1	75.083	89.167	86.833	83.694
K_2	74.417	84.083	78.083	78.861
Mean	72.333	83.278	81.277	

	N	P	K	NP	NK	PK	NPK
S.E. ±	1.149	0.995	0.995	1.991	1.991	1.724	3.448
C.D. at 5%	3.183	2.756	2.756	5.515	N.S.	N.S.	N.S.

Fig.3 : MEAN TOTAL NUMBER OF FRUITS HARVESTED PER PLANT AS INFLUENCED BY VARIOUS LEVELS OF N, P AND K



It is seen from the data given in Table 6.1 that N_3P_1 combination induced significantly more number of fruits per plant as compared with all other NP combinations. It was followed by N_3P_2 combination. The N_0P_0 combination produced lowest number of fruits and it was significantly inferior to all other NP combinations.

The interaction effects of NK, PK and NPK were found to be non-significant.

2. Yield (kg) per plant :

The data related to the mean yield (kg) per plant are presented in Tables 7.1, 7.2, 7.3, 7.4 and Fig.4.

On perusal of the data given in Table 7.1, it is observed that the application of nitrogen proved to be beneficial in increasing the yield per plant. The nitrogen application resulted in significant linear increase in yield per plant.

The data given in Table 7.1 indicate that the P_1 level of phosphorus significantly increased the yield as compared with P_2 and control. The yield in P_2 treatment was also significantly more than that noticed in control.

From the data given in Table 7.2, it is noticed that the K_1 level induced significantly more yield than K_2 level and control. The K_2 level was significantly superior to control.

The data presented in Table 7.1 show that the N_3P_1 combination produced significantly higher yields than all other NP combinations. The N_0P_0 combination was significantly inferior to all other NP combinations.

Table 7 : Mean total yield of fruits in kg per plant as influenced by varying levels of N, P and K

Table 7.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	3.497	4.370	5.660	6.875	5.100
P_1	3.969	5.157	6.239	8.355	5.930
P_2	4.289	5.258	5.726	7.802	5.769
Mean	3.918	4.928	5.875	7.677	

Table 7.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	3.544	4.574	5.681	7.260	5.265
K_1	4.102	5.200	6.162	8.326	5.947
K_2	4.109	5.010	5.782	7.446	5.587
Mean	3.918	4.928	5.875	7.677	

Table 7.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	4.745	5.445	5.604	5.265
K_1	5.303	6.361	6.178	5.947
K_2	5.253	5.984	5.524	5.587
Mean	5.100	5.930	5.769	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.052	0.045	0.045	0.089	0.089	0.077	0.155
C.D. at 5%	0.144	0.125	0.125	0.246	0.246	0.213	0.429

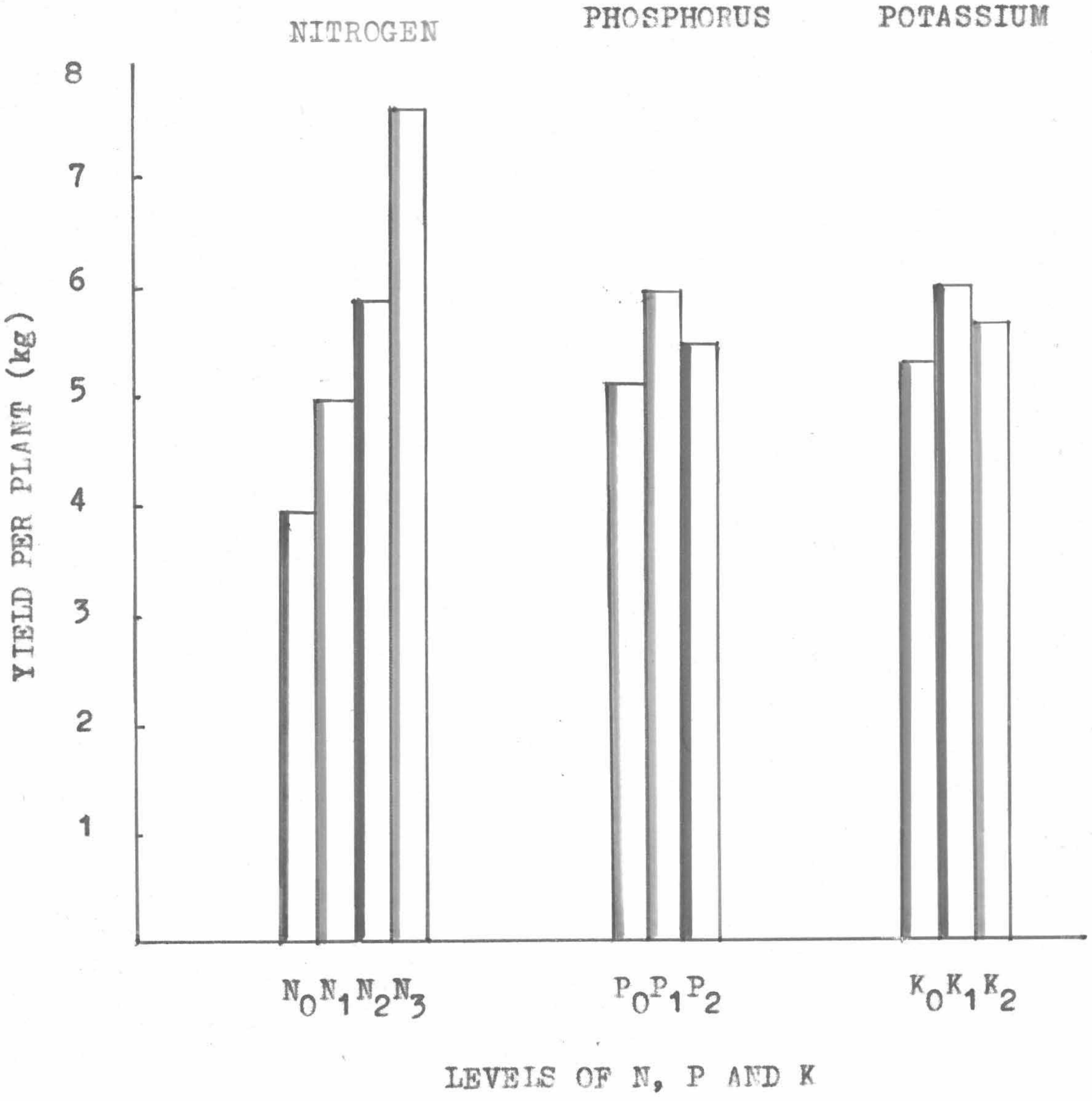
Table 7.4 : Mean total yieldof fruits per plant as influenced by various treatments

Sr. No.	Treatments	Total yield of fruits per plant (kg)	Sr. No.	Treatments	Total yield of fruits per plant (kg)
1	$N_0P_0K_0$	3.137	19	$N_2P_0K_0$	5.230
2	$N_0P_0K_1$	3.636	20	$N_2P_0K_1$	5.862
3	$N_0P_0K_2$	3.718	21	$N_2P_0K_2$	5.888
4	$N_0P_1K_0$	3.402	22	$N_2P_1K_0$	5.968
5	$N_0P_1K_1$	4.223	23	$N_2P_1K_1$	6.512
6	$N_0P_1K_2$	4.281	24	$N_2P_1K_2$	6.236
7	$N_0P_2K_0$	4.094	25	$N_2P_2K_0$	5.844
8	$N_0P_2K_1$	4.446	26	$N_2P_2K_1$	6.111
9	$N_0P_2K_2$	4.328	27	$N_2P_2K_2$	5.223
10	$N_1P_0K_0$	4.270	28	$N_3P_0K_0$	6.344
11	$N_1P_0K_1$	4.440	29	$N_3P_0K_1$	7.276
12	$N_1P_0K_2$	4.399	30	$N_3P_0K_2$	7.005
13	$N_1P_1K_0$	4.869	31	$N_3P_1K_0$	7.541
14	$N_1P_1K_1$	5.417	32	$N_3P_1K_1$	9.291
15	$N_1P_1K_2$	5.186	33	$N_3P_1K_2$	8.235
16	$N_1P_2K_0$	4.584	34	$N_3P_2K_0$	7.896
17	$N_1P_2K_1$	5.744	35	$N_3P_2K_1$	8.411
18	$N_1P_2K_2$	5.446	36	$N_3P_2K_2$	7.098

S.E. ± 0.155

C.D. at 5% 0.429

Fig.4 : MEAN TOTAL YIELD OF FRUITS PER PLANT INFLUENCED BY VARYING LEVELS OF N, P AND K



The data presented in Table 7.2 reveal that the N_3K_1 combination significantly increased yield as compared with all other NK combinations. The lowest yield was obtained in N_0K_0 combination which was significantly inferior to all other NK combinations.

The data given in Table 7.3 show that the P_1K_1 combination produced significantly higher yield than all other PK combinations except P_2K_1 combination which was at par with it. The least yield was obtained in P_0K_0 combination which was significantly inferior to all other PK combinations.

From the data presented in Table 7.4, it is observed that the $N_3P_1K_1$ combination significantly increased the yield as compared with all other combinations. The yield obtained in $N_0P_0K_0$ combination was significantly inferior to all other NPK combinations.

III <u>Fruit characters</u> :

1. <u>Diameter of fruit</u> :

The data regarding the diameter of fruit in cm are presented in Table 8.1, 8.2 and 8.3.

From the data presented in Table 8.1, it is seen that the N_3 level significantly increased the diameter of fruit over N_1 and control but at par with N_2 level. The N_2, N_1 levels and control were at par with each other.

The application of phosphorus and potassium at various levels failed to produce any significant difference in fruit diameter.

Table 8 : Mean diameter of the fruit in cm as influenced by varying levels of N, P and K

Table 8.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	4.570	4.705	4.840	4.947	4.765
P_1	4.624	4.796	4.888	5.111	4.855
P_2	4.678	4.821	4.910	5.094	4.876
Mean	4.624	4.774	4.879	5.051	

Table 8.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	4.578	4.738	4.861	4.986	4.791
K_1	4.641	4.802	4.924	5.093	4.865
K_2	4.653	4.782	4.853	5.073	4.840
Mean	4.624	4.774	4.879	5.051	

Table 8.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	4.712	4.804	4.856	4.791
K_1	4.793	4.887	4.915	4.865
K_2	4.791	4.873	4.857	4.840
Mean	4.765	4.855	4.876	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.093	0.080	0.080	0.161	0.161	0.139	0.279
C.D. at 5%	0.257	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

The NP, NK, PK and NPK interactions were found to be non-significant.

2. Length of fruit :

The data in respect of the length of fruit are presented in Tables 9.1, 9.2 and 9.3.

The data presented in Table 9.1 show that the nitrogen application resulted in significant linear increase in the length of fruit.

The application of phosphorus and potassium did not significantly increase the length of fruit. The interaction effects of NP, NK, PK and NPK were found to be non-significant.

3. Average weight of fruit :

The data in respect of average weight of fruit are given in Table 10.1, 10.2 and 10.3.

On perusal of the data given in Table 10.1, it is observed that the nitrogen application resulted in significant linear increase in average weight of fruit.

It is observed from the data given in Table 10.1 that the application of phosphorus at both the levels significantly increased the average weight of fruit as compared with control. However, both the levels were at par with each other.

It is seen from the data presented in Table 10.2 that the application of potassium also significantly increased average fruit weight. The K_1 level significantly increased average fruit weight over control but at par with K_2 level. The K_2 level was at par with control.

Table 9 : Mean length of the fruit in cm as influenced by varying levels of N, P and K

Table 9.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	5.721	5.887	5.981	6.455	6.011
P_1	5.778	5.965	6.138	6.570	6.113
P_2	5.854	5.961	6.284	6.540	6.160
Mean	5.784	5.938	6.134	6.522	

Table 9.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	5.717	5.919	6.101	6.466	6.051
K_1	5.812	5.954	6.192	6.586	6.136
K_2	5.824	5.940	6.110	6.514	6.097
Mean	5.784	5.938	6.134	6.522	

Table 9.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	5.951	6.071	6.130	6.051
K_1	6.070	6.143	6.195	6.136
K_2	6.012	6.124	6.155	6.097
Mean	6.011	6.113	6.160	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.055	0.047	0.047	0.095	0.095	0.083	0.165
C.D. at 5%	0.152	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 10 : Average weight of fruit in g as influenced by varying levels of N, P and K

Table 10.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	68.677	70.104	71.144	71.205	70.282
P_1	69.491	70.534	71.074	72.580	70.920
P_2	69.435	70.615	70.872	72.154	70.769
Mean	69.201	70.418	71.030	71.980	

Table 10.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	68.847	70.250	71.010	72.004	70.528
K_1	69.252	70.659	71.101	72.138	70.787
K_2	69.504	70.345	70.979	71.798	70.656
Mean	69.201	70.418	71.030	71.980	

Table 10.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	69.998	70.808	70.777	70.528
K_1	70.422	71.020	70.920	70.787
K_2	70.427	70.932	70.610	70.656
Mean	70.282	70.920	70.769	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.077	0.067	0.067	0.134	0.134	0.116	0.232
C.D. at 5%	0.213	0.185	0.185	0.371	N.S.	N.S.	N.S.

The perusal of the data given in Table 10.1 indicate that the NP interaction was significant. The highest average weight of fruit was observed in N_3P_1 combination which was significantly superior to all other NP combinations. The lowest average weight of fruit was observed in N_0P_0 combination which was significantly inferior to all other NP combinations.

The interaction effect of NK, PK and NPK were found to be non-significant.

4. Average volume of fruit :

The data in respect of average volume of fruit are given in Tables 11.1, 11.2 and 11.3.

On perusal of the data given in Table 11.1, it is seen that nitrogen application resulted in significant linear increase in average volume of fruit.

The data given in Table 11.1 indicate that the application of phosphorus at both the levels significantly increased the average volume of fruit as compared with control. However, both the levels were at par with each other. The data presented in Table 11.2 show that the application of potassium also significantly increased the average volume of fruit. Both the levels of potassium (i.e. K_1 and K_2) increased the average volume of fruit over control, however, they were at par with each other.

It is evident from the data presented in Table 11.1 that the N_3P_1 combination significantly increased volume of fruit as compared with all other NP combinations but at par with N_3P_2

Table 11 : Average volume of the fruit in ml as influenced by varying levels of N, P and K

Table 11.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	65.10	66.81	67.89	68.33	67.03
P_1	66.68	67.21	68.05	69.06	67.75
P_2	66.71	67.80	67.97	68.67	67.79
Mean	66.16	67.27	67.97	68.68	

Table 11.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	65.50	66.66	67.90	68.65	67.18
K_1	66.52	67.54	68.04	68.82	67.73
K_2	66.48	67.62	67.98	68.59	67.67
Mean	66.16	67.27	67.97	68.68	

Table 11.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	66.41	67.47	67.66	67.18
K_1	67.41	67.93	67.85	67.73
K_2	67.28	67.85	67.87	67.67
Mean	67.03	67.75	67.79	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.105	0.091	0.091	0.183	0.183	0.158	0.317
C.D. at 5%	0.291	0.252	0.252	0.507	0.507	N.S.	N.S.

combination. The N_0P_0 combination was significantly inferior to all other NP combinations.

The data regarding NK interaction presented in Table 11.2 reveal that N_3K_1 combination was significantly superior to other NK combinations except N_3K_0 and N_3K_2 combinations. The N_0K_0 combination was inferior to all other NK combinations.

The interaction effects of PK and NPK were found to be non-significant.

5. Percentage of fruit pulp :

The data in respect of percentage of fruit pulp are presented in Tables 12.1, 12.2 and 12.3.

The data presented in Table 12.1 show that all the levels of nitrogen significantly increased percentage of fruit pulp over control, however, they were at par with each other.

It is clear from the data presented in Table 12.1 that the P_1 level significantly increased percentage of fruit pulp over P_2 level and control. The P_2 level and control were at par.

The data presented in Table 12.2 reveal that the K_1 level of potassium significantly increased percentage of fruit pulp over K_2 level and control. However, the K_2 level and control were at par with each other.

The NP, NK, PK and NPK interactions were non-significant.

6. Percentage of seed :

The data presented in Tables 13.1, 13.2 and 13.3 show that the application of nitrogen, phosphorus and potassium failed

Table 12 : Mean percentage of fruit pulp as influenced by varying levels of N, P and K

Table 12.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	88.263	88.667	88.780	88.853	88.641
P_1	88.713	89.107	89.337	89.252	89.102
P_2	88.033	88.903	88.836	88.923	88.674
Mean	88.336	88.892	88.984	89.009	

Table 12.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	88.266	88.707	88.273	88.907	88.651
K_1	88.693	89.083	89.270	89.155	89.050
K_2	88.050	88.887	88.960	88.966	88.716
Mean	88.336	88.892	88.984	89.009	

Table 12.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	88.450	88.842	88.660	88.651
K_1	88.735	89.646	88.770	89.050
K_2	88.737	88.818	88.592	88.716
Mean	88.641	89.102	88.674	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.135	0.117	0.117	0.234	0.234	0.202	0.405
C.D. at 5%	0.374	0.324	0.324	N.S.	N.S.	N.S.	N.S.

Table 13: Mean percentage of seed as influenced by varying levels of N, P and K

Table 13.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	1.323	1.390	1.400	1.477	1.397
P_1	1.337	1.407	1.420	1.457	1.405
P_2	1.380	1.416	1.463	1.443	1.425
Mean	1.347	1.404	1.428	1.459	

Table 13.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	1.327	1.393	1.413	1.443	1.394
K_1	1.357	1.410	1.443	1.470	1.420
K_2	1.356	1.410	1.427	1.463	1.414
Mean	1.347	1.404	1.428	1.459	

Table 13.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	1.380	1.392	1.410	1.394
K_1	1.412	1.411	1.436	1.420
K_2	1.400	1.412	1.430	1.414
Mean	1.397	1.405	1.425	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.024	0.021	0.021	0.042	0.042	0.036	0.073
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

to produce any significant influence on the percentage of seed in fruit.

The interaction effects of NP, NK, PK and NPK were also observed to be non-significant.

7. Percentage of skin :

The data given in Table 14.1, 14.2 and 14.3 reveal that the percentage of skin was not significantly affected with the application of nitrogen, phosphorus and potassium.

The interaction effects of NP, NK, PK and NPK were also observed to be non-significant.

8. Total Soluble Solids (T.S.S.) :

The data in respect of total soluble solids are presented in Tables 15.1, 15.2, 15.3 and 15.4

It is evident from the data presented in Table 15.1 that the T.S.S. was significantly influenced with the application of nitrogen. The highest T.S.S. was recorded in N_2 level and it was significantly superior to N_3 and control. The N_1 level was at par with N_3 and the level N_3 was at par with control.

Perusal of the data from Table 15.1 reveals that T.S.S. was significantly increased with application of phosphorus at both the levels in comparison with control. However, these two levels were at par with each other.

It is observed from the data given in Table 15.2 that the application of potassium at both the levels significantly increased the T.S.S. as compared with control. However, both the levels of potassium were at par with each other.

Table 14 : Mean percentage of skin as influenced by varying levels of N, P and K

Table 14.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	10.415	9.944	9.820	9.672	9.963
P_1	9.950	9.487	9.245	9.293	9.494
P_2	10.254	9.681	9.699	9.633	9.817
Mean	10.206	9.704	9.588	9.533	

Table 14.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	10.407	9.900	9.863	9.651	9.955
K_1	9.950	9.507	9.288	9.378	9.531
K_2	10.262	9.705	9.613	9.570	9.787
Mean	10.206	9.704	9.588	9.533	

Table 14.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	10.171	9.765	9.930	9.955
K_1	9.853	8.946	9.793	9.531
K_2	9.864	9.770	9.728	9.787
Mean	9.963	9.494	9.817	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.263	0.228	0.288	0.456	0.456	0.395	0.790
C.D. at 5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 15 : Mean percentage of total soluble solids as influenced by varying levels of N, P and K

Table 15.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	20.305	21.722	21.917	19.667	20.903
P_1	22.694	22.500	22.722	21.361	22.319
P_2	20.278	21.750	21.805	23.194	21.757
Mean	21.092	21.991	22.148	21.407	

Table 15.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	20.305	20.639	20.722	19.889	20.389
K_1	22.083	22.500	22.194	21.889	22.166
K_2	20.889	22.833	23.529	22.444	22.424
Mean	21.092	21.991	22.148	21.407	

Table 15.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	19.354	21.500	20.312	20.389
K_1	21.729	22.708	22.062	22.166
K_2	21.625	22.750	22.896	22.424
Mean	20.903	22.319	21.757	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.249	0.216	0.216	0.432	0.432	0.374	0.749
C.D. at 5%	0.690	0.598	0.598	1.197	N.S.	1.036	2.075

Table 15.4 : Mean percentage of total soluble solids as influenced by various treatments

Sr. No.	Treatments	T.S.S.	Sr. No.	Treatments	T.S.S.
1	$N_0P_0K_0$	18.75	19	$N_2P_0K_0$	20.25
2	$N_0P_0K_1$	21.17	20	$N_2P_0K_1$	22.33
3	$N_0P_0K_2$	21.00	21	$N_2P_0K_2$	23.17
4	$N_0P_1K_0$	23.83	22	$N_2P_1K_0$	21.83
5	$N_0P_1K_1$	23.42	23	$N_2P_1K_1$	22.92
6	$N_0P_1K_2$	20.83	24	$N_2P_1K_2$	23.42
7	$N_0P_2K_0$	18.33	25	$N_2P_2K_0$	20.08
8	$N_0P_2K_1$	21.67	26	$N_2P_2K_1$	21.33
9	$N_0P_2K_2$	20.83	27	$N_2P_2K_2$	24.00
10	$N_1P_0K_0$	20.58	28	$N_3P_0K_0$	17.83
11	$N_1P_0K_1$	22.58	29	$N_3P_0K_1$	20.83
12	$N_1P_0K_2$	22.00	30	$N_3P_0K_2$	20.33
13	$N_1P_1K_0$	21.33	31	$N_3P_1K_0$	19.00
14	$N_1P_1K_1$	22.50	32	$N_3P_1K_1$	22.00
15	$N_1P_1K_2$	23.67	33	$N_3P_1K_2$	23.08
16	$N_1P_2K_0$	20.00	34	$N_3P_2K_0$	22.83
17	$N_1P_2K_1$	22.42	35	$N_3P_2K_1$	22.83
18	$N_1P_2K_2$	22.83	36	$N_3P_2K_2$	23.88

S.E. ± 0.749

C.D. at 5% 2.075

The data regarding NP interaction presented in Table 15.1 indicate that N_3P_2 combination induced highest T.S.S. but it was at par with N_2P_1 and N_0P_1 combinations. The lowest T.S.S. was observed under N_3P_0 combination which was significantly inferior to all other NP combinations.

The interaction effects, NK and PK were found to be non-significant.

It is clear from the results presented in Table 15.4 that the significantly higher T.S.S. was recorded under $N_2P_2K_2$ combination which was at par with $N_3P_1K_1$ combination. The lowest T.S.S. was observed under $N_3P_0K_0$ combination which was at par with $N_3P_1K_1$ combination. The lowest T.S.S. was observed under $N_3P_0K_0$ combination which was at par with $N_3P_1K_0$, $N_0P_0K_0$ and $N_0P_2K_0$ combinations.

9. <u>Fruit acidity</u> :

The data in respect of acidity are given in Tables 16.1, 16.2 and 16.3.

It is seen from the data presented in Table 16.1 that the N_3 level significantly increased acidity as compared with N_2, N_1 and control. The N_2 level also significantly increased acidity as compared with N_1 and control. However, N_1 and control were at par with each other.

The data presented in Table 16.1 show that the P_1 and P_2 levels significantly reduced acidity as compared with control, however, they were at par with each other.

Table 16 : Mean percentage of acidity as influenced by varying levels of N, P and K

Table 16.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	0.103	0.096	0.101	0.130	0.107
P_1	0.084	0.085	0.093	0.126	0.097
P_2	0.081	0.096	0.102	0.122	0.100
Mean	0.089	0.092	0.099	0.126	

Table 16.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	0.104	0.105	0.112	0.139	0.115
K_1	0.091	0.088	0.096	0.123	0.099
K_2	0.073	0.083	0.089	0.117	0.090
Mean	0.089	0.092	0.099	0.126	

Table 16.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	0.124	0.110	0.110	0.115
K_1	0.102	0.096	0.100	0.099
K_2	0.095	0.086	0.090	0.090
Mean	0.107	0.097	0.100	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.0017	0.0015	0.0015	0.0030	0.0030	0.0026	0.0052
C.D. at 5%	0.0047	0.0041	0.0041	0.0083	N.S.	N.S.	N.S.

The acidity was significantly decreased in linear order as the levels of potassium increased.

The data presented in Table 16.1 show that N_3P_0 combination significantly increased acidity as compared with all other combination but at par with N_3P_1 and N_3P_2 combinations. The N_0P_2 combination had minimum acidity and it was significantly lower than all other combinations except N_0P_1 and N_1P_1.

10. Reducing sugars :

The data in respect of percentage reducing sugars are presented in Table 17.1, 17.2 and 17.3.

From the data given in Table 17.1, it is observed that N_2 level significantly increased the percentage of reducing sugars as compared with N_3, N_1 and control. The N_3 level was significantly superior to control but at par with N_1 level. The N_1 level was also at par with control.

On perusal of the data given in Table 17.1, it is seen that both the levels of phosphorus significantly increased the percentage reducing sugars as compared with control. However, both the levels of phosphorus were at par with each other.

The data presented in Table 17.2 indicate that both the levels of potassium significantly increased percentage of reducing sugars over control. However, these two levels were at par with each other.

It is observed from the Table 17.1 that N_2P_1 combination significantly induced more percentage reducing sugars than

Table 17 : Mean percentage of reducing sugars as influenced by varying levels of N, P and K

Table 17.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	12.830	13.337	13.764	13.333	13.316
P_1	13.510	13.812	14.311	13.510	13.786
P_2	13.492	13.331	14.096	14.007	13.731
Mean	13.277	13.493	14.057	13.617	

Table 17.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	12.944	13.287	13.807	13.510	13.387
K_1	13.432	13.640	14.158	13.686	13.729
K_2	13.456	13.553	14.207	13.654	13.717
Mean	13.277	13.493	14.057	13.617	

Table 17.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	13.006	13.496	13.659	13.387
K_1	13.465	13.917	13.804	13.729
K_2	13.477	13.944	13.731	13.717
Mean	13.316	13.786	13.731	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.082	0.071	0.071	0.142	0.142	0.123	0.247
C.D. at 5%	0.227	0.197	0.197	0.393	N.S.	N.S.	N.S.

other NP combinations except N_2P_2 and N_3P_2. The N_0P_0 combination was significantly inferior to all other NP combinations.

The NK, PK and NPK interactions were found to be non-significant.

11. Non reducing sugars :

The data in respect of percentage of non-reducing sugars are presented in Tables 18.1, 18.2 and 18.3.

The data given in Table 18.1 show that all the three levels of nitrogen (i.e. N_1, N_2 and N_3) significantly increased percentage of non-reducing sugars over control, however, they were at par with each other.

There were no significant influences of various levels of phosphorus and potassium on the percentage of non-reducing sugars.

The interaction effects of NP, NK, PK and NPK were found to be non-significant.

IV Nutrient status of leaf :

The data in respect of effect of soil application of nitrogen, phosphorus and potassium on the N, P, K, Ca and Mg content of chiku leaf are presented here under :

1. Nitrogen :

The data regarding the nitrogen content of the leaf are presented in Tables 19.1, 19.2 and 19.3.

Table 18: Mean percentage of non-reducing sugars as influenced by varying levels of N, P and K

Table 18.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	4.691	4.940	5.130	5.082	4.961
P_1	4.904	5.019	5.223	5.015	5.040
P_2	4.847	5.211	5.089	5.032	5.045
Mean	4.814	5.057	5.147	5.043	

Table 18.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	4.812	4.971	5.135	5.080	4.999
K_1	4.820	5.090	5.215	5.030	5.039
K_2	4.810	5.109	5.091	5.020	5.007
Mean	4.814	5.057	5.147	5.043	

Table 18.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	4.937	5.035	5.027	4.999
K_1	4.965	5.054	5.097	5.039
K_2	4.980	5.032	5.010	5.007
Mean	4.961	5.040	5.045	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.064	0.055	0.055	0.110	0.110	0.096	0.191
C.D. at 5%	0.177	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 19 : Mean percentage of leaf nitrogen as influenced by varying levels of N, P and K

Table 19.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	1.152	1.365	1.519	1.669	1.426
P_1	1.221	1.403	1.548	1.721	1.473
P_2	1.248	1.433	1.544	1.682	1.477
Mean	1.207	1.400	1.537	1.691	

Table 19.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	1.150	1.364	1.515	1.678	1.427
K_1	1.228	1.398	1.550	1.690	1.466
K_2	1.243	1.439	1.546	1.704	1.483
Mean	1.207	1.400	1.537	1.691	

Table 19.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	1.395	1.437	1.448	1.427
K_1	1.432	1.486	1.481	1.466
K_2	1.452	1.495	1.502	1.483
Mean	1.426	1.473	1.477	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.023	0.020	0.020	0.040	0.040	0.035	0.070
C.D. at 5%	0.064	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

The data given in Table 19.1 show that the nitrogen application resulted in significant linear increase in nitrogen content of chiku leaf.

The leaf nitrogen was not significantly increased with the application of phosphorus and potassium.

The interaction effects of NP, NK, PK and NPK were found to be non-significant.

2. Phosphorus :

The data in respect of phosphorus content of the leaf are given in Tables 20.1, 20.2 and 20.3.

It is observed from the data given in Table 20.1 that the all levels of nitrogen significantly increased the leaf P content as compared with control. However, they were at par with each other.

It is clear from the data given in Table 20.1 that leaf P status was increased with the application of phosphorus. Both the levels of phosphorus significantly increased the leaf P content as compared with control. However, these two levels of phosphorus were at par with each other.

The effect of potassium was non-significant. The interaction effects were also found to be non-significant.

3. Potassium :

The data pertaining to the potassium content of the leaf are presented in Table 21.1, 21.2 and 21.3.

Table 20 : Mean percentage of leaf phosphorus as influenced by varying levels of N, P and K

Table 20.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	0.390	0.421	0.456	0.428	0.424
P_1	0.442	0.512	0.530	0.537	0.505
P_2	0.477	0.524	0.548	0.552	0.525
Mean	0.436	0.486	0.511	0.506	

Table 20.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	0.435	0.476	0.492	0.496	0.475
K_1	0.424	0.499	0.521	0.516	0.490
K_2	0.450	0.482	0.521	0.505	0.489
Mean	0.436	0.486	0.511	0.506	

Table 20.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	0.419	0.494	0.511	0.475
K_1	0.415	0.519	0.535	0.490
K_2	0.437	0.501	0.530	0.489
Mean	0.424	0.505	0.525	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.009	0.008	0.008	0.016	0.016	0.013	0.027
C.D. at 5%	0.025	0.022	N.S.	N.S.	N.S.	N.S.	N.S.

Table 21 : Mean percentage leaf K as influenced by varying levels of N, P and K

Table 21.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	1.632	1.812	2.216	1.899	1.890
P_1	1.658	1.952	2.298	1.800	1.927
P_2	1.688	1.918	2.137	1.794	1.884
Mean	1.659	1.894	2.217	1.831	

Table 21.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	1.542	1.703	2.021	1.727	1.748
K_1	1.699	1.946	2.235	1.859	1.935
K_2	1.737	2.032	2.396	1.908	2.018
Mean	1.659	1.894	2.217	1.831	

Table 21.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	1.759	1.772	1.712	1.748
K_1	1.904	1.997	1.905	1.935
K_2	2.006	2.012	2.036	2.018
Mean	1.890	1.927	1.884	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.032	0.028	0.028	0.056	0.056	0.048	0.096
C.D. at 5%	0.089	N.S.	0.077	N.S.	N.S.	N.S.	N.S.

It is observed from the data presented in Table 21.1 that the N_2 level significantly increased leaf K content over N_1, N_3 and control. The N_1 and N_3 levels significantly increased leaf K content as compared with control, however, they were at par with each other.

It is clear from the data presented in Table 21.2 that the application of potassium resulted in significant linear increase in leaf K content.

The effect phosphorus application was non-significant.

The interaction effects of NP, NK, PK and NPK were also non-significant.

4. Calcium :

The data in respect of calcium content of the leaf are given in Table 22.1, 22.2 and 22.3.

The data presented in Table 22.1 show that the N_3 and N_2 levels increased leaf calcium content as compared with N_1 and control but there was no significant difference between N_3 and N_2. The N_1 level was also significantly superior over control.

The application of phosphorus and potassium failed to produce any significant effect on leaf calcium content of chiku. The interactions were also non-significant.

5. Magnesium :

The data in respect of magnesium content of leaf are given in Tables 23.1, 23.2 and 23.3.

On perusal of data given in Table 23.1, it is observed that all the levels of nitrogen application significantly increased

Table 22 : Mean percentage of leaf Ca as influenced by varying levels of N, P and K

Table 22.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	2.998	3.214	3.761	3.670	3.411
P_1	3.169	3.400	3.655	3.803	3.507
P_2	3.104	3.526	3.687	3.782	3.525
Mean	3.090	3.380	3.701	3.752	

Table 22.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	3.037	3.350	3.668	3.672	3.432
K_1	3.099	3.439	3.739	3.803	3.520
K_2	3.135	3.351	3.696	3.780	3.490
Mean	3.090	3.380	3.701	3.752	

Table 22.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	3.419	3.431	3.445	3.432
K_1	3.401	3.578	3.581	3.520
K_2	3.412	3.511	3.548	3.490
Mean	3.411	3.507	3.525	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.046	0.039	0.039	0.079	0.079	0.068	0.137
C.D.at 5%	0.127	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

Table 23 : Mean percentage of leaf magnesium as influenced by varying levels of N, P and K

Table 23.1 Nitrogen x Phosphorus

P/N	N_0	N_1	N_2	N_3	Mean
P_0	0.309	0.425	0.433	0.428	0.399
P_1	0.371	0.440	0.434	0.471	0.429
P_2	0.394	0.429	0.448	0.429	0.425
Mean	0.358	0.431	0.438	0.443	

Table 23.2 Nitrogen x Potassium

K/N	N_0	N_1	N_2	N_3	Mean
K_0	0.360	0.415	0.468	0.446	0.422
K_1	0.373	0.434	0.459	0.471	0.434
K_2	0.341	0.444	0.387	0.411	0.396
Mean	0.358	0.431	0.438	0.443	

Table 23.3 Phosphorus x Potassium

K/P	P_0	P_1	P_2	Mean
K_0	0.379	0.453	0.435	0.422
K_1	0.418	0.453	0.432	0.434
K_2	0.399	0.381	0.408	0.396
Mean	0.399	0.429	0.425	

	N	P	K	NP	NK	PK	NPK
S.E. ±	0.015	0.013	0.013	0.025	0.025	0.022	0.044
C.D. at 5%	0.041	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

the leaf magnesium content as compared with control. However, N_3, N_2 and N_1 were at par with each other. The application of phosphorus and potassium did not give any significant response in leaf Mg content.

V <u>Response curve and economics of fertilization</u> :

a) <u>Response curve</u> :

The response to nitrogen was found significant at linear level while response to phosphorus and potassium was found significant at quadratic level.

The formulae used are given in Chapter III and the equations thus fitted are given in Table 24. The predicted yields are presented in Table 25 and the curves are shown in Fig.5.1, 5.2 and 5.3.

The data presented in Table 25 and Fig.5.1 show that the yield of chiku increased with increasing levels of nitrogen in linear order.

From the data presented in Table 25 andFig.5.2, it is clear that after reaching a certain maximum level at a particular dose, the yield decreased with further increase in the dose of phosphorus.

It is observed from the Fig.5.3 that the potassium also showed similar yield response as that of phosphorus.

b) <u>Economics of fertilization</u> :

As there is a linear trend for the response of nitrogen level, it can be concluded that the yield of chiku can be

Table 24 : Equations for fitting response curves to nitrogen, phosphorus and potassium fertilisation

Treatments	Response equation
Nitrogen	$Y = 3.766 + 0.002037X$
Phosphorus	$Y = 5.100 + 0.002209X - 0.0000013X^2$
Potassium	$Y = 5.265 + 0.002005X - 0.0000014X^2$

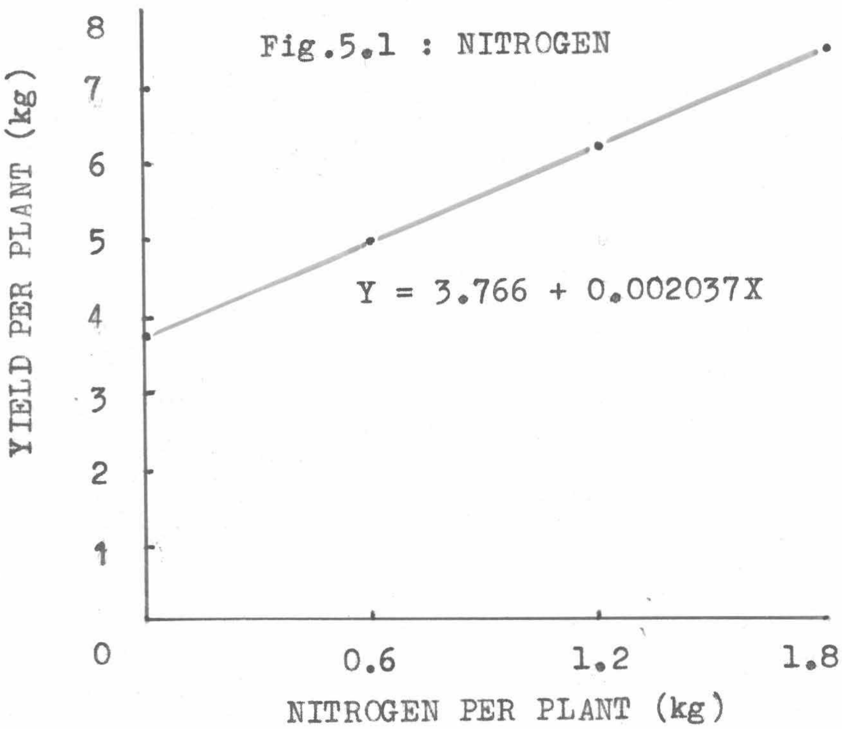
Table 25 : Observed and predicted yields (kg/plant)

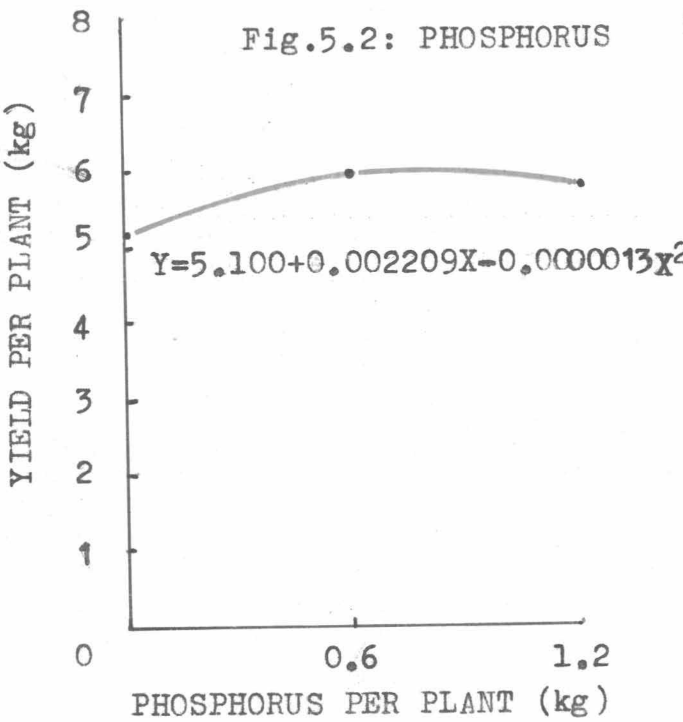
Treatments	Observed yield	Predicted yield
Nitrogen		
N_0 (0.0 kg)	3.918	3.766
N_1 (0.6 kg)	4.928	4.988
N_2 (1.2 kg)	5.875	6.210
N_3 (1.8 kg)	7.677	7.433
Phosphorus		
P_0 (0.0 kg)	5.100	5.100
P_1 (0.6 kg)	5.930	5.957
P_2 (1.2 kg)	5.769	5.879
Potassium		
K_0 (0.0 kg)	5.265	5.265
K_1 (0.6 kg)	5.947	5.964
K_2 (1.2 kg)	5.587	5.655

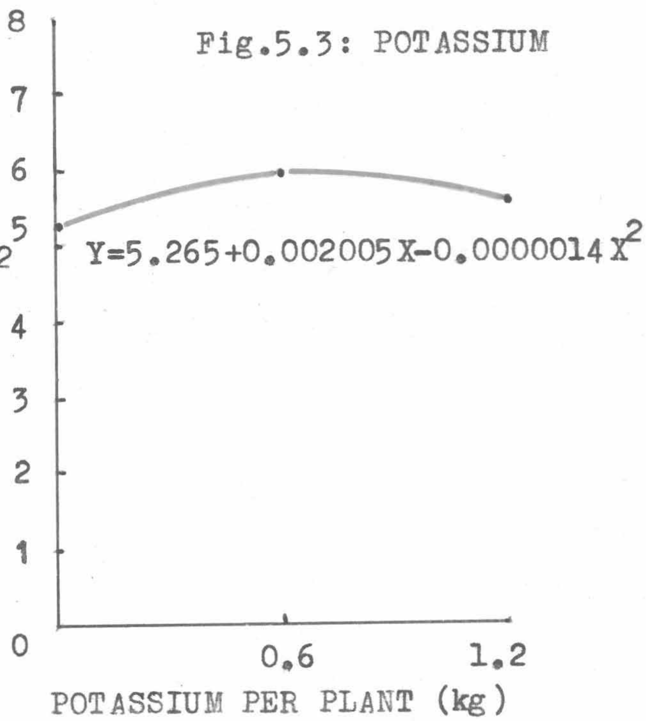
Table 26 : Optimum doses of phosphorus and potassium (kg/plant)

Fertiliser element	Optimum dose
Phosphorus	0.451
Potassium	0.584

Fig.5 : RESPONSE OF CHIKU TO N, P AND K FERTILIZATION







increased further through increased application of nitrogen. Therefore, it is not possible to work out optimum dose of nitrogen.

The data in respect of optimum doses of phosphorus and potassium are given in Table 26. It is observed from the Table 26, that by considering the rate of single superphosphate and muriate of potash at Rs.58/- and Rs.78/- per quintal (rate existing at the time of fertilizer application) respectively and selling market price of chiku at Rs.3.5 per kg of fruit, the optimum doses of phosphorus and potassium worked out to be 0.451 and 0.584 kg respectively per plant.

Chapter V

D I S C U S S I O N

CHAPTER V

D I S C U S S I O N

The results presented in Chapter IV in respect of growth, yield, fruit quality and leaf nutrient status of chiku, var. 'Kalipatti' as influenced by varying levels of nitrogen, phosphorus and potassium are discussed here in brief.

I <u>Effect of nitrogen</u> :

The significant results obtained have indicated that the application of nitrogen resulted in increase in growth in respect of stem girth, height, spread, volume of plant and leaf area of chiku plant as compared with no nitrogen application. The highest vegetative growth was observed at the N_3 (1.8 kg) level of nitrogen application.

Similar observations ~~in the~~ showing increase in the vegetative growth of the plant, with the application of nitrogen was noticed by Arora (1969) in guava and Singh <u>et al</u>. (1973) in mango.

The yield of chiku increased with nitrogen application. Total yield (in kg) increased by 25.78, 49.95 and 95.94 per cent with N_1 (0.6 kg), N_2 (1.2 kg) and N_3(1.8 kg) levels of nitrogen respectively over control, while the fruit number increased by 23.63, 46.14 and 88.35 per cent in N_1 (0.6 kg), N_2 (1.2 kg) and N_3 (1.8 kg) levels respectively.

Along with the increase in number of fruits and yield (kg) per plant, the fruit sise and average weight of fruit also increased due to nitrogen application.

Similar increase in yield with nitrogen application have been reported by Tiwari et al. (1968) in guava and Shende (1977) in pomegranate.

The increase in yield of chiku due to nitrogen appears to be a mainly due to higher plant growth. The nitrogen application produced more vegetative growth such as height, leaf area and volume of plant over control. This might have increased the synthesis of food which might have been diverted to higher fruit production. The increase in yield also appears to be due to increase in average weight of fruit and number of fruits per plant.

In the present studies, the fruit quality in respect of T.S.S., acidity and sugars improved after application of nitrogen when it was applied at medium (1.2 kg) level while at higher (1.8 kg) level there was deterioration of fruit quality. The highest T.S.S. (22.148 per cent) and reducing sugars (14.057 per cent) were observed at N_2 (1.2 kg) level. There was reduction in T.S.S. and reducing sugars at N_3 (1.8 kg) level as compared with medium level of nitrogen. The percentage acidity increased at N_3 (1.8 kg) and N_2 (1.2 kg) levels of nitrogen. The percentage of fruit pulp increased with the nitrogen application. The application of nitrogen failed to produce any significant affect on the percentage of seed and percentage of skin of fruit. The fruit quality improvement due to nitrogen can be expected only up to certain limit.

Improvement in fruit quality was noticed by Srivastava and Muthappa (1972) in Coorg mandarin. The increase in yield due to high nitrogen application and deterioration of fruit quality was reported by Chitkara _et al_. (1972) in grapes. The increase in acidity with nitrogen application has been reported by Arutyunyan _et al_. (1964) and Desai (1972) in grapes.

The N status of leaf increased with the nitrogen doses in linear order. These findings are in conformity with those of Bansal and Motiramani (1968) in guava and Shende (1977) in pomegranate.

The application of nitrogen also increased leaf P, K, Ca and Mg status. In phalsa, Sadhu _et al_. (1975) reported that the foliar P content was increased with added P and N. Christ and Ulrich (1954) observed that the addition of nitrogen to grapes not only resulted in better vine growth and higher production but actually increased potassium content of the vine.

The effect of nitrogen application on leaf calcium content was noticed by Patil (1978) in guava and Nijjar (1972) in grapes. They observed that the leaf Ca increased due to nitrogen application.

The application of nitrogen also increased the leaf Mg status. These results were similar to as obtained by Chapman (1952) in citrus and Patil (1978) in guava.

The results obtained in respect of growth, yield, fruit quality and leaf nutrient status are in line with those observed by Kamble (1980) in his studies in 1978-79 in chiku.

Gotmare (1960) reported 1.07 per cent N in chiku leaf as an average N content. Kamble (1980) reported 1.57 to 1.62 per cent leaf N as optimum. The values observed in the present studies are about the same. However, they are comparatively higher to those reported by Gotmare (1960).

In the present studies the beneficial effects of nitrogen application appeared mainly due to low nitrogen status of the soil. The soil analysis data given in Appendix-I show that the soils on which the experiment was laid out were low in nitrogen content. In semi-arid zone, the soils are generally deficient in nitrogen and therefore they respond to nitrogen application. From the present studies, it was observed that 1.8 kg N per plant gave more yield. Therefore, a dose of 1.8 kg N per plant per year appears to be optimum.

II <u>Effect of phosphorus</u> :

The results obtained from the present studies indicate that the height, spread, leaf area and volume of the plant significantly increased with phosphorus application. The maximum growth was recorded at P_1 level. However, there was no proportionate increase in growth with higher level of phosphorus (P_2).

The results are in harmony with those of Fleming (1961) who observed vigorous vine growth with phosphorus application. Singh (1973) observed that length of terminal shoots increased with P application in Allahabad Safeda guava.

It appears from the results obtained regarding growth of chiku plant that the application of phosphorus at lower

(0.6 kg) level was beneficial.

The yield significantly increased with the application of phosphorus. The number of fruits increased by 15.13 and 12.36 per cent and the yield (kg) increased by 16.27 and 13.12 per cent with P_1 (0.6 kg) and P_2 (1.2 kg) levels of phosphorus respectively over control. The average weight and volume of the fruit also increased with phosphorus application as compared to control.

The results are in agreement with the findings of Arora and Singh (1970), Teaotia et al. (1972) in guava who observed good response with phosphorus application for increasing the yield of guava.

The results obtained in respect of fruit quality show that T.S.S. and reducing sugar content increased with the application of phosphorus. The pulp percentage significantly increased at P_1 (0.6 kg) level over control and also P_2 (1.2 kg) level. These findings are in agreement with those of Arora and Singh (1970), Teaotia et al. (1972) in guava, who observed maximum production of T.S.S., reducing sugars, total sugars, ascorbic acid and pectin content with the application of phosphorus.

The phosphorus content of the leaf increased with the phosphorus application. Similar results were also observed by Reese and Koo (1977) in orange, Patil (1978) in guava and Shende (1977) in pomegranate.

In general, it was observed that a lower (0.6 kg) dose was optimum to chiku while the higher (1.2 kg) dose of phosphorus did not give beneficial effects on growth, yield and fruit quality as compared with P_1 (0.6 kg) level.

The soils of arid and semi-arid zones are generally high in phosphate. The lower level of phosphorus was found sufficient for the plant and therefore, there was no response to higher level. On the other hand it had adverse effect and the yield was reduced. Kamble (1980) did not notice beneficial effects of higher level of phosphorus (1.00 kg/plant) on growth and yield. He also reported reduction in yield with higher dose of phosphorus.

The leaf P content of 0.505 per cent was optimum which was comparatively higher than that reported by Gotmare (1960) who reported 0.35 per cent leaf P content. Kamble (1980) reported 0.49 to 0.55 per cent leaf P content.

III <u>Effect of potassium</u> :

From the results obtained, it is evident that the application of potassium had beneficial effects on growth, yield and quality of chiku as compared with no application.

In the present studies, the application of potassium significantly increased the height, leaf area and volume of the plant. These findings are in harmony with those of Dornelles (1963) in citrus and Patil (1978) in guava who observed increased growth of plant by potassium application.

In general, the response of plant to potassium application was noticed mainly up to K_1 (0.6 kg) level while at K_2 (1.2 kg) level, there was no significant increase in growth of plant as compared with K_1 (0.6 kg) level.

The data of soil analysis presented in Appendix-I show that the soils were rich in potassium. The potassium requirement of chiku plant might have been fulfilled with the lower (0.6 kg) level of potassium. There was no significant response to higher (1.2 kg) level in comparison with lower (0.6 kg) level of potassium on growth of chiku plant.

The application of potassium was found beneficial in increasing the yield. These results are in conformity with those of Martin (1973) and Reese and Koo (1975) in citrus, Chougule (1976) in pomegranate observed that the yield increased with the application of potassium.

The yield (kg) increased by 12.95 and 6.11 per cent while the number of fruits increased by 12.59 and 6.09 per cent with K_1 (0.6 kg) and K_2 (1.2 kg) levels respectively. The average weight of fruit also significantly increased over control. The yield obtained at K_2 (1.2 kg) level was lower than the yield obtained at K_1 (0.6 kg) level of potassium. These results are in agreement with those of Smith and Rasmussen (1961) in grapefruit trees. They reported that on low K status large number of fruits were produced as compared with high levels of K.

The pulp percentage significantly increased at K_1 (0.6 kg) level over control and K_2 (1.2 kg) level. The fruit quality improved by potassium application. There was increase in T.S.S. and reducing sugars while decrease in acidity with the application of potassium. These results are in agreement with those of Singh and Rajput (1977) in guava and Khandagale (1977) in grapes who reported that the K application improved the fruit quality.

The potassium application increased leaf K status as compared with no potassium application. The increase in leaf K status with the application of potassium has been reported by Desai (1972) and Divate (1967) in grape and Shende (1977) in pomegranate. In the present studies the leaf K status of 1.935 per cent observed at K_1 level was sufficient. Kamble (1980) reported 1.73 to 1.93 per cent leaf K content.

In the present studies it was observed that a dose of 0.6 kg of potassium per plant was optimum for chiku as it resulted in optimum growth with increased production and improvement in fruit quality.

IV <u>Effect of nitrogen, phosphorus and potassium in combination</u> :

The elements play an important role in combination rather than individually. Generally, the fruit crops are supplied with complete fertilizers containing N, P and K. Hence, the effect of N, P, K combinations on growth, yield, quality and leaf nutrient status are discussed below.

(a) <u>Nitrogen x Phosphorus</u> :

The average weight and average volume of fruit increased significantly by NP interactions. The number of fruits and total yield (kg) per plant also significantly influenced due to NP interaction. These results are in agreement with those of Merrill and Greer (1946) in tung trees who reported that the interaction between N and P was more effective than when N and P were used separately in increasing productiveness and growth.

In present studies, the N_3 (1.8 kg) and N_2 (1.2 kg) levels increased the yield by 95.94 and 49.95 per cent respectively over control, while N_3P_1 and N_2P_1 combinations increased the yield by 138.92 and 78.41 per cent respectively over N_0P_0 combination. The yield at N_3 (1.8 kg) level increased due to the added effect of phosphorus.

The T.S.S. and reducing sugar increased with the medium (1.2 kg) level of nitrogen in combination with lower (0.6 kg) level of phosphorus. Semochkina (1977) reported that when nitrogen was applied in combination with phosphorus, the fruit sugar content increased in fig.

The combination of 1.8 kg N + 0.6 kg P per plant was found beneficial in increasing yield and fruit quality of chiku.

(b) Nitrogen x Potassium :

There was significant effect due to NK interaction, in respect of average volume of fruit and yield. The NK interaction showed general trend which was similar to that obtained with NP interaction. Young and Koo (1968) in Persian lime observed an increase in growth and yield due to combined effect of nitrogen and potassium.

The N_3 (1.8 kg) and N_2 (1.2 kg) levels increased the yield by 95.94 and 49.95 per cent respectively over control. While N_3K_1 and N_2K_1 combination increased the yield by 134.93 and 73.87 per cent respectively over N_0K_0 combination. These results clearly indicate that the yield at N_3 and N_2 levels increased due to the added effect of potassium.

Considering above effects, it can stated that a combination of 1.8 kg N + 0.6 kg K per plant was beneficial for better growth, optimum yield and quality in chiku.

(c) Phosphorus x Potassium :

The P_1K_1 combination significantly increased the volume of plant and yield over P_0K_0 combination. The combined effect of P and K in respect of yield at P_1K_1 combination was higher than at P_2K_2 combination. It was observed that P and K if applied in combination gave beneficial effect as compared to individual application of potassium. These findings are in harmony with those of Shende (1977) in pomegranate who observed that the combined application of P and K was better than their individual applications.

In short, it can be concluded, that a combination of 0.6 kg P + 0.6 kg K was beneficial in increasing growth and yield of chiku.

(d) Nitrogen x Phosphorus x Potassium :

The fruit crops are supplied with complete fertilizers containing N, P and K. The proportion of these elements vary from crop to crop as the requirements are different. So the beneficial effects can only be obtained when these elements are supplied in balanced proportion.

In the present studies, the results indicate that a combination of 1.8 kg N + 0.6 kg P + 0.6 kg K per plant gave significantly higher yield than all other combinations. These beneficial effects might be due to the combination of these elements. These results are in conformity with those of Prudente and Mendoza (1976) in coconut and Shende (1977) in pomegranate, who reported increased yields with NPK combinations in comparison with their separate applications.

The leaf nutrient values of 1.691 to 1.721 per cent N, 0.505 to 0.537 per cent P, 1.859 to 1.935 per cent K, 3.752 to 3.803 per cent Ca and 0.443 to 0.471 per cent Mg were optimum for optimum growth and yield of chiku.

V <u>Response curve and economics of fertilisation</u> :

In the present studies, the response of chiku to nitrogen application was linear and therefore, for obtaining the economic optimum dose of nitrogen, the levels beyond present dose need to be tried.

The optimum doses for phosphorus and potassium were obtained in present studies by fitting the quadratic response curve. According to this method the optimum doses of P and K worked out to be 0.451 and 0.584 kg per plant respectively.

The chiku plant having a age of 6 years should be given a dose of 1.800 kg N + 0.451 kg P + 0.584 kg K per plant per year.

Chapter VI

SUMMARY AND CONCLUSIONS

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SUMMARY AND CONCLUSIONS

The experiment was laid out during 1977-78 in 4 x 3 x 3 randomised block design (factorial) with 36 treatment combinations replicated thrice. The treatment combinations were formulated by taking four levels of nitrogen (0.0, 0.6, 1.2 and 1.8 kg) and three levels of each of phosphorus and potassium (0.0, 0.6 and 1.2 kg).

The present trial was carried out in chiku block planted in July 1973 at the Instructional-cum-Research Orchard of Department of Horticulture, Mahatma Phule Krishi Vidyapeeth, Rahuri to find out an optimum dose of fertilisers for chiku under local conditions.

The results obtained regarding growth, yield, fruit quality and leaf nutrient status as influenced by varying levels of N, P and K are summarised here under.

The application of nitrogen significantly increased the growth of plant in linear order, except in case of stem girth and leaf area, where medium (N_2) and higher (N_3) levels of nitrogen were at par.

The growth of the plant significantly increased with the application of phosphorus at both the levels as compared with no application. The differences in growth characters such as height, spread, volume of plant and leaf area were not differing significantly at two levels of phosphorus.

The growth in respect of height, leaf area and volume of the plant significantly increased with application of potassium.

Highest volume of plant was recorded at P_1K_2 combination in P x K interaction while at $N_3P_1K_2$ combination in N x P x K interaction.

The number of fruits and weight of fruits increased in linear order with the application of nitrogen. The average weight and volume of fruit and fruit length significantly increased in linear order with nitrogen application. The fruit diameter was significantly higher at N_3 level as compared with N_1 and control but at par with N_2.

The highest weight of fruit was noticed at lower (0.6 kg P/plant) level of phosphorus. The fruit number was increased with phosphorus application. However, two levels of phosphorus were at par with each other. Though phosphorus application at higher (1.2 kg/plant) level increased the fruit number and weight of fruit over control, there was no linear increase over P_1 level. On the other hand the yield at P_2 level was significantly lower than that of P_1 level.

The application of potassium at both the levels significantly increased the fruit number and weight of fruits over control. Highest number of fruits and weight of fruits were observed at K_1 level. The K_1 level was significantly superior to even K_2 level.

Highest number of fruits was observed at N_3P_1 combination while lowest at N_0P_0 combination.

In respect of weight of fruits, it was noticed that highest weight of fruits was recorded with N_3P_1, N_3K_1, P_1K_1 and $N_3P_1K_1$ combinations of NP, NK, PK and NPK interactions respectively.

The fruit quality in respect of T.S.S. and reducing sugar content was improved with nitrogen application as compared with no nitrogen application. Highest T.S.S. and reducing sugar content were observed at N_2 level. However, the acidity and non-reducing sugar content were increased with nitrogen application. The fruit quality at N_2 level was good while at N_3 level it was slightly reduced. The pulp content was significantly increased with nitrogen application.

The application of phosphorus increased the T.S.S. and reducing sugar content while acidity was lowered. Two levels of phosphorus were at par with each other. The pulp content was increased with lower level of phosphorus.

The application of potassium improved the T.S.S. and reducing sugar content over control, however, two levels of potassium were at par. The acidity of pulp decreased in linear order with potash levels. The fruit pulp was significantly increased with K_1 level.

The leaf N content increased in linear order with the levels of nitrogen. The leaf P, K, Ca and Mg status was improved with nitrogen application. The application of phosphorus also resulted in increase of leaf P content. There was linear increase in leaf K status with potassic levels.

The leaf nutrient values of 1.691 to 1.721 N, 0.505 to 0.537 P, 1.859 to 1.935 K, 3.752 to 3.803 Ca and 0.443 to 0.471 Mg appear to be sufficient.

The studies regarding the response curve and economics of fertilization revealed that the chiku, variety 'Kalipatti' showed a significant linear response to nitrogen while quadratic response to phosphorus and potassium applications.

It was thus observed that the chiku variety Kalipatti was capable of responding to nitrogen beyond 1.8 kg/plant and therefore, for finding out the economic optimum dose, it is necessary to conduct further studies with nitrogen levels exceeding 1.8 kg/plant.

The optimum economic doses of phosphorus and potassium worked out to be 0.451 and 0.584 kg/plant respectively under this experimental conditions. As the plants are young having the age of 6 years at the time of experimentation, this trial needs to be continued further till a full dose of fertilizers is applied at 10 years age. To find out the optimum levels of fertilizers, it will be also necessary to find out effects of constant doses of fertilizers applied for some years after 10 years age.

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*Originals seen.

APPENDIX

A P P E N D I X - I

Soil analysis data

(Kamble, 1980)

Total N	:	0.071%
Available P	:	0.00091%
Available K	:	0.020%
Exchangeable Ca	:	32.41 me/100 g soil
Exchangeable Mg	:	9.87 me/100 g soil
Soil pH (1:2.5)	:	8.5
Electric conductivity	:	0.330 millimhos/ cm at 25°C.