STUDIES ON THE EFFECT OF N, P AND K FERTILIZATION ON THE GROWTH AND YIELD OF CHILLI (*Capsicum annuum*, L.) IN RED LOAM SOILS OF KERALA

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THESIS

SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
MASTER OF SCIENCE IN AGRICULTURE (AGRONOMY)
OF THE UNIVERSITY OF KERALA

DIVISION OF AGRONOMY
AGRICULTURAL COLLEGE AND RESEARCH INSTITUTE
VELLAYANI, TRIVANDRUM.

1968

CERTIFICATE

This is to certify that the thesis herewith submitted contains the results of bona fide research work carried out by Shri U. Mohamed Kunju, under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

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ACKNOWLEDGMENTS

The author wishes to place on record his deep sense of gratitude and indebtedness to:

Shri C.M. George, B.Sc. (Ag.), M.S.A. (Toronto), Professor of Agronomy, Agricultural College and Research Institute, Vellayani, for his valuable guidance, critical suggestions and encouragement;

Shri P. Kumara Pillai, M.Sc., M.S. (U.S.A.), Vice-Principal in charge, Agricultural College and Research Institute, Vellayani for providing necessary facilities to carry out this investigation;

Shri E.J. Thomas, M.Sc., M.S. (Iowa), Junior Professor of Agricultural Statistics for the help rendered in the statistical layout of the experiment and analysis of the data;

Shri C. Sreedharan, B.Sc. (Ag.), M.Sc. (Ag.), Junior Professor of Agronomy for the valuable help rendered; and

the members of the staff, Division of Agronomy for the help rendered by them.

The author is also grateful to the Government of Kerala for deputing him for Post-Graduate studies.

U. Mohamed Kunju

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INTRODUCTION

INTRODUCTION

Chilli (Capsicum annuum L.) otherwise known as red pepper or Cayenne pepper in other parts of the world, is an important condiment of every day use in Indian dietary and forms an indispensable and common ingredient in the South Indian foods. It is consumed in a variety of ways and is used either in the green state as a vegetable or in the dried form as chilli powder. Chilli preparations are also used as counter irritants in lumbago, neuralgia and rheumatic disorders. It has a carminative action and is useful in atonic dyspepsia.

Chilli fruit contains carbohydrates, proteins, fats, fibre, mineral matter and vitamins especially vitamin C. The pungency of chilli is due to the active principle "capsaicin" which is mostly contained in the skin and septa of fruits. The chief function of chillies as a condiment is to increase the appetite and to make the rather coarse and insipid grain food more palatable and acceptable to the tongue and therefore to be consumed in sufficient quantities. In Western countries the alkaloid extracted out of chillies is used for table purposes, particularly as an appetiser.

Chilli is a native of South America and is grown in countries like South and Central America, Central and East Africa, U.S.A. and Ceylon. In India it is cultivated in almost all the States over an area of approximately 6.74 lakh hectares with an annual production of 4.03 lakh tons of dry pods, besides the green ones which are picked in immature condition. Dry chilli is one of the important commercial crops all over the country. Green chilli is raised as a market crop as vegetables. Most of the production of chillies is consumed internally and only a small percentage of the dry chillies is exported to other countries. The principal chilli growing States in India are Andhra Pradesh, Maharastra, Mysore, Madras, Madhya Pradesh and Punjab. In Kerala, it is cultivated commercially in an area of 3095 hectares besides the smaller areas occupied in every homestead. The agro-climatic conditions of many parts of this State are quite conducive for the expansion of this crop. It may also be mentioned that during recent years the cultivation of this crop is giving substantial economic returns to the cultivators. The cultivation of chilli is rapidly gaining popularity among the cultivators and the area under this crop is increasing rapidly in the State.

Among the many factors that contribute to the successful growing of chillies, plant nutrition occupies

the most important role because it is an exhaustive crop. In addition, chilli, being a typical garden land crop responds well to manuring. Some of the experiments conducted on this crop in different areas have shown that the nutrient requirements of the crop vary from place to place.

Joachim and Paul as early as 1938 have reported that from the economic stand point, the manuring of chillies is undoubtedly profitable. The importance of proper nutrition of this crop is being increasingly realised now, as observed by Ramanathan (1965) and Pillay (1967) who reported the responses of this crop to NPK fertilization and micronutrients respectively.

In Madras and Andhra, there are departmental recommendations for this crop. At present there is no departmental recommendation in Kerala. The recommended dose of Madras is 60 lb. nitrogen, 30 lb. phosphoric acid and 30 lb. potash per acre whereas in Andhra it is 60-50-50.

It is seen that most of the Kerala soils are deficient in all the three major plant nutrients and require adequate fertilization to obtain maximum production. In Kerala however, no systematic manurial experiments to study the requirement of the chilli crop for major nutrients have been conducted so far.

Therefore, the present investigation was undertaken to study the effects of different levels of nitrogen, phosphorus and potash on growth, yield and quality of the crop and to fix an optimum fertilizer dose for chillies under the red loam soil conditions of Kerala.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Although chilli (Capsicum annuum) is extensively grown in South India, very little work has been done on the manurial requirements of the crop. The available literature on the manurial trials on chilli crop and some of the related works on allied crops are reviewed here.

Some of the experiments conducted on chilli crop showed the necessity of application of all the three essential elements nitrogen, phosphorus and potash for obtaining higher production and quality produce. Ramanathan (1965) observed that complete and balanced NPK fertilizers gave substantially higher yields. The trials conducted by Indian Potash Supply Agency on chilli crop also confirmed this finding.

Effect of nitrogen on growth

Almost all the works carried out on chilli crop showed that application of nitrogen was beneficial in increasing the general growth and vigour of the plant.

Murty and Murty (1963) reported that plants

receiving urea recorded maximum plant growth while those supplied with no nitrogen were poor in plant height and spread.

James et al (1967) observed that significant increase in total dry matter, root and shoot yields were obtained from the application of nitrogen. The response of the shoot growth to nitrogen application was greater than that of the root growth and this resulted in an increased shoot/root ratio.

Mehrotra et al (1968) found that branching was significantly impaired in chilli crop by the deficiencies of nitrogen, there being less number of branching in nitrogen deficient plants than plants supplied with sufficient nitrogen.

Shende (1962) found that the length of side branches in tomato was increased corresponding to the levels of nitrogen, whereas nitrogen had no effect in increasing the root growth.

In the case of bhindi, a similar response in height and number of leaves was reported by Chhonkar and Singh (1963).

Barooah et al (1964) found that application

of nitrogen brought about a very large increase in plant growth by significantly increasing the height of the plant, number of branches and number of leaves in tomato.

Patnaik and Farooqui (1964) noticed an increasing trend in the height of brinjal by increasing the level of nitrogen.

Effect of nitrogen on earliness, flower production and setting percentage

Joachim et al (1939) reported that though there appeared to be a tendency for nitrogen to delay the ripening of chilli pods slightly, there was no certainty that such was actually the case always.

James et al (1967) found that the number of buds and flowers was significantly increased with the application of nitrogen. Plants supplied with graded doses of nitrogen produced corresponding increases in the number of buds per plant.

Mehrotra et al (1968) observed that the deficiency of nitrogen adversely affected the production of flowers and fruits in chilli crop, there being no flower formed in the nitrogen deficient plants.

Assami and Kodata (1933) stated an increasing

trend in flower formation in brinjal by increasing the dose of nitrogen, but with excessive supply, there was a decline in flower production.

Patnaik and Farooqui (1964) noticed that flower production in brinjal was increased by nitrogen fertilization.

Shende (1962) found that increasing doses of nitrogen induced higher percentage of fruit set in tomato.

Effect of nitrogen on yield and quality of fruits

Joachim and Paul (1938) reported that application of 40 lb nitrogen per acre as nitrate of soda gave significantly higher yield than 20 lb nitrogen per acre. The yield in the former case was double than that of the latter. By the application of 40 lb nitrogen, the net increased return was approximately twice that of the application of 20 lb nitrogen. They concluded that the yield of chilli crop could be appreciably increased by nitrogenous fertilizers.

Joachim et al (1939) found that the average increase in the yield of chilli crop in terms of fresh weight due to the application of 20 lb and 40 lb nitrogen per acre were 27% and 50% respectively. They opined that application of nitrate of soda upto 2.5 cwt per acre would be definitely

beneficial in respect of yield under Jaffna conditions. They also observed that there were no appreciable variations in average weight of pods due to nitrogen application.

Murty (1954) reported that chilli crop responded to the application of groundnut cake and cattle manure. It was also seen that cattle manure applied every year at the rate of 4 to 5 cartloads per acre was found to be more beneficial than applying the entire manure once in three years.

The results of the experiments conducted at Poona by Vaidhyanathan (1955) had shown that the average response per pound of nitrogen worked out to 20.3 lb. of chilli pods which was undoubtedly a very high response.

Panikkar (1960) while reviewing the results of simple manurial trials in cultivators' fields, reported that in Sirhind the maximum yield of chilli was obtained with 80 lb nitrogen.

Maynard (1962) in his studies on Capsicum, recorded a high percentage of fruit setting by the application of nitrogen.

Relwani (1963) got a result wherein the application of 3 levels of nitrogen viz. 0, 40 and 80 lb. per

acre produced statistically significant increase in yield at each level, thereby showing the importance of nitrogen in increasing the yield of chilli crop.

Murty and Murty (1963) found that addition of nitrogen in any form or at any level had considerably increased the yield of chilli pods. The 100 pod weight and the number of pods per plant were also increased by nitrogen application whereas the length and girth of pod did not vary very much due to the treatment.

Arora et al. (1965) summarising the results of the manurial experiments conducted at I.A.R.I. on chilli crop reported that there was a progressive increase in the yield of chillies due to nitrogen fertilization. Application of 60 Kg nitrogen per hectare gave significantly more yield over control, though the difference between 60 Kg and 120 Kg nitrogen per hectare was not significant.

Dhulappanavar (1965) recorded good response of chilli crop to nitrogen in Mysore State at the levels of 15 and 30 lb nitrogen per acre, the increase being 63 and 103 lb dry chilli respectively.

Morani et al (1965) found from water culture studies that the optimum concentration of nitrogen was

around 100 ppm for giving high yield of sweet pepper.

James et al (1967) obtained significant increase in total number and yield of fruits by application of nitrogen.

Stromme (1957) observed that tomato responded positively to nitrogen application.

Kushpe (1958) reported that 40 lb nitrogen in the form of ammonium sulphate gave a good yield of tomatoes.

Sundara Rao and Seth (1959) noticed an increase in yield of tomato by nitrogen application.

Kulkarni (1960) found at I.A.R.I. that nitrogen levels of 80 lb and 120 lb per acre gave significantly higher yields in tomato than the 40 lb level.

Shende (1962) noted that increasing doses of nitrogen increased the number of green fruits per branch in tomato. He also found that total marketable produce of ripe tomatoes was significantly increased by increased doses of nitrogen. The nature of response was found to be linear with the regression equation as

$y = 486.2 + 0.855 x$. He got the

highest net profit of Rs.1,511.80 per acre by a soil application of 200 lb nitrogen per acre. He found that the economic dose was 50 lb nitrogen per acre.

Barooah et al (1964) observed that application of nitrogen at various levels brought about a considerable increase in the number of tomato fruits and yield. But the yield was reduced by the addition of every pound of nitrogen beyond 120 lb per acre.

Patnaik and Farooqui (1964) reported that 60 lb nitrogen per acre gave the maximum number of flowers and an increase in the fruit set, fruit size and ultimately in the total yield of brinjal.

Aso et al (1966) recorded that highest yields of tomatoes were obtained with 100 Kg nitrogen per hectare applied half at transplanting and half at the fruit setting stage.

Jyotishi and Choubey (1966) found that the application of 40, 80 and 120 lb nitrogen significantly increased the yield of tomato over the zero level. 80 lb nitrogen appeared to be the optimum level and at 120 lb nitrogen the yield was reduced, although not significantly.

Effect of phosphorus on growth

James et al (1967) reported that application of phosphorus increased the shoot growth in sweet pepper relative to root growth and increasing the supply of this element enhanced the shoot/root ratio.

Vyas (1967) stated that maximum vigour was found in chilli plants supplied with phosphorus.

Mehrotra et al (1968) found that branching was significantly impaired in chilli crop by the deficiency of phosphorus.

Koles and Vander (1953) emphasised that phosphorus requirement was highest in vegetative stage of tomato plants.

Dotti and Cobianchi (1960) reported that superphosphate application at the rate of 10 to 12 quintals per hectare increased the vigour of tomato plants.

Loccasio and Warren (1960) stated that in tomato, growth was increased with increasing rates of phosphorus application.

Shende (1962) found that root growth as measured in terms of dry weight per plant was enhanced with application of phosphorus in tomato.

Barooah et al (1964) observed a significant influence on all growth characters of tomato plant.

Effect of phosphorus on earliness, flower production and setting percentage

Mehrotra et al (1968) found that deficiencies of phosphorus adversely affected flower production and fruit production in chilli crop, there being no flowers formed in phosphorus deficient plants.

The effect of phosphorus in inducing earliness in tomato was observed by several workers like Baker (1937) Tiessen (1957) and Gericke (1966).

Tiessen (loc. cit) also noticed an increased fruit setting by the application of phosphorus in tomato.

Dotti and Cobianchi (1960) observed that superphosphate application at 10 to 20 quintals per hectare promoted early maturity of tomato.

Patnaik and Farooqui (1964) found that application of 40 lb. phosphoric acid per acre was found to increase the percentage of fruit setting as compared to no phosphoric acid in the case of brinjal.

Effect of phosphorus on yield and quality of fruits

Joachim and Paul (1938) reported that phosphoric acid appeared to have no significant effect on yield of chilli crops either at Anuradhapura or at Vavuniya in Ceylon. These soils were fairly well supplied with this nutrient which apparently was available in sufficient amount for the needs of the crops.

Purewal (1954) recommended fertilization with superphosphate at 2 to 3 maunds per acre to chilli crop on sandy and sandy loam soils for getting higher yields.

Relwani (1963) reported that the increase in yield of chilli crop due to application of 40 lb phosphoric acid per acre was significant only for the first year of an experiment conducted continuously for three years. On the other hand, 80 lb phosphoric acid per acre dose produced fairly appreciable responses over the control in all the years. He found that on an average 40 lb and 80 lb phosphoric acid doses per acre produced increases of 1.65 and 5.68 maunds per acre of wet chilli respectively. The nature of yield response curve for phosphoric acid was found to be linear. Phosphorus application at 40 and 80 lb levels produced profits of Rs.28.05 and Rs.96.56 respectively and the net profits per rupee invested in fertilizers were Rs.1.05 and

Rs.1.80 for 40 lb and 80 lb phosphoric acid doses respectively. The price of chilli pods and cost of fertilizer interrelationships showed that in the case of phosphorus, satisfactory profits could be obtained only with 80 lb phosphoric acid dose per acre.

Arora et al (1965) recorded that the differences in yield of chilli due to application of different doses of phosphoric acid were not significant.

Dhulappanavar (1965) reported that there was no significant difference in yield of chilli due to different levels of phosphorus in Mysore State.

Morani et al (1965) found that superphosphate applied at 150 ppm in the soil produced significant increase in yield of sweet pepper.

James et al (1967) recorded significant increase in the yield of total fruits due to the application of phosphorus.

Vyas (1967) reported that the yield of chilli pods was found to be maximum in the plants supplied with phosphorus through soil application after planting and foliar spray after first flowering.

Mehrotra et al (1968) noted that a deficiency of phosphorus adversely affected the production of fruit in chilli crop.

Baker (1937), Landrauand Samuels (1956) and Pudelski (1960) reported that the total yielding ability of tomato plants was increased by the application of soluble phosphates.

Dotti and Cobianchi (1960) indicated that application of superphosphate at 10 - 12 quintals per hectare increased the yield of tomatoes.

Shende (1962) found that phosphorus had no effect on fruit setting, and fruit development in tomatoes. He also found that there was no effect due to different doses on yield of tomatoes.

Yokoi et al (1962) observed that the yield of tomato was increased by higher doses of phosphorus.

Sarma and Mahendra Singh (1963) obtained similar results. The application of 60 lb phosphorus per acre increased the yield of tomato over 20 lb and 40 lb which did not differ significantly.

Barooah et al (1964) also found that application

of every pound of phosphorus beyond 60 lb showed a depressing trend in yield.

Patnaik and Farooqui (1964) noticed no increase in yield with different levels of phosphorus in brinjal even though the fruit weight and size were highest at the highest level of fertilization.

Aso et al (1966) reported that there was no response to phosphorus at 100 Kg per hectare in a soil of pH 5.4.

Winsor et al (1967) observed that there was an overall increase due to application of phosphorus in the yield of tomato under glass house conditions.

Effect of potash on growth

Russell (1961) stated that the potash supply in the soil may be adequate for crops growing under conditions of low nitrogen and phosphorus supply, but becomes inadequate if they are increased.

Cazi (1961) reported that potash was useful for the chilli plant to resist the adverse effect of weather, to impart resistance to pests and disease and to withstand drought conditions.

Mehrotra et al (1968) found that branching in chilli was significantly impaired by the deficiency of potash, there being less number of branches per plant in potassium deficient plants.

In the case of tomato, Barooah et al (1964) observed that potash application increased the growth significantly. However, it did not show any influence at early stages of plant growth.

Hallig et al (1966) reported that higher amount of soluble potassium and higher conductivity in the peat soils gave the tomato plants thinner stems and smaller size.

Effect of potash on earliness, yield and quality of crops

Joachim and Paul (1938) reported that potash appeared to have no significant effect on yield of chilli crop in Ceylon.

Arora et al (1965) recorded that there was no difference in the yield of chilli crop due to application of different doses of potash at I.A.R.I.

Dhulappanavar (1965) observed that there was no significant difference in yield by the application of different levels of potash in Mysore State.

Mehrotra et al (1968) found that deficiencies of potash adversely affected the production of flowers and fruits in chilli crops.

Tiessen (1957) noticed that application of potassium increased fruit yield in tomato compared to no potash application.

Sundara Rao and Seth (1959) found potassium had beneficial effects on the yield of tomato.

Lingle (1960) reported that there was no response for potash in increasing the yield of tomato.

Yokoi et al (1962) observed that an increase in potassium application brought about considerable enlargement of tomato fruits.

Barooah et al (1964) observed that potassium had little effect on the yield of tomato.

Patnaik and Farooqui (1964) noticed that application of potash proved desirable for enhancing the number of fruits and fruit set per plant in brinjal. The fruit weight and size were also high with potassium application.

Aso et al (1966) reported that in a soil of

pH 5.0, there was no response to potash at 100 Kg per hectare for tomato.

Winsor et al (1967) found that there was an over all increase in yield due to the application of potash in tomatoes grown in glass house condition.

Effect of combined application of nutrients on growth

Mehrotra et al (1968) reported that the mass of roots from NPK deficient chilli plant was less owing to restricted branching of roots. As for plant height NPK deficient plant had a significantly lesser height.

General reduction in growth and reproduction as indicated by a decrease in plant height, production of leaves and branches, flowering and fruiting in NPK deficient plants were reported in almost all crops by Bear et al (1949).

Lingle (1960) stated that nitrogen and phosphorus supplied together at planting time promoted early vigour and early maturity in tomatoes.

Shende (1962) found that increasing doses of nitrogen increased the length of side branches in tomato which was not influenced by phosphorus application.

Chinnaswamy (1963) observed that the height of

tomato plant was increased by the application of NPK in the form of both organic and inorganic, the inorganic form being better than organic.

Patnaik and Farooqui (1964) from their studies on brinjal observed an increase in plant height with phosphorus and potash. They noticed that a combination of phosphorus and potash in the absence of nitrogen was inferior to their separate application on many plant characters such as height, branches and stem diameter etc.

Patnaik and Farooqui (loc. cit) also indicated that 80 lb. nitrogen per acre in combination with 40 lb potash was found to be more effective in producing better growth and yield in brinjal than all other NPK combinations.

Effect of combined application of nutrients on yield

Gopalaratna (1933) reported that chilli being a soil exhausting crop must be manured in large quantities of 15 to 20 cartloads of cattle manure per acre.

Joachim and Paul (1938) noted that in Ceylon all the fertilizer treatments had given markedly increased yields of chilli pods. The average yield of fresh chilli pods from unfertilized plot was 23.9 cwt per acre as against

yields varying from 31.9 to 42.1 cwt per acre from the fertilized plots. They also observed that there was no significant difference in yield between the NP and NPK treatments.

The manurial requirement of chilli crop was found to be 250 lb ammonium sulphate, 600 lb superphosphate and 150 lb sulphate of potash per acre for giving better yields (Anon. 1954).

A full combination of 100 lb ammonium sulphate and 2 cwt of superphosphate over a basal dressing of cattle manure at 2 tons per acre was found very effective in increasing the yields of chilli crop in Guntur (Anon. 1954).

Purewal (1954) recommended incorporation of 20 tons of farmyard manure supplemented by ammonium sulphate for higher yields in chilli.

The State Fertilizer Workshop Seminar held at Himachal Pradesh proposed a general dose of NPK at the rate of 50:50:25 over a basal dose of 250 maunds per acre of farmyard manure for chilli, brinjal and tomato (Anon. 1959).

Panikkar (1960) while reviewing the results of simple manurial trials on chilli crop in cultivators'

field observed that in Pepsu, application of 40 lb and 80 lb nitrogen per acre alone and in combination with 25 lb phosphoric acid per acre gave a significant increase in yield over no manure control. Application of 80 lb nitrogen with 25 lb phosphoric acid was the best followed by 40 lb nitrogen with 25 lb phosphoric acid. The combination of N and P was found to be better than nitrogen alone, whereas, Cazi (1961) reported that chilli crop required a full supply of all the three principal elements viz. nitrogen, phosphorus and potash to obtain higher yields combined with good qualities.

Murty and Murty (1963) also noted from the manurial trials conducted at the Lam Station, that a combination of 60 lb nitrogen, 30 lb phosphoric acid and 50 lb potash was an ideal manurial regimen to rainfed chilli.

Relwani (1963) stated that application of 80 lb nitrogen and 80 lb phosphoric acid per acre over a basal dressing of 250 maunds of cattle manure per acre resulted in high yields and maximum profits.

Rao (1964) prescribed a manurial schedule of 60 lb nitrogen, 30 lb phosphoric acid and 50 lb potash for dry chilli crop and 100 to 120 lb nitrogen, 80 lb phosphoric acid and 50 lb potash for the irrigated crop, half the dose to be applied in the organic form.

Dhulappanavar (1965) reported that though the chilli crop gave good response to nitrogen, the application of P_2O_5 gave small increase in yield and he advocated the application of phosphoric acid and potash with a view to maintain soil fertility and also to obtain better yields in more favourable seasons. The economics of fertilizer application indicated that 30 lb nitrogen gave a net profit of ₹.195.37 per acre while application of combination of 30 lb nitrogen, 30 lb phosphorus and 30 lb potash further increased the net profit by ₹.220.49 per hectare.

Ramanathan (1965) observed that complete and balanced NPK fertilizers gave increased yields over the cultivators' usual practice of applying nitrogenous fertilizers with very little phosphatic and potassic fertilizers. It was also observed that maximum efficiency of applied nitrogen to chilli crop was obtained when it was supplemented with adequate quantities of phosphatic and potassic fertilizers.

Chadha (1967) noted, from the results of trials conducted under Indian Potash Supply Agency, that nitrogen alone did not give the maximum returns from fertilizer use in the absence of phosphorus and potash in adequate quantities.

Pillay (1967) also reported that the average

number of chilli fruits produced per plant were substantially increased by a balanced application of NPK fertilizers.

Crowther and Yates (1941) while discussing the effects of NPK fertilization suggested that there was a positive interaction between nitrogen and potash while the interaction between nitrogen and phosphorus was only to a smaller extent. Little interaction was reported between potassium and phosphorus.

In an experiment at I.A.R.I., it was observed that tomato gave 16% more yield by plants supplied with nitrogen and phosphorus together than with nitrogen alone (Anon. 1956).

Staton (1958) showed that nitrogen applied with potash tended to produce higher yields in tomato.

Sundara Rao and Seth (1959) in their studies on tomato observed that the addition of phosphorus together with nitrogen especially at higher doses enhanced the yield, as compared to the application of nitrogen alone.

Elykova (1960) found that application of a combination of 30 tons of dung with fertilizer nitrogen and phosphorus increased the tomato yield as much as inorganic nitrogen, phosphorus and potash alone did. Doubling the

dose of phosphorus in the inorganic mixture increased the yield of tomato still further.

Panikkar (1960) while reviewing the results of simple manurial trials found that a dose of nitrogen, phosphorus and potash at the rate of 80, 80 and 130 lb per acre respectively produced the highest yield of tomato in Bihar, even though the application of half of this rate was more economical.

Shende (1962) found that increasing doses of nitrogen increased the number of green fruits per branch in tomato which remained unchanged with increasing levels of phosphorus.

Sarma and Mahendra Singh (1963) observed that nitrogen-phosphorus interaction was not significant in tomato yield.

Barooah et al (1964) pointed out that among all nutrient combinations tried N x P interaction had a pronounced effect on the growth and yield of tomato plants especially during the late period of its life cycle. It had also been observed that phosphorus fed plants were able to absorb more nitrogen than other nutrients.

Gericke (1966) reported that tomatoes responded well to the application of NPK.

MATERIALS AND METHODS

MATERIALS AND METHODS

This investigation was undertaken to study the effects of nitrogen, phosphorus and potash on the growth and yield of chilli crop under the soil and climatic conditions of Vellayani. The materials employed and the methods adopted in this investigation are given below.

1. Experimental site

The experiment was conducted in the Agricultural College Farm, Vellayani. The area selected was uniform in soil conditions and was topographically even and free from any shade. The soil belongs to the group of red loam. The chemical analysis of the soil gives the following results.

Total nitrogen	..	0.031%
Total phosphoric acid	..	0.032%
Total potash	..	0.083%
Available phosphoric acid	..	0.002%
Available potash	..	0.0009%

2. Season

The experiment was carried out from June to

November 1967. The season was normal for the satisfactory growth of the crop.

3. Seed material

The "South Malabar" variety was selected for carrying out the trial. This variety is most popularly grown in the northern districts of Kerala for dry pods. The crop has a duration of 5 to 6 months and the plant flowers profusely and bears large number of fruits. The pods are long, having an average length of 9.4 cm. and an average girth of 1.2 cm.

The seed materials for this investigation were obtained from the Agricultural Research Station, Taliparamba.

4. Nursery

An area of about 2 cent was selected for the nursery. The field was dug, stubbles and weeds removed. Well rotted and well powdered cattle manure at the rate of 5 tons per acre was applied in the nursery area.

Seeds were sown on 25-5-67 in raised seed beds. The seed rate used was 0.7 lb./2 cent area. Regular watering with rose can and hand weeding were given. Plant protection measures were also taken for the young seedlings.

5. Manures and fertilizers

A uniform dose of 1200 Kg. lime per hectare was incorporated well in the experimental area before the preparatory cultivation.

Cattle manure was applied uniformly in the experimental area at the rate of 10 tons per hectare at the time of preparatory cultivation. The analysis of the farmyard manure is given below.

Nitrogen	..	0.51%
Phosphoric acid	..	0.29%
Potash	..	0.48%

Ammonium sulphate, super phosphate and muriate of potash were used to supply nitrogen, phosphoric acid and potash respectively, the compositions of which are given below.

Ammonium sulphate	..	20.5% N
Superphosphate	..	16.0% P_2O_5
Muriate of potash	..	50.0% K_2O

6. Layout of the experiment

The design adopted for this experiment was a 3^3

partially confounded factorial experiment in randomised block design with two replications. The higher order interactions NPK^2 and NP^2K^2 were partially confounded in replication I and II respectively. The details of the layout are given below.

Number of treatments	:	27
Number of blocks	:	6 blocks of 9 plots each
Gross plot size	:	4.9 m. x 4.9 m.
Net plot size	:	3.5 m. x 3.5 m.
Spacing	:	70 cm. x 70 cm.
Number of plants in gross plot	:	49
Number of plants in net plot	:	25

Five plants were selected in each plot for detailed observations.

Treatments

The treatments consisted of 3 levels each of nitrogen, phosphoric acid and potash and their combinations. The following were the levels.

i) Nitrogen

n_0 .. 25 Kg. N/ha.

n_1	..	50 Kg. N/ha.
n_2	..	75 Kg. N/ha.

ii) Phosphorus

p_0	..	20 Kg. P_2O_5/ha.
p_1	..	40 Kg. P_2O_5/ha.
p_2	..	60 Kg. P_2O_5/ha.

iii) Potash

k_0	..	20 Kg. K_2O/ha.
k_1	..	40 Kg. K_2O/ha.
k_2	..	60 Kg. K_2O/ha.

The different treatment combinations were;

$n_0p_0k_0$	$n_1p_0k_0$	$n_2p_0k_0$
$n_0p_0k_1$	$n_1p_0k_1$	$n_2p_0k_1$
$n_0p_0k_2$	$n_1p_0k_2$	$n_2p_0k_2$
$n_0p_1k_0$	$n_1p_1k_0$	$n_2p_1k_0$
$n_0p_1k_1$	$n_1p_1k_1$	$n_2p_1k_1$
$n_0p_1k_2$	$n_1p_1k_2$	$n_2p_1k_2$
$n_0p_2k_0$	$n_1p_2k_0$	$n_2p_2k_0$
$n_0p_2k_1$	$n_1p_2k_1$	$n_2p_2k_1$
$n_0p_2k_2$	$n_1p_2k_2$	$n_2p_2k_2$

7. Field culture

Preparatory cultivation

The experimental area received one ploughing with garden tractor 2 months before planting. The field was dug twice and the stubbles, grasses and other weeds were removed. Plots of 4.9 m. x 4.9 m. size were laid out. Shallow pits of about 25 cm. diameter were dug at a spacing of 70 cm. in either directions.

Thirtyone day old seedlings were planted in pits on the afternoon of 25-6-1967. The plants were given uniform waterings. Necessary shade was also provided for the first four days after transplanting.

Manuring

The entire dose of superphosphate and muriate of potash and half the dose of ammonium sulphate were applied as basal dressing. The remaining dose of ammonium sulphate was applied as top dressing 5 weeks after transplanting.

After cultivation and plant protection

Weeding and watering were systematically carried out. Three hoeings were done, one at the time of top dressing

with ammonium sulphate and the other two at one and two months after the first hoeing respectively.

Regular prophylatic sprayings with Malathion and Bordeaux mixture were given against the incidence of pests and diseases respectively. No serious pest or disease was noticed.

Harvest

The fully riped pods were harvested from the plants. First harvesting was done on 10-9-1967 and the subsequent harvests were made at an interval of 8 - 10 days. Harvesting was completed in seven rounds and the final harvest was done on 14-11-1967.

8. Characters studied

(i) Height of plants

The height of plants was recorded periodically on the 40th, 80th and 120th days after planting. The plant height was taken from the ground level to the tip of the longest shoot.

(ii) Number of branches

The total number of branches produced were

counted and recorded at the time of final harvest.

(iii) Total dry weight per plant and shoot/root ratio

After the final harvest, the plants were pulled out without damaging the roots. The dry weights of shoots and roots were recorded after drying in sun. From this, the shoot/root ratio was calculated.

(iv) Earliness in flowering

The number of days taken for the first flower opening was recorded and from this flowering duration is calculated.

(v) Number of flowers produced

Flower production was recorded on alternate days from the first flower opening till the flower production was almost ceased.

(vi) Number of pods per plant

The number of pods in each harvest was separately recorded and the total number of pods produced per plant was calculated.

(vii) Setting percentage

This observation was calculated by dividing the

total number of pods with the total number of flowers produced and expressed as percentage.

(viii) Yield of dry chillies

The produce from each harvest was uniformly dried and the total weight recorded.

(ix) Length and girth of pods

The total length of fruit including the calyx and the maximum girth were measured taking a sample of 25 fruits from each plot and the average worked out.

(x) Weight of 100 pods

The weight of 100 pods selected at random from each plot was recorded.

RESULTS

RESULTS

Biometric observations relating to growth characters, yield attributes and yield of the crop were statistically analysed. The results are furnished below.

1. Height of plants

The data on the height of plant taken on the 40th, 80th and 120th day after transplanting were statistically analysed. The analyses of variance are given in Appendices I to III. The Tables 1 to 3 summarise the mean height of plants in different treatments.

It is observed that there are significant differences in the height of plants due to different levels of nitrogen. The height is increased significantly with the increased doses of nitrogen in all the three periods.

The incremental dose of phosphoric acid has given a significant increase in height on the 40th day. The difference due to the treatment level p_1 is significant over the p_0 level, and the treatments p_1 and p_2 are on par. During the second and third stages of observations, the increased doses of phosphate application have given an increase in height though it is not statistically significant.

TABLE I

Mean height of plants on 40th day in cm

	n_0	n_1	n_2	Mean
p_0	27.93	34.07	39.20	33.73
p_1	32.47	37.80	40.60	36.96
p_2	31.30	35.40	40.97	35.89
k_0	29.80	37.60	40.30	35.95
k_1	30.20	35.63	39.60	35.14
k_2	31.53	34.03	40.87	35.48
Mean	30.54	37.75	40.26	---

	p_0	p_1	p_2	Mean
k_0	36.03	36.30	35.33	35.95
k_1	32.37	36.63	36.43	35.14
k_2	32.80	37.93	35.70	35.48
Mean	33.73	36.96	35.89	---

C.D. (5%) for comparison between marginal means : 2.10
C.D. (5%) for comparison between combinations : 3.63

TABLE 2

Mean height of plants on 80th day in cm

	n_0	n_1	n_2	Mean
p_0	52.00	60.87	64.20	59.02
p_1	55.40	62.87	67.37	61.88
p_2	56.90	59.90	67.53	61.44
k_0	53.00	60.70	65.63	59.78
k_1	55.47	62.40	67.30	61.72
k_2	55.83	60.53	66.17	60.84
Mean	54.77	61.21	66.37	---

	p_0	p_1	p_2	Mean
k_0	59.10	59.07	61.17	59.78
k_1	58.93	64.60	61.53	61.72
k_2	59.03	61.97	61.53	60.84
Mean	59.02	61.88	61.44	---

C.D. (5%) for comparison between marginal means : 5.55

C.D. (5%) for comparison between combinations : 9.65

TABLE 3

Mean height of plants on 120th day in cm

	n_0	n_1	n_2	Mean
p_0	70.83	82.20	89.20	80.74
p_1	71.50	80.37	89.00	80.29
p_2	74.53	78.03	92.93	81.83
k_0	71.20	79.93	89.57	80.23
k_1	72.83	80.50	89.93	81.09
k_2	72.83	80.17	91.63	81.54
Mean	72.29	80.20	90.38	---

	p_0	p_1	p_2	Mean
k_0	82.27	78.83	79.60	80.23
k_1	80.10	81.07	82.10	81.09
k_2	79.87	80.97	83.80	81.54
Mean	80.74	80.29	81.83	---

C.D. (5%) for comparison between marginal means : 1.43
C.D. (5%) for comparison between combinations : 2.48

There is no significant difference in plant height due to levels of potash at all stages.

The interactions between nitrogen and phosphorus, and phosphorus and potash are found to be significant at the final stage. Among the NP combinations, the maximum mean height of 92.93 cm has been recorded by the treatment combination n_2p_2 and among the PK combinations, the treatment p_2k_2 has given the maximum height of 83.80 cm.

2. Number of total branches per plant

The analysis of variance is given in appendix IV and the mean number of branches per plant is furnished in Table 4.

The results have indicated that there are significant differences due to the effect of different doses of nitrogen, The higher levels of nitrogen have significantly increased the number of branches over the lower level. The average number of total branches produced due to the levels n_0, n_1 and n_2 are 222.07, 279.12 and 324.06 respectively and the difference between treatments are significant.

As regards phosphoric acid the level p_1 has given a significant increase in the number of branches per

TABLE 4

Mean number of branches per plant

	n_0	n_1	n_2	Mean
p_0	194.57	249.97	297.00	247.18
p_1	236.78	287.93	335.37	286.69
p_2	234.87	299.47	339.80	291.38
k_0	210.87	266.97	318.80	265.54
k_1	222.23	288.93	324.57	278.58
k_2	233.10	281.47	328.80	281.12
Mean	222.07	279.12	324.06	----

	p_0	p_1	p_2	Mean
k_0	232.10	277.17	287.37	265.54
k_1	251.30	293.20	291.23	278.58
k_2	258.13	289.70	295.53	281.12
Mean	247.18	286.69	291.38	----

C.D. (5%) for comparison between marginal means : 13.84
C.D. (5%) for comparison between combinations : 23.97

NUMBER OF BRANCHES PER PLANT

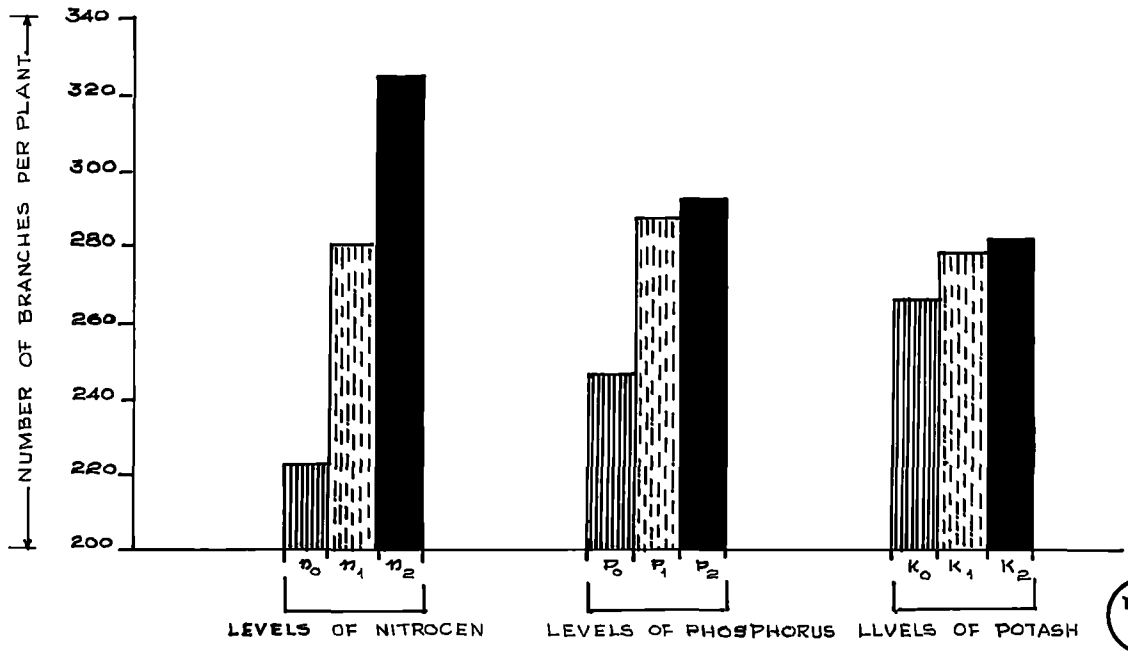

Fig 1

NUMBER OF FLOWERS PER PLANT

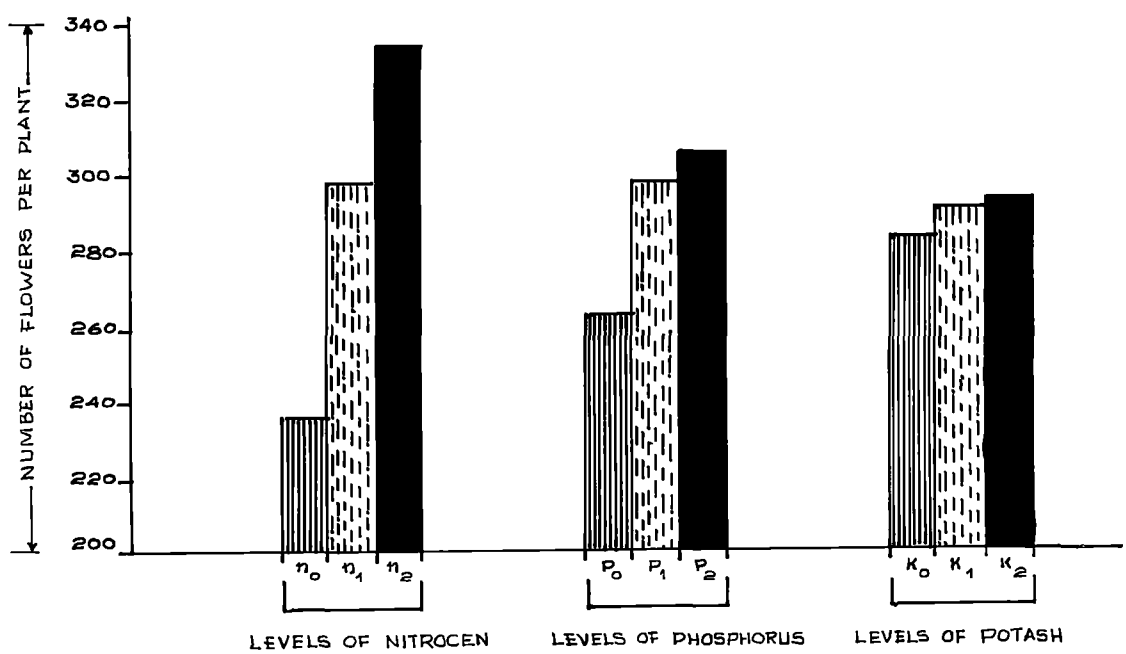

Fig 2

plant over the p_0 level and the levels p_1 and p_2 are on par. The mean values corresponding to p_0, p_1 and p_2 are 247.18, 286.69 and 291.38 respectively.

From the analysis of variance table it is seen that potash is not found to influence the number of branches significantly.

The various interactions of NPK have not given any significant effect on this character.

3. Total dry weight per plant

The results of analysis are given in Appendix V and the mean values are shown in Table 5.

There are significant differences due to the levels of nitrogen applied. It is seen that there is progressive increase in dry matter production by the application of higher doses of nitrogen, the response being linear. The mean values corresponding to n_0, n_1 and n_2 are 49.22, 56.01 and 63.62 gm respectively.

Phosphorus has also influenced the dry matter production significantly. The higher levels of phosphorus viz. p_1 and p_2 have given significantly higher amounts of dry matter over the p_0 level, but p_1 and p_2 are on par. The

TABLE 5

Mean weight of dry matter per plant in gm

	n_0	n_1	n_2	Mean
p_0	47.47	58.60	62.50	54.19
p_1	49.97	58.27	63.53	57.26
p_2	50.23	57.17	64.83	57.41
k_0	49.10	54.23	63.20	55.51
k_1	49.33	56.33	63.57	56.41
k_2	49.23	57.47	64.10	56.93
Mean	49.22	56.01	63.62	---
k_0	53.67	56.43	56.43	55.51
k_1	53.87	57.47	57.90	56.41
k_2	55.03	57.87	57.90	56.93
Mean	54.19	57.26	57.41	---

C.D. (5%) for comparison between the marginal means : 1.29
C.D. (5%) for comparison between combinations : 2.24

different levels of P_0, P_1 and P_2 have given mean values 54.19, 57.26 and 57.41 gm respectively.

It is seen that application of potash is not found to influence significantly the dry matter production even though a trend has been noticed to increase the same by increasing the levels of potash.

The various interactions are not significant.

4. Shoot/root ratio

The shoot/root ratios calculated are subjected to statistical analysis and the analysis of variance is given in Appendix VI. The mean ratios are furnished in Table 6.

It is seen that the effects of nitrogen alone are significant. The ratio has become wider viz. 4.13 by the highest dose of nitrogen while it is 3.9 with the lowest level. The incremental doses of nitrogen have produced comparatively higher increases in the shoot weights than in the root weights.

From the mean table it is seen that the application of increased dose of phosphorus has given a decrease in the shoot/root ratio at the various levels tried though

TABLE 6

Mean shoot/root ratio

	n_0	n_1	n_2	Mean
p_0	3.96	4.04	4.19	4.07
p_1	3.88	4.04	4.14	4.02
p_2	3.86	3.95	4.06	3.96
k_0	3.91	4.07	4.12	4.03
k_1	3.87	3.95	4.09	3.97
k_2	3.93	4.01	4.18	4.04
Mean	3.90	4.01	4.13	----

	p_0	p_1	p_2	Mean
k_0	4.07	4.02	4.01	4.03
k_1	4.00	3.97	3.94	3.97
k_2	4.13	4.07	3.93	4.04
Mean	4.07	4.02	3.96	----

C.D. (5%) for comparison between marginal means : 0.14
C.D. (5%) for comparison between combinations : 0.25

it is not statistically significant. The mean values are 4.07, 4.02 and 3.96 for the levels p_0, p_1 and p_2 respectively.

Potash fertilization at the different levels tried has not resulted in any significant difference in shoot/root ratio.

5. Earliness in flowering

The data on the number of days required for the first flower opening in different treatments were statistically analysed and the analysis of variance is given in Appendix VII and the mean values are presented in Table 7.

It is seen that there is no significant difference in the number of days required for the first flower opening due to any of the treatments. However, a slight earliness in flowering has been noticed for the higher levels of phosphorus application.

6. Number of flowers per plant

The analysis of variance is given in Appendix VIII and the mean values of flowers produced per plant are shown in Table 8.

It is observed from the analysis of variance table

TABLE 7

Mean number of days for first flower opening

	n_0	n_1	n_2	Mean
p_0	32.53	32.60	32.50	32.54
p_1	32.37	32.60	32.53	32.44
p_2	32.37	32.20	32.43	32.33
k_0	32.36	32.43	32.47	32.42
k_1	32.43	32.40	32.50	32.44
k_2	32.46	32.37	32.50	32.44
Mean	32.42	32.40	32.50	-----

	p_0	p_1	p_2	Mean
k_0	32.50	32.43	32.33	32.42
k_1	32.57	32.43	32.37	32.44
k_2	32.57	32.47	32.30	32.44
Mean	32.54	32.44	32.33	-----

TABLE 8

Mean number of flowers per plant

	n_0	n_1	n_2	Mean
p_0	208.60	264.93	316.07	263.20
p_1	240.87	311.13	343.77	298.59
p_2	257.78	317.33	343.50	306.20
k_0	227.53	289.63	332.07	283.08
k_1	234.33	304.80	334.60	291.24
k_2	245.37	298.97	336.67	293.67
Mean	235.74	297.80	334.44	----

	p_0	p_1	p_2	Mean
k_0	255.93	293.50	299.80	283.08
k_1	269.83	301.00	302.90	291.24
k_2	263.83	301.27	315.90	293.67
Mean	263.20	298.59	306.20	----

C.D. (5%) for comparison between marginal means : 10.96
C.D. (5%) for comparison between combinations : 18.99

that both nitrogen and phosphorus have influenced the flower production significantly. The increase in the number of flowers produced due to the various levels of nitrogen is found to be linear and significant. The highest level of nitrogen (n_2) has given a mean number of 334.44 flowers per plant, while the lowest dose has given only 235.74 flowers.

In the case of phosphorus, the higher levels p_1 and p_2 have brought about significant increases in flower production over the lowest level (p_0), even though p_1 and p_2 are on par. Maximum number of flower production has been recorded by p_2 level (306.20 flowers).

It is seen that the application of potash at the levels tried has given increased flower production even though it is not statistically significant. The mean values for the levels of k_0, k_1 and k_2 are 283.08, 291.24 and 293.67 respectively.

The combined effects are also not significant. However, the maximum number of 343.77 flowers has been noticed in treatment combination n_2p_1, closely followed by n_2p_2.

7. Number of pods per plant

The analysis of variance is furnished in Appendix IX and the mean number of pods per plant under different treatments are given in Table 9.

TABLE 9

Mean number of pods per plant

	n_0	n_1	n_2	Mean
p_0	75.83	107.70	129.83	104.45
p_1	98.27	128.57	141.70	122.84
p_2	103.93	130.27	146.13	126.78
k_0	87.97	120.13	136.87	114.99
k_1	94.40	124.33	140.07	119.60
k_2	95.67	122.07	140.67	119.47
Mean	92.68	122.18	139.21	----

	p_0	p_1	p_2	Mean
k_0	100.90	119.67	124.40	114.99
k_1	106.43	125.33	127.03	119.60
k_2	106.03	123.53	128.90	119.47
Mean	104.45	122.84	126.78	----

C.D. (5%) for comparison between marginal means : 3.42
C.D. (5%) for comparison between combinations : 5.92

The main effects due to the various levels of nitrogen, phosphorus and potash are significant.

It is noticed that n_1 has produced a significantly higher number of pods over n_0 and n_2 produced a significant increase over n_1. The average numbers of 92.68, 122.18 and 139.21 fruits per plant have been recorded by n_0, n_1 and n_2 respectively.

Progressively significant increases in the number of pods per plant have been noticed due to the graded doses of phosphorus. The mean numbers of pods corresponding to p_0, p_1 and p_2 are 104.45, 122.84 and 126.78 respectively.

In the case of potash, the higher doses viz. k_1 and k_2 have given significantly higher number of pods per plant over k_0, even though there is no significant difference between these two levels. The mean number of pods produced in different levels of potash are 114.99, 119.60 and 119.47 by k_0, k_1 and k_2 respectively.

Among the various combinations, the N x P interaction is found to be significant. The maximum number of fruits of 146.13 per plant has been recorded by the combination n_2p_2.

TABLE 10

Mean setting percentage

	n_0	n_1	n_2	Mean
p_0	36.35	40.65	41.16	39.38
p_1	40.81	41.35	41.22	41.13
p_2	40.44	41.02	42.53	41.33
k_0	38.44	41.44	41.33	40.41
k_1	40.11	40.75	41.82	40.89
k_2	39.04	40.82	41.76	40.54
Mean	39.20	41.01	41.64	---

	p_0	p_1	p_2	Mean
k_0	38.99	40.74	41.49	40.41
k_1	39.08	41.69	41.91	40.89
k_2	40.09	40.27	40.60	40.54
Mean	39.38	41.13	41.33	---

C.D. (5%) for comparison between marginal means : 0.94

C.D. (5%) for comparison between combinations : 1.63

8. Setting percentage

The analysis of variance is given in Appendix X and the mean setting percentage in Table 10.

It is seen that the nutrients nitrogen and phosphorus influenced the percentage of fruit setting significantly. Nitrogen at the higher levels viz. n_1 and n_2 has given significantly increased fruit setting over the lower dose n_0. The difference noted between n_1 and n_2 is not statistically significant.

In the case of phosphorus, the differences in the setting percentage are significant only between the levels p_0 and p_1 and beyond p_1 level there is no significant increase.

Application of different levels of potash has given no significant difference in setting percentage.

The combined effect of nitrogen and phosphorus and the interactions NPK and NPK^2 are significant.

9. Yield of chillies

The analysis of variance for yield of dry pods as influenced by the various treatments is furnished in Appendix XI.

TABLE 11

Yield of dry chilli pods in Kg/ha

	n_0	n_1	n_2	Mean
p_0	626.53	844.90	1346.20	939.18
p_1	737.39	942.86	1456.41	1045.55
p_2	787.76	1046.29	1648.33	1160.73
k_0	685.71	914.29	1442.20	1014.04
k_1	706.12	948.98	1455.10	1036.73
k_2	759.84	970.78	1553.71	1094.78
Mean	717.22	944.65	1483.67	-----

	p_0	p_1	p_2	Mean
k_0	956.49	1000.65	1084.98	1014.04
k_1	900.65	1051.02	1158.53	1036.73
k_2	960.57	1085.06	1238.78	1094.78
Mean	939.18	1045.55	1160.73	-----

C.D. (5%) for comparison between marginal means : 130.69
C.D. (5%) for comparison between combinations : 226.37

NUMBER OF PODS PER PLANT

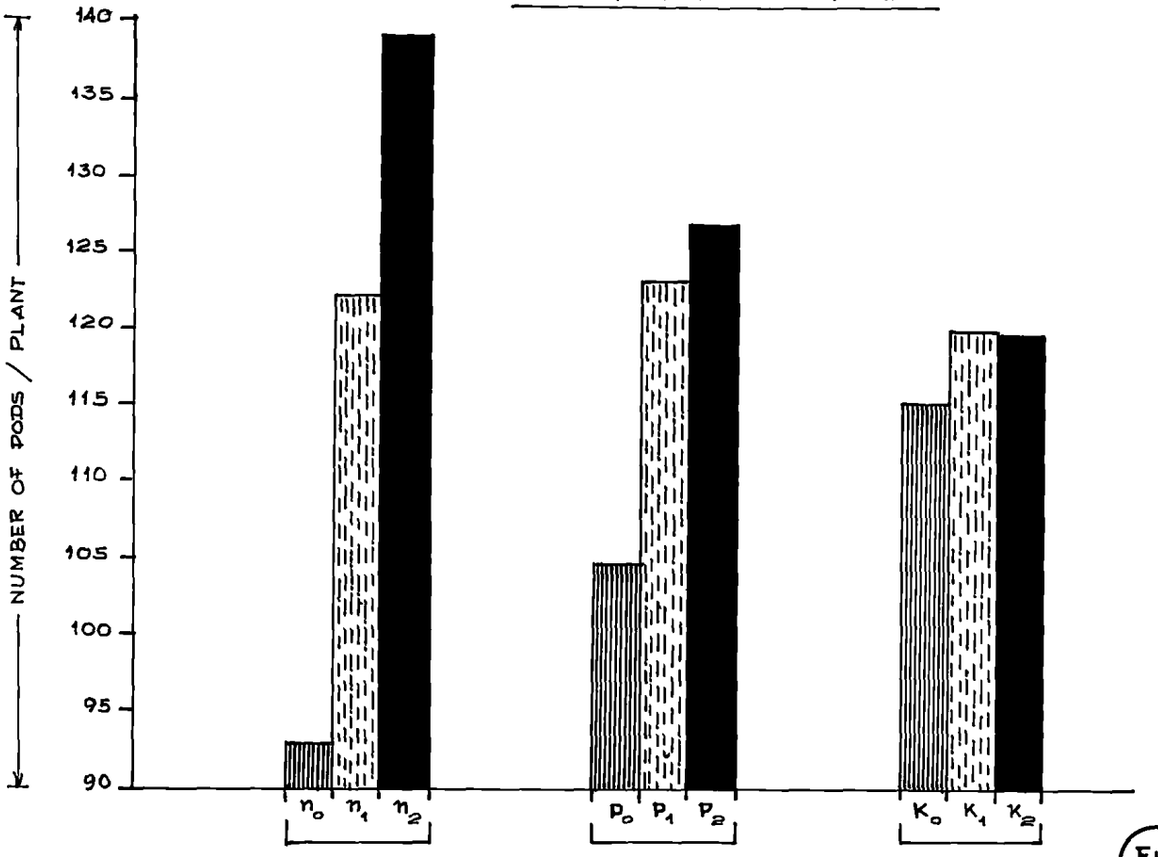

Fig 3

YIELD OF DRY CHILLI PER HECTARE

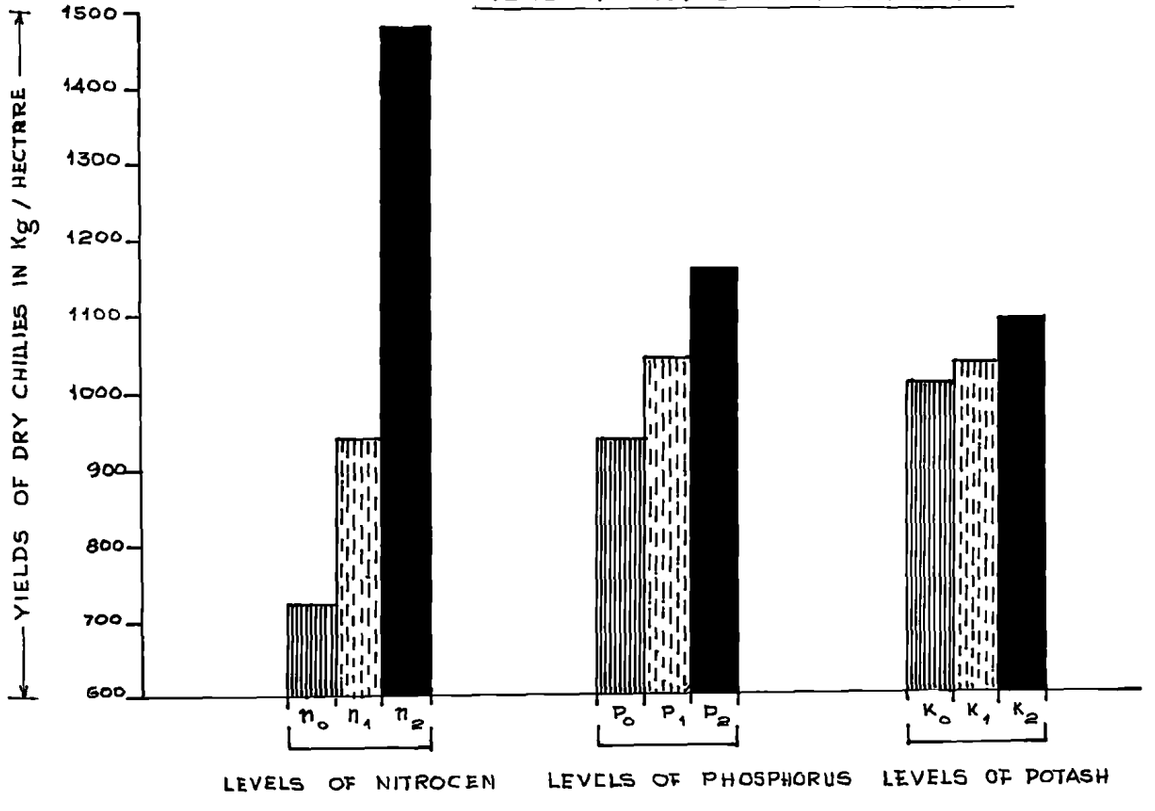

Fig 4

It is seen that the effects of nitrogen and phosphorus are significant in increasing the yield. Table 11 summarises the mean yield of dry pods as influenced by the various treatments.

There are significant progressive increases in the yield of pods corresponding to the increased levels of nitrogen application. The mean yields due to n_0, n_1 and n_2 are 717.22, 944.65 and 1483.67 Kg per hectare respectively. The percentage of increase due to n_1 over n_0 is 31.7 and that of n_2 over n_1 is 57.6 . The increase due to the highest dose of nitrogen over the lowest dose is 106.8%. The yield obtained by 75 Kg nitrogen per hectare is almost double than that obtained by 25 Kg nitrogen level.

In the case of phosphorus, the highest level p_2 has significantly increased the yield over the lowest level p_0 while the effects of treatments p_0 and p_1 and, p_1 and p_2 are on par. The average yield per hectare under the various levels of phosphorus are 939.18, 1045.65 and 1160.73 Kg respectively. The increase due to p_2 over p_0 is 23.5%.

The various levels of potash have not given any significant difference in yield of pods. But there is a corresponding trend to increase the yield by the application of higher levels of potash. The yields due to the various

levels of potash k_0, k_1 and k_2 are 1014.04, 1036.73 and 1094.78 Kg per hectare respectively.

The effects of various interactions are not significant. However, within the various combinations of nitrogen and phosphorus, the maximum yield of 1648.33 Kg per hectare of dry pod has been recorded by the treatment n_2p_2. It is also seen that the treatment $n_2p_2k_2$ has given the maximum yield of 1824.49 Kg per hectare among all the treatment combinations.

10. Length of pod

It is seen (Appendix XII and Table 12) that there is no significant difference in pod length due to different levels of nitrogen, phosphorus or potash. The interaction P x K is found to be significant. The maximum length of 9.66 cm was noticed in p_2k_2 treatment.

11. Girth of pod

The results (Appendix XIII and Table 13) have shown that there is no significant difference in girth of fruits in any of the levels of nitrogen, phosphorus or potash. None of the interactions is found to be significant.

TABLE 12

Mean length of pods in cm

	n_0	n_1	n_2	Mean
p_0	9.54	9.37	9.48	9.46
p_1	9.41	9.27	9.45	9.37
p_2	9.63	9.55	9.26	9.48
k_0	9.56	9.37	9.42	9.45
k_1	9.55	9.31	9.46	9.44
k_2	9.47	9.49	9.31	9.43
Mean	9.53	9.39	9.40	----

	p_0	p_1	p_2	Mean
k_0	9.34	9.44	9.58	9.45
k_1	9.62	9.49	9.21	9.44
k_2	9.43	9.19	9.66	9.43
Mean	9.46	9.37	9.48	----

C.D. (5%) for comparison between marginal means : 0.22
C.D. (5%) for comparison between combinations : 0.39

TABLE 13

Mean girth of pods in cm

	n_0	n_1	n_2	Mean
p_0	1.24	1.24	1.25	1.24
p_1	1.20	1.28	1.26	1.25
p_2	1.24	1.24	1.19	1.22
k_0	1.20	1.23	1.24	1.23
k_1	1.24	1.29	1.21	1.24
k_2	1.24	1.25	1.25	1.25
Mean	1.23	1.26	1.23	----

	p_0	p_1	p_2	Mean
k_0	1.22	1.24	1.22	1.23
k_1	1.27	1.24	1.22	1.24
k_2	1.25	1.26	1.22	1.25
Mean	1.24	1.25	1.22	----

12. 100 pods weight

The analysis of variance is given in Appendix XIV and the mean values are in Table 14. It is evident from the result that there is significant difference in the weight of 100 pods due to the effect of different levels of nitrogen and potash. The higher levels of nitrogen viz. n_1 and n_2 have increased the 100 pods weight significantly over the lowest level n_0 and n_2 is found to be significantly superior to n_1 in this respect.

There is no significant effect due to application of phosphorus.

The k_1 and k_2 levels of potash have increased the weight of 100 pods significantly over k_0 while k_1 and k_2 are on par.

The effects of various interactions are not significant.

13. Response curves and economics of manuring

The average response per Kg of nitrogen applied in the range of 25-50 Kg per hectare is 11.10 Kg whereas at 50-75 range, it is 15.56 Kg. The average response per Kg of nitrogen over the whole range is 15.33 Kg.

TABLE 14

Mean weight of 100 pods in gm

	n_0	n_1	n_2	Mean
p_0	73.17	74.67	75.83	74.55
p_1	72.50	74.83	75.67	74.33
p_2	73.00	74.17	75.83	74.33
k_0	72.50	72.67	75.17	73.44
k_1	72.83	75.67	76.00	74.83
k_2	73.33	75.33	76.17	74.94
Mean	72.89	74.55	75.78	----

	p_1	p_2	p_3	Mean
k_0	72.83	73.50	74.00	73.44
k_1	75.67	74.33	74.50	74.83
k_2	75.17	75.17	74.50	74.94
Mean	74.55	74.33	74.33	----

C.D. (5%) for comparison between marginal means : 1.22
C.D. (5%) for comparison between combinations : 2.11

RESPONSE OF NITROGEN ON YIELD OF CHILLI

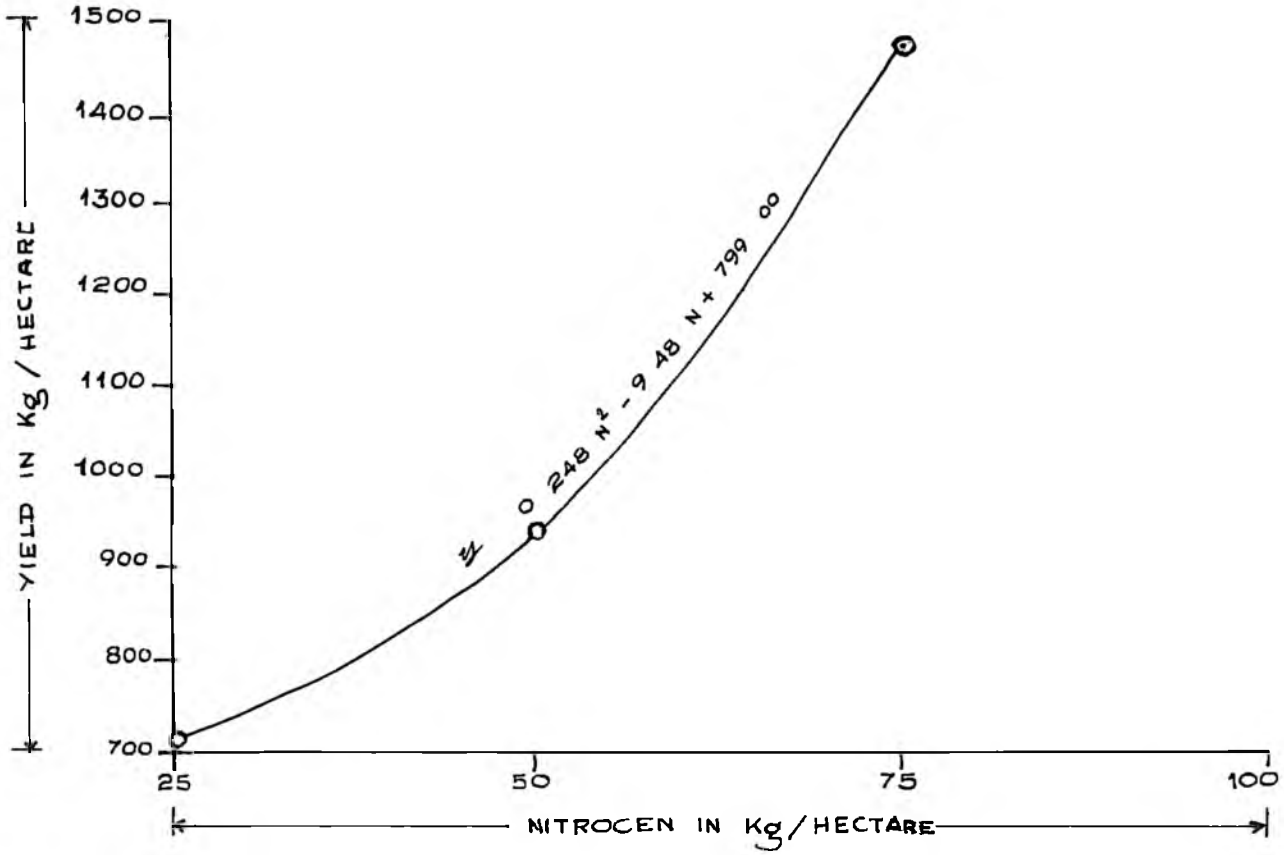

Fig 5

Quadratic model has been found to be the best for the response of nitrogen on yield. The curve fitted is

$$y = 0.248\ N^2 - 9.48\ N + 799.00$$

In the case of phosphorus the average response per Kg of phosphoric acid in the range of 20-40 Kg per hectare is 5.32 Kg dry pods while it is 5.76 Kg in the range of 40-60 Kg per hectare. Mean response per Kg P_2O_5 in the whole range is 5.50 Kg. Linear response function has been found to be best fit and is given by

$$y = 5.525\ P + 827.3$$

As regards the application of potash, the average response per Kg of potash is 1.14 Kg dry pods in the range of 20-40 Kg K_2O per hectare and 2.90 Kg in the range of 40-60 Kg potash. The mean response per Kg K_2O over the entire range has been found to be 2.02 Kg. Linear function has been found to be best fit and is given by

$$y = 2.025\ K + 967.66$$

The economics of application of different doses of nitrogen, phosphorus and potash are presented in Table 15. It is observed from the data that among the nutrients, nitrogen has given the highest profit per hectare and phosphorus and potash ranked second and third in order. The treatment $n_2p_2k_2$, which has given the maximum yield among all the treatment combinations has recorded a profit of ₹.2703.30 over the treatment $n_0p_0k_0$.

RESPONSE OF PHOSPHORUS ON YIELD

OF CHILLI CROP

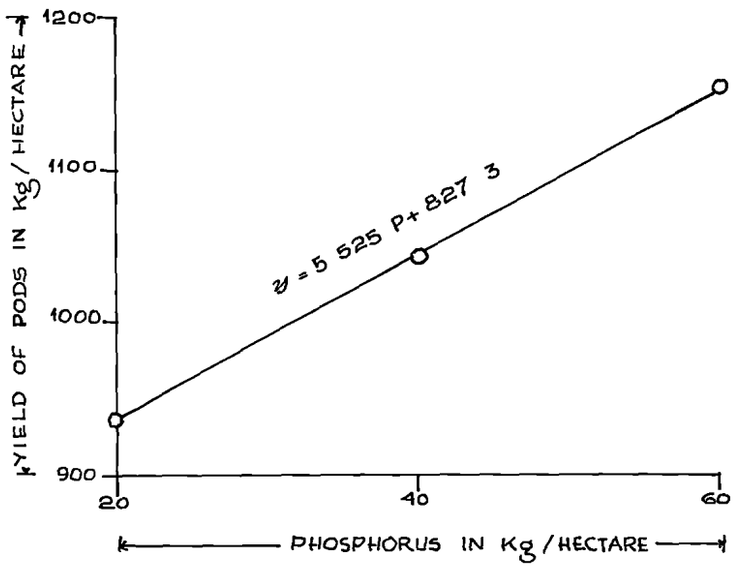

Fig 6

RESPONSE OF POTASH ON YIELD

OF CHILLI CROP

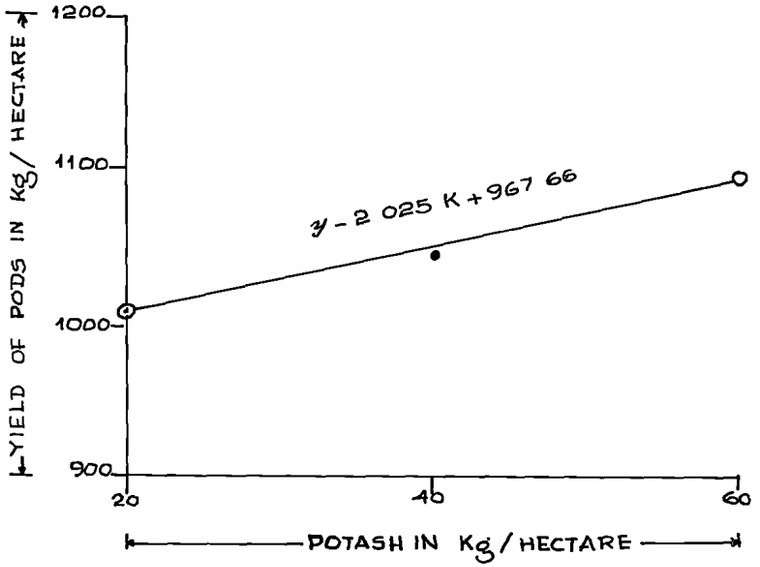

Fig 7

TABLE 15

Economics of manuring of chilli crop

Nutrient	Level/ha	Yield in Kg per hectare	Value in Rs. per hectare	Extra yield over the lowest level Kg/ha	Value of extra yield in Rs.	Extra cost of fertilizers in Rs.	Extra harvesting charges at Rs. 10.00/ quintal	Total additional expenditure in Rs.	Profit or loss in Rs.
N	25 Kg	717.22	1793.05	--	--	--	--	--	--
	50 "	944.65	2361.63	227.43	568.58	61.25	22.75	84.00	484.58
	75 "	1483.67	3709.17	766.45	1926.12	122.50	76.65	209.15	1716.97
P_2O_5	20 "	939.18	2347.95	--	--	--	--	--	--
	40 "	1045.55	2613.88	106.37	265.93	47.80	10.64	58.44	207.49
	60 "	1160.73	2901.83	221.55	553.87	95.60	22.15	117.75	436.09
K_2O	20 "	1014.04	2535.10	--	--	--	--	--	--
	40 "	1036.73	2591.83	22.69	56.73	16.40	2.27	18.67	38.06
	60 "	1094.78	2736.95	80.74	201.85	32.80	8.07	40.87	160.98
$n_0p_0k_0$	25:20:20	689.80	1474.50	--	--	--	--	--	--
$n_2p_2k_2$	75:60:60	1824.48	4561.20	1324.68	3086.70	250.90	132.50	383.40	2703.30

Note:- Ammonium sulphate @ Rs.503.00/ton
Superphosphate @ Rs.382.00/ton
Muriate of potash (50%) @ Rs.408.00/ton
Dry chilli pods @ Rs.2,500.00/ton

DISCUSSION

DISCUSSION

The present investigation has been taken up with a view to study the effects of different levels of nitrogen, phosphorus and potash on the growth and yield of chilli variety, "South Malabar".

Biometric observations, relating to growth characters, yield attributes, yield and quality of chilli crop, taken were statistically analysed. The results are discussed hereunder.

1. Height of plants

The results show that different levels of nitrogen have significantly influenced the height of plants at all stages, the response being linear upto the maximum level tried.

Role of nitrogen in enhancing the vegetative growth of plants is well known. Russell (1961) stated that nitrogen increases the size of plant cells, promotes leaf growth and thus brings about enhanced photosynthesis which assists the growth process.

The significant increases in height obtained at all stages in this investigation is in conformity with the results obtained by Murty and Murty (1963) in chillies. Patnaik and Farooqui (1964) reported similar results in brinjal.

The results also indicate that the effect of phosphorus is not so marked as that of nitrogen. There is significant difference in height on the 40th day between the levels of 20 and 40 Kg. phosphoric acid per hectare, whereas the difference in height at 40 and 60 Kg. are on par. During the subsequent observations the effects due to the various levels are not significant.

The increase in height may be due to the increased rate of metabolic activity and rate of cell division brought about by phosphorus. The response of crops to phosphorus fertilization usually is greatest early in the season when the growth rate is high and decreases gradually as maturity is approached (Black, 1957). Further phosphorus is better utilised in early stages of growth of plants as has been reported by Yawalkar and Agarwal (1962) and this enhanced uptake of phosphorus might have resulted in increased utilization of nitrogen leading to an increase in vegetative growth.

The absence of increase in height noticed at higher level of 60 Kg P_2O_5 might be attributed to the fact that the growth of plants is not influenced by phosphorus beyond a certain limit (Black, 1957).

Potash has not significantly influenced the height at any stage. This may be due to the fact that the role played by potash in increasing the vegetative growth is less marked than the other two nutrients. Investigations conducted on similar crops to study the effect of potash on vegetative growth have also indicated only a very slight increase in height (Chhonkar and Singh, 1963). Chandrasekharan (1965) also observed that the application of potash at different levels has not significantly influenced the height of bhindi.

2. Branching

It can be seen from the results that the total number of branches produced per plant is significantly influenced by the application of increased doses of nitrogen. The mean number of branches produced per plant due to the application of nitrogen at the rate of 25, 50 and 75 Kg per hectare are 222.07, 279.12 and 324.06 respectively. Increase in the number of branches in chillies due to nitrogen application was reported by Mehrotra et al (1968). In the case of tomato

an increase in the number of branches was noticed by Barooah et al (1964) which is in agreement with the findings of the present investigation.

Branching in chilli plant is also influenced significantly by phosphate application. When the dose of phosphorus is increased from 20 to 40 Kg per hectare, there is a corresponding increase in the mean number of branches from 247.18 to 286.69. Application of phosphorus at 60 Kg per hectare has increased the number of branches to 291.38, even though this is on par with the immediate lower level. Vyas (1967) observed maximum vigour in chilli plants supplied with phosphorus. Mehrotra et al (1968) recorded significant decrease in branching in phosphorus deficient chilli plants. Barooah et al (1964) observed significant influence in all growth characters including branching in tomato due to phosphorus application. The result of this trial is also in accordance with the above findings.

The application of different levels of potash is not found to influence this character significantly. However, an increasing trend in branching has been noted with the application of incremental doses of potash. Mehrotra et al (1968) however, found that branching was significantly impaired by the deficiency of potassium. In the case of

tomato, Barooah et al (1964) observed that potash application increased the number of branches significantly. Experiments conducted by Patnaik and Farooqui (1964) also revealed that potash upto 40 lb per acre has got beneficial effects in increasing the number of branches.

3. Total dry weight per plant

Table 5 shows that the total dry weight per plant is considerably influenced by different nutrient doses. The graded doses of nitrogen have increased the weight of total dry matter, the response being linear upto the 75 Kg level. The mean weight of dry matter produced per plant at the different levels of nitrogen application viz. n_0, n_1 and n_2 are 49.2, 56.0 and 63.6 gm respectively. This finding is in conformity with the results of James et al (1967) who observed significant increase in the total dry matter and root and shoot yields due to increased nitrogen application. The application of increased doses of nitrogen has not only increased the plant height, but also increased the number of branches per plant. Thus the increased dry matter production at the higher levels of nitrogen may be attributed to the rank vegetative growth induced.

Phosphorus also influences significantly the dry

matter production, though the response is not so marked as that of nitrogen. The difference in response between the levels 20 Kg and 40 Kg phosphoric acid per hectare is statistically significant, while difference between 40 and 60 Kg is not significant. This increase in the total dry matter production may be due to the increase in height and number of branches per plant by the graded doses of phosphorus. Similar increases in dry weight were also reported by James et al (1967). Vyas (1967) noticed maximum vigour in chilli plants supplied with phosphorus.

Potash has no significant effect on this character even though an increasing trend is noticed with graded doses of potash application. Chhonkar and Singh (1963) reported that the growth and development of bhindi was not significantly influenced by potash.

4. Shoot/root ratio

It is evident from the results that nitrogen has significant effect in increasing this ratio while phosphorus and potash have no direct influence. Application of higher doses of nitrogen has given successively wider ratios indicating that shoot weight is enhanced more when compared to root growth thereby again showing the influence of nitrogen on shoot growth. Similar results were also obtained by

James et al (1967) who found that the response of graded doses of nitrogen on shoot growth was greater than that on the root growth.

Even though the direct effect of phosphorus on shoot/root ratio is not significant, there appears to be a trend in decreasing the ratio due to increased levels of phosphate application. This decrease in shoot/root ratio observed may be attributed to better development of roots by increased level of phosphate application (Buckman and Brady, 1960). This may also be due to an increased sugar availability in roots due to phosphorus thereby enhancing the growth of roots more than the shoots (Curtis and Clark, 1941) thus resulting in a decrease in the shoot/root ratio.

Shende (1962) also reported that root growth as measured in terms of dry weight per plant was enhanced with application of phosphorus in tomato.

It was noticed that potash has not influenced the shoot/root ratio. This may be due to the lack of response of potash on vegetative growth of plants as reported by Chhonkar and Singh (1963).

5. Earliness in flowering

From Table 7, it is seen that nitrogen has not

influenced earliness in flowering. Joachim et al (1939) reported that though nitrogen has a tendency to delay the maturity of chilli crop generally, it will not be the same always.

But in the case of application of different levels of phosphorus, there is a slight increase in earliness of flowering due to higher doses, even though it is not significant. Various workers have pointed out the influence of phosphorus in inducing earliness in flowering. Baker (1937), Tiessen (1957) and Gerieke (1966) observed early flowering and fruiting in tomato at higher levels of phosphorus application. Thus the trend noticed in the present investigation is in agreement with the above findings.

Potash is not found to influence the earliness in flowering. This may be due to the effect of nitrogen in offsetting the influence of potash in inducing earliness (Dastur, 1962). Chandrasekharan (1965) has also obtained similar result in bhindi.

6. Number of flowers

The result given in Table 8 shows that different levels of nitrogen have significant effect in increasing the flower production. The responses due to 50 and 75 Kg

levels are significantly superior to 25 Kg level of nitrogen application. The result of the present investigation is in conformity with the results of James et al (1967) who have reported that the number of buds and flowers is significantly increased with the application of nitrogen. Plants supplied with graded doses of nitrogen have produced corresponding increases in the number of buds. Mehrotra et al (1968) also observed that the deficiency of nitrogen adversely affected the production of flowers in chilli. Assami and Kodata (1933) found, increased flower production in brinjal with increasing levels of nitrogen. The effect of nitrogen in increasing flower production is found to be linear upto the maximum level of 75 Kg per hectare tried in the present investigation.

Table 8 shows significant increase in flower production due to application of graded doses of phosphorus. Phosphorus at the levels of 40 Kg per hectare is significantly superior to 20 Kg level and is on par with 60 Kg. An adequate supply of phosphorus early in the life of the plant is important in laying down the flower primordia for the reproductive parts of the plant (Tisdale and Nelson, 1965). Mehrotra et al (1968) found adverse effects of phosphorus deficiency in flower production in this crop.

Potash has increased the flower production appreciably. Mehrotra et al (1968) noticed that deficiency of potash caused significant reduction in the flower production in chilli.

Though the combined application of the various nutrients has no significant effect on flower production, the maximum number of 343.77 flowers per plant is produced by the combination n_2p_1. This may be due to the individual effects of higher level of nitrogen and the p_1 level of phosphorus.

7. Number of pods per plant

The result (Table 9) clearly shows the beneficial influence of nitrogen in increasing the number of pods produced per plant. The higher levels of the nutrient have given significantly higher number of pods over the lowest level of 25 Kg nitrogen per hectare. The mean number of pods produced per plant under the various levels of 25, 50 and 75 Kg nitrogen per hectare are 92.68, 122.18 and 139.21 respectively. Similar results in increasing the number of pods per plant by increased doses of nitrogen have been reported by workers like James et al (1967) in the case of chilli and by Shende (1962) and Barooah et al (1964) in tomato.

The influence of phosphorus in increasing the pod production in chillies is found to be significant upto the 60 Kg per hectare level of its application. Increased fruit production due to phosphorus application has been reported by Vyas (1967) and Mehrotra et al (1968) in chillies.

Potash has also significantly increased the production of pods upto the 40 Kg K_2O per hectare, but the effect is less pronounced than that of nitrogen and phosphorus. The effect of potash in increasing the number of pods per plant in chilli has been reported by Mehrotra et al (1968). Patnaik and Farooqui (1964) have also reported the desirable effect of potash in increasing the number of fruits in brinjal.

8. Setting percentage

It is evident from Table 10, that nitrogen has a profound influence in increasing the setting percentage in chillies. Nitrogen at 75 Kg per hectare has given the maximum setting percentage followed by 50 Kg nitrogen. The 50 Kg level is significantly superior to 25 Kg even though it is on par with 75 Kg. This increase in the setting percentage by the application of nitrogen is due to the

increase in number of pods produced by this nutrient as is seen from Table 9. Similar results regarding the effects of nitrogen have been reported by several workers. Maynard (1962) in his studies on capsicum has recorded a high percentage of fruit setting by application of nitrogen. Patnaik and Farooqui (1964) and Shende (1962) obtained similar results in brinjal and tomato respectively.

In the case of phosphorus also there is significant increase in fruit setting upto 40 Kg P_2O_5/ha. The difference between 40 Kg and 60 Kg levels is not significant though the 60 Kg level has given the maximum setting percentage. Since phosphorus has been considered essential for seed formation and found in large quantities in seeds and fruits (Tisdale and Nelson, 1965), this element might have influenced the fruit formation in this crop. Similar results have also been reported by Tiessen (1957) in tomatoes and Patnaik and Farooqui (1964) in brinjal.

The effect of potash in increasing the setting percentage in chillies is not found to be significant, though there is an increasing trend upto the level of 40 Kg per hectare. The lack of significant response due to potash application may be due to the uniform rate of increase in flower and pod production by this nutrient, whereby the

setting percentage is not altered much by the different rates of potash. Increases in setting percentage in crops like brinjal have been reported by Patnaik and Farooqui (1964).

9. Yield of chilli pods

The results (Table 11) show that graded doses of nitrogen have given significant increase in yield of chilli pods. The mean yields per hectare of dry chillies under the different levels of 25, 50 and 75 Kg nitrogen are 717.22, 944.65 and 1483.67 Kg respectively. The percentage increase in yield obtained due to the application of 50 Kg nitrogen per hectare over 25 Kg is 31.7 and that of 75 Kg over 50 Kg is 57.6. The influence of nitrogen in increasing the yield of chillies has been proved conclusively on the basis of trials conducted by Maynard (1962), Relwani (1963), Murty and Murty (1963), Arora et al (1965), Dhulappanawar (1965), Morani et al (1965) and James et al (1967).

The beneficial effects of graded doses of nitrogen in increasing the height, branching, number of flowers, setting percentage, number of fruits and weight of pods might have together contributed to an increase in yield. The relatively low response at the lower level of nitrogen may be due to the insufficiency of added nitrogen coupled

with the low nitrogen status of the soil and the relatively higher requirement of the crop for nitrogen.

The linear nature of the response of nitrogen even at the highest level tried in this investigation indicates that the yield can be increased by adding still higher doses. Ramanathan (1965) reported that the chilli can give economically higher yields upto 120 lb nitrogen per acre under irrigated condition.

It is also seen that phosphate fertilization enhances the yield of pods significantly. But the magnitude of response is much lower than that of nitrogen. There is a linear increase in yield from 20 Kg level to 60 Kg level which is statistically significant. Application of phosphoric acid at 20, 40 and 60 Kg per hectare, has given the average yield of 939.18, 1045.55 and 1160.73 Kg respectively.

The linear response of phosphorus even at the highest level tried in this investigation also indicates that yield can be increased by adding still higher doses.

Increases in yield due to phosphate application were observed by Purewal (1954), Relwani (1963), Morani et al (1965), James et al (1967) and Vyas (1967). In tomato also similar increases in yield due to phosphorus fertilization

had been reported by Pudelski (1960), Shende (1962), Yokoi et al (1962), Sharma and Singh (1963) and Winsor (1967).

It is evident from the results that graded doses of potash have no significant effect in increasing the yield of chilli pods. The average yield of dry pods per hectare due to 20, 40 and 60 Kg potash are 1014.04, 1036.73 and 1094.78 Kg respectively. Though the differences are not significant there appears to have a trend to increase yield due to application of graded doses of potash.

This is in agreement with the findings of Joachim and Paul (1938) and Dhulappanawar (1965).

The additional increases in yield due to combined application of nutrients have not been found significant. However, the highest yield of 1648.33 Kg dry pod per hectare has been recorded as a result of the combined application of 75 Kg nitrogen and 60 Kg phosphoric acid whereas the individual mean yields are 1483.67 and 1160.73 Kg respectively. This is in conformity with the findings of Relwani (1963) who has stated that application of 80 lb nitrogen plus 80 lb phosphoric acid over a basal dressing of 250 md of cattle manure resulted in high yields in chilli. Similar results were also reported from Guntur (Anon. 1954) and in Pepsu (Panikkar, 1960).

Among the nitrogen and potash combinations, the maximum yield of 1553.71 Kg dry pod is recorded by 75 Kg nitrogen and 60 Kg potash whereas their individual means are 1483.67 Kg and 1094.78 Kg respectively. Among the combinations of all the 3 nutrients, the highest yield of 1824.49 Kg per hectare dry pod is obtained by the application of 75 Kg nitrogen 60 Kg phosphoric acid and 60 Kg potash per hectare.

Several workers like Cazi (1961), Murty and Murty (1963), Dhulappanawar (1965) and Pillay (1967) have reported increased yields by balanced application of these 3 nutrients.

This increase in yield obtained in this study due to application of NPK may be due to more efficient utilization of the applied nitrogen by chilli crop when it is supplemented with adequate quantities of phosphorus and potash as reported by Ramanathan (1965) and Chadha (1967). They also observed that combined application of these nutrients was important for maintaining the fertility of the soil.

10. Length of fruits

An examination of the Table 12 reveals that the

effects of nutrients nitrogen, phosphorus and potash are not significant in influencing the length of fruit. Murty and Murty (1963) found that the length of pod did not vary due to application of nitrogen in chillies. This may be due to the fact that the fruit length is mainly a varietal character and is not much influenced by fertilizer treatments.

11. Girth of fruits

The various doses of the different nutrients either individually or in combination have not influenced the girth of fruits. Similar results have been reported by Murty and Murty (1963). This can also possibly be attributed to the fact that the girth of pods in chillies is governed mainly by genetic factors.

12. 100 pods weight

The results indicate that the effects of the doses of nitrogen and potash on the weight of 100 pods are significant. By increasing the doses of nitrogen from 25 Kg to 50 and 75 Kg levels, significant increases in the weight of pods are obtained. Such increases in pod weight can be attributed to the succulence and plumpiness of the fruits and to the increased rate of synthesis of carbohydrates at

higher levels of nitrogen application. Similar result in increasing the pod weight due to increased doses of nitrogen has been reported by Murty and Murty (1963).

Phosphorus does not show any increase in the 100 pod weight in chillies even though the yield is found to be influenced by this nutrient significantly. This increase in yield is due to the increase in the number of pods and not due to an increase in pod weight. As is expected, phosphorus might have played a significant role in increasing the pod set and thereby the pod number, and does not have any effect on pod weight.

There is an increase in pod weight due to application of higher doses of potash. This may possibly be due to the role of potash in the formation and translocation of carbohydrates as reported by Tisdale and Nelson (1965) thereby resulting an increase in pod weight.

13. Economics of manuring

Joachim and Paul (1938) and Ramanathan (1965) stated that application of fertilizer to chilli is justified by increased yields. In the present investigation also application of fertilizers has increased the yield. Maximum increase in yield is noticed due to application

of nitrogen especially at higher level.

With the levels of nutrients tried under the present investigation, the response in yield is found to be linear, and compared to the cost of fertilizers, the increase in yield is found to be highly profitable.

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

An investigation was undertaken in the red loam soils of the farm attached to the Agricultural College and Research Institute, Vellayani during 1967-68 to study the effects of graded doses of nitrogen (25, 50 and 75 Kg per hectare), phosphorus (20, 40 and 60 Kg per hectare) and potash (20, 40 and 60 Kg per hectare) in factorial combinations, on the growth, yield and quality of a popular variety of chilli "South Malabar". A 3^3 partially confounded factorial experiment was laid out with 27 treatment combinations.

Characters like height, branching, total dry weight per plant, shoot/root ratio, earliness in flowering, flower production, pod production, setting percentage, yield of pods, length of pods, girth of pods and weight of 100 pods were studied. The results obtained in the investigation are summarised below.

1. Plant height was significantly increased by the application of nitrogen and the increase was linear.

Phosphorus increased plant height significantly in the early stages. Potash had no influence in increasing the height of plants.

2. Branching was significantly increased by nitrogen and phosphorus. The maximum number of branches was noticed in the treatment combination of 75 Kg nitrogen and 60 Kg phosphorus per hectare. Potash had no significant influence on branching.

3. Higher doses of nitrogen and phosphorus significantly increased the total weight of dry matter produced per plant.

4. The shoot/root ratio was increased significantly by graded doses of nitrogen while a decrease in the ratio was noticed due to increased application of phosphorus though it was not significant. Potash did not influence shoot/root ratio.

5. No significant change in the earliness of flowering was noticed due to any of the nutrients.

6. Nitrogen and phosphorus increased significantly the flower production in chilli.

7. The total number of pods produced per plant

was significantly increased by increased doses of all the three nutrients in this crop.

8. Application of graded doses of nitrogen upto 50 Kg and phosphorus upto 40 Kg per hectare increased the setting percentage significantly, beyond which the increase was not significant.

9. The yield of dry pods was increased significantly by the application of graded doses of nitrogen and phosphorus. Potash was not found to influence the yield of pods to a significant extent. Among all the treatment combinations tried, application of 75 Kg nitrogen, 60 Kg phosphoric acid and 60 Kg potash recorded the maximum yield of 1824.49 Kg dry pods per hectare.

10. The length of fruit was not seen influenced by any of the treatments.

11. Application of graded doses of nitrogen, phosphorus and potash had not influenced the girth of pods.

12. The weight of 100 pods was increased by graded doses of nitrogen and potash.

13. Application of nitrogen at higher levels was

found to be highly profitable and economical followed by phosphorus and potash.

The progressive increase in yield due to graded doses of NPK fertilization noticed in the present investigation emphasises the need for further studies using still higher levels of these nutrients for determining the optimum and economic doses for this crop.

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* Original not seen

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APPENDICES

APPENDIX I

HEIGHT OF PLANT ON 40TH DAY

(Analysis of variance)

Source	SS	DF	Variance	F
Total	1574.50	53		
Block	170.90	5	34.18	3.7192 *
N	846.30	2	423.15	46.0446 **
P	97.00	2	48.50	5.2774 *
N x P	22.90	4	5.72	<1
K	6.00	2	3.00	<1
N x K	45.70	4	11.42	1.2426
P x K	53.90	4	13.47	1.4657
NPK	85.50	2	42.75	4.6518 *
NPK^2	21.50	2	10.75	1.1697
NP^2K	8.10	2	4.05	<1
NP^2K^2	14.60	2	7.30	<1
Error	202.10	22	9.19	

* Significant at 5% level

** Significant at 1% level

APPENDIX II

HEIGHT OF PLANT ON 80TH DAY

(Analysis of variance)

Source	SS	DF	Variance	F
Total	3435.30	53		
Block	480.10	5	96.02	1.4875
N	1216.10	2	608.05	9.4198 **
P	85.30	2	42.65	<1
N x P	60.10	4	15.02	<1
K	34.20	2	17.10	<1
N x K	15.70	4	3.92	<1
P x K	58.50	4	14.62	<1
NPK	1.90	2	0.95	<1
NPK^2	11.02	2	5.50	<1
NP^2K	42.80	2	21.40	<1
NP^2K^2	9.40	2	4.70	<1
Error	1420.20	22	64.55	

** Significant at 1% level

APPENDIX III

HEIGHT OF PLANT ON 120TH DAY

(Analysis of variance)

Source	SS	DF	Variance	F
Total	3404.50	53		
Block	49.50	5	9.90	2.3131
N	2960.30	2	1480.15	345.8295 **
P	22.70	2	11.35	2.6519
N x P	135.20	4	33.75	7.8855 **
K	16.00	2	8.00	1.8692
N x K	10.20	4	2.55	< 1
P x K	77.70	4	19.42	4.5374 **
NPK	8.10	2	4.05	< 1
NPK^2	2.40	2	1.20	< 1
NP^2K	17.80	2	8.90	2.0794
NP^2K^2	10.50	2	5.25	1.2266
Error	94.10	22	4.28	

** Significant at 1% level

APPENDIX IV

NUMBER OF BRANCHES PER PLANT

(Analysis of variance)

Source	SS	DF	Variance	F
Total	134784.00	53		
Block	2736.50	5	547.30	1.3657
N	94056.50	2	47028.25	117.3506 **
P	21220.50	2	10610.25	26.4760 **
N x P	293.00	4	73.25	< 1
K	2514.10	2	1257.05	3.1367
N x K	768.50	4	192.12	< 1
P x K	725.20	4	181.30	< 1
NPK	78.30	2	39.15	< 1
NPK^2	219.50	2	109.75	< 1
NP^2K	2689.10	2	1344.55	3.3551
NP^2K^2	666.20	2	333.10	< 1
Error	8816.60	22	400.75	

** Significant at 1% level

APPENDIX V

TOTAL DRY WEIGHT PER PLANT

(Analysis of variance)

Source	SS	DF	Variance	F
Total	2200.90	53		
Block	44.70	5	8.94	2.5542
N	1868.30	2	934.15	266.9000 **
P	118.90	2	59.45	16.9857 **
N x P	33.80	4	8.45	2.4142
K	18.60	2	9.30	2.5571
N x K	16.30	4	4.07	1.1628
P x K	3.10	4	0.78	<1
NPK	13.30	2	6.65	1.9000
NPK^2	2.50	2	1.25	<1
NP^2K	3.40	2	1.70	<1
NP^2K^2	1.10	2	0.55	<1
Error	77.90	22	3.50	

** Significant at 1% level

APPENDIX VI

SHOOT/ROOT RATIO

(Analysis of variance)

Source	SS	DF	Variance	F
Total	1.8834	53		
Block	0.0641	5	0.0125	< 1
N	0.4767	2	0.2383	5.4531 *
P	0.1073	2	0.0536	1.2265
N x P	0.0116	4	0.0029	< 1
K	0.0566	2	0.0283	< 1
N x K	0.0212	4	0.0053	< 1
P x K	0.0503	4	0.0126	< 1
NPK	0.0231	2	0.0115	< 1
NPK^2	0.0264	2	0.0132	< 1
NP^2K	0.0463	2	0.0231	< 1
NP^2K^2	0.0385	2	0.0192	< 1
Error	0.9613	22	0.0437	

* Significant at 5% level

APPENDIX VII

EARLINESS IN FLOWERING

(Analysis of variance)

Source	SS	DF	Variance	F
Total	2.646	53		
Block	0.059	5	0.0118	< 1
N	0.077	2	0.0385	< 1
P	0.401	2	0.2005	2.84
N x P	0.221	4	0.0552	< 1
K	0.006	2	0.0030	< 1
N x K	0.043	4	0.0107	< 1
P x K	0.040	4	0.0100	< 1
NPK	0.002	2	0.0010	< 1
NPK^2	0.011	2	0.0055	< 1
NP^2K	0.117	2	0.0585	< 1
NP^2K^2	0.116	2	0.0580	< 1
Error	1.553	22	0.0706	

APPENDIX VIII

NUMBER OF FLOWERS PER PLANT

(Analysis of variance)

Source	SS	DF	Variance	F
Total	125691.22	53		
Block	5623.40	5	1124.68	4.4681 **
N	89612.39	2	44806.19	178.0072 **
P	18955.82	2	9477.91	37.6541 **
N x P	1409.58	4	352.39	1.4000
K	1108.12	2	554.06	2.2012
N x K	629.92	4	157.48	< 1
P x K	584.05	4	146.01	< 1
NPK	631.30	2	315.65	1.2540
NPK^2	1064.22	2	532.11	2.1140
NP^2K	726.24	2	363.12	1.4426
NP^2K^2	8.64	2	4.32	< 1
Error	5537.54	22	251.71	

** Significant at 1% level

APPENDIX IX

NUMBER OF PODS PER PLANT

(Analysis of variance)

Source	SS	DF	Variance	F
Total	28386.60	53		
Block	2077.30	5	415.46	16.99 **
N	19962.90	2	9981.45	408.24 **
P	5111.40	2	2555.70	104.52 **
N x P	286.00	4	71.50	2.92 *
K	249.10	2	124.55	5.09 *
N x K	59.70	4	14.75	< 1
P x K	27.10	4	6.77	< 1
NPK	53.10	2	26.55	1.08
NPK^2	2.60	2	1.30	< 1
NP^2K	16.90	2	8.45	< 1
NP^2K^2	2.40	2	1.20	< 1
Error	538.10	22	24.45	

* Significant at 5% level

** Significant at 1% level

APPENDIX X

SETTING PERCENTAGE

(Analysis of variance)

Source	SS	DF	Variance	F
Total	285.21	53		
Block	31.71	5	6.34	3.4270
N	57.63	2	28.81	15.5729 **
P	41.23	2	20.61	11.1405 **
N x P	41.01	4	10.25	5.5405 **
K	2.28	2	1.14	< 1
N x K	9.34	4	2.33	1.2594
P x K	10.54	4	2.64	1.4270
NPK	21.96	2	10.98	5.9189 **
NPK^2	19.10	2	9.55	5.1621 *
NP^2K	7.93	2	3.97	2.1459
NP^2K^2	1.83	2	0.91	< 1
Error	40.65	22	1.85	

* Significant at 5% level

** Significant at 1% level

APPENDIX XI

YIELD OF DRY CHILLI PODS PER PLOT

(Analysis of variance)

Source	SS	DF	Variance	F
Total	12.7024	53		
Block	2.1037	5	0.4207	7.85 **
N	8.3707	2	4.1853	78.08 **
P	0.6633	2	0.3317	6.18 **
N x P	0.0625	4	0.0156	< 1
K	0.0937	2	0.0469	< 1
N x K	0.0144	4	0.0036	< 1
P x K	0.0653	4	0.0163	< 1
NPK	0.0029	2	0.0014	< 1
NPK^2	0.0607	2	0.0303	< 1
NP^2K	0.0378	2	0.0189	< 1
NP^2K^2	0.0469	2	0.0234	< 1
Error	1.1805	22	0.0536	

** Significant at 1% level

APPENDIX XII

LENGTH OF PODS

(Analysis of variance)

Source	SS	DF	Variance	F
Total	4.9642	53		
Block	0.1702	5	0.0340	< 1
N	0.2125	2	0.1062	1.0162
P	0.1183	2	0.0592	< 1
N x P	0.0977	4	0.0244	< 1
K	0.0053	2	0.0027	< 1
N x K	0.2018	4	0.0505	< 1
P x K	1.2859	4	0.3215	3.0765 *
NPK	0.0425	2	0.0212	< 1
NPK^2	0.0011	2	0.0005	< 1
NP^2K	0.3459	2	0.1729	1.6545
NP^2K^2	0.1840	2	0.0920	< 1
Error	2.2990	22	0.1045	

* Significant at 5% level

APPENDIX XIII

GIRTH OF PODS

(Analysis of variance)

Source	SS	DF	Variance	F
Total	0.3292	53		
Block	0.0717	5	0.0143	2.1000
N	0.0089	2	0.0044	< 1
P	0.0070	2	0.0035	< 1
N x P	0.0197	4	0.0049	< 1
K	0.0043	2	0.0022	< 1
N x K	0.0153	4	0.0038	< 1
P x K	0.0063	4	0.0016	< 1
NPK	0.0100	2	0.0050	< 1
NPK^2	0.0065	2	0.0033	< 1
NP^2K	0.0285	2	0.0143	2.0900
NP^2K^2	0.0009	2	0.0005	< 1
Error	0.1501	22	0.0068	

APPENDIX XIV

WEIGHT OF 100 PODS

(Analysis of variance)

Source	SS	DF	Variance	F
Total	255.10	53		
Block	27.10	5	5.420	1.7382
N	75.80	2	37.900	12.1552 **
P	0.70	2	0.350	< 1
N x P	2.30	4	0.575	< 1
K	25.20	2	12.600	4.0410 *
N x K	12.80	4	3.200	1.0262
P x K	11.50	4	2.875	< 1
NPK	4.10	2	2.0500	< 1
NPK^2	14.30	2	7.150	2.2931
NP^2K	6.40	2	3.200	1.0262
NP^2K^2	6.30	2	3.150	1.0102
Error	68.60	22	3.118	

* Significant at 5% level

** Significant at 1% level