NUTRIENT MANAGEMENT IN VEGETABLE CHILLI [Capsicum annuum] VARIETY JWALA SAKHI

by
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THESIS
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DECLARATION

I hereby declare that this thesis entitled "Nutrient management in vegetable chilli (*Capsicum annuum*) variety Jwala Sakhi" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of this or any other University or Society.

SAJI JOHN

Vellayani,
15-05-1989.

CERTIFICATE

Certified that this thesis entitled "Nutrient management in vegetable chilli (Capsicum annuum) variety Jwala Sakhi" is a bonafide record of research work done independently by Mr. Saji John, under my guidance and supervision and that this has not previously formed the basis for the award of any degree, diploma, fellowship or associateship to him.

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INTRODUCTION

1. INTRODUCTION

The food and nutrition situation in many developing countries will not present a pleasant picture when the human race steps into the 21st century. This is especially true with reference to India, where, the food production can hardly keep pace with the ever increasing population. Moreover, the available land resources have almost reached a plateau in terms of arability. The only alternative to meet the food requirements of the growing population is to make maximum exploitation of land resources through intensive cultivation of such crops which grow quickly and give high yields per unit area.

Most of the vegetables, if properly grown, can yield 5 to 10 times higher than any cereal crop. Besides, for a healthy and productive nation, one should not only to consider increasing the food production, but also assure a balanced diet to the people. Indian rural diet is not yet balanced in both quality and calorific values.

Though Indian population is predominantly vegetarian, the vegetable production has not made adequate progress. Considering the special relevance of vegetables in Indian diet, and the higher economics they possess, our vegetable cultivation must be given the much deserving thrust.

At present the area under vegetables in India works out to hardly 2% of the total cropped area. We produce only 45 mt of vegetables, whereas our national requirement is more than 98 mt, calculated on the basis of 280 g/day/person, by the dieticians. In Kerala, the per capita consumption of vegetables is a low 8.3 kg/year with the national average of 54.7 kg. At present, the State depends on neighbouring States Tamil Nadu, Karnataka and Andhra Pradesh for a major part of its vegetable requirement (Anon., 1988). A planned development in the field of vegetable production will not only improve the nutritional requirement of the masses, but can also meet the challenge of adequate food supply to the growing population in our country.

Chilli (*Capsicum annuum* L), one of the most important solanaceous vegetables has got a pre-eminent position among the minor crops of India. It is an indispensable adjunct to the diet of the people. Chilli imparts pungency for culinary purpose and is used for adding red colour and seasoning. It is a rich source of vitamin C in its fresh state. The pungency is due to the active principle capsaicin. Extracts of chillies are used in the manufacture of ginger beer and other beverages. Capsicum oleoresin is a powerful stimulant and carminative.

The geographical distribution of this crop extends to tropical and sub tropical parts of a number of countries in the world. Its adaptability to varying agro-climatic situations makes it suitable for growing in almost all regions in India. It is practically grown all over India and there is not a single household in the country in which it is not utilized in one form or the other.

India is one of the leading producers of chilli accounting for about 50% of the world's share both in area and production. The area under cultivation of chilli in India is about 9.041 lakh ha, with an annual production of 7.8 lakh tonnes. India exports 43,200 tonnes of dry chillies, fetching an amount of Rs.49.98 crores as foreign exchange (Anon., 1984).

The principal chilli growing states in India are Andhra Pradesh, Maharashtra, Karnataka, Orissa and Tamil Nadu which cover 75% of the country's area and production under this crop. In Kerala, it is cultivated commercially in an area of about 1000 ha with a production of 1000 tonnes of dry chilli (Anon., 1984). Besides in every homestead a small area is occupied by this crop. The agro-climatic conditions of many parts of the state are quite conducive for the expansion of this crop. Moreover, with the increase in population and demand, there is every need to step up the production of chillies. Recently more attention is being paid to increase the production of vegetable chilli.

Jwala Sakhi, is a newly developed high yielding vegetable chilli variety, by the Kerala Agricultural University. It has resulted from a cross between Vellanotchi, a popular local cultivar of southern Kerala and Pusa jwala. It is ideal for culinary purpose. The pungency is low and the vitamin C content is high. It is also ideal for high density planting.

Chilli is a fertilizer responsive crop and it requires a good nutrient supply. However, nutrient management studies on this crop are meagre especially for the improved varieties that have been recently released. In order to exploit the maximum production potential from the chilli variety Jwala sakhi, its nutrient management has to be standardised. The present study envisages the management of three major nutrients for this variety with the following objectives.

1. To find out the effects of nitrogen, phosphorus and potassium on the growth, yield and quality of vegetable chilli variety Jwala Sakhi.
2. To find out the optimum nitrogen, phosphorus and potassium requirements for high yields from the crop.
3. To work out the economics of cultivation of the chilli variety Jwala Sakhi under varying nutrient levels.

REVIEW OF LITERATURE

2. REVIEW OF LITERATURE

A brief review of research work done on the effect of different levels of nitrogen, phosphorus and potassium on the growth, yield, quality and nutrient uptake of chilli is presented below.

2.1. Effect of Nitrogen

2.1.1. Effect of Nitrogen on growth characters

2.1.1.1. Height of plant

Mohamed Kunju (1968) observed a linear increase in plant height by the application of nitrogen. Lal and Pundrik (1971) reported that an increase in the level of nitrogen from 0 to 100 kg/ha resulted in a sequential increase in plant height. According to Alagai Pillai et al. (1977) plants receiving the highest dose of 150 kg N/ha were taller, and was followed by those receiving 120 kg N/ha. Rajagopal et al. (1977) observed a progressive increase in plant height with the nitrogen levels. Joseph (1982) from his experiment on chilli for two seasons concluded that, incremental doses of nitrogen increased the height of plants at all the stages of observations in both the seasons. Similar effects of nitrogen were also observed by Subbiah (1983), Sundstrom et al. (1984); Paraminder Singh et al. (1986); Hegde (1986) Prabhakar et al. (1987) and Shukla et al. (1987).

2.1.1.2. No. of branches/plant

Mehrotra et al. (1968) observed significantly reduced branching in chilli crop by the deficiency of nitrogen. Mohamed Kunju (1968) reported that branching was significantly increased by nitrogen application. Increased number of branches with increased nitrogen application was also recorded by Gill et al. (1974), Rajagopal et al. (1979), Ramachandran and Subhiah (1980), Joseph (1982), Paraminder Singh et al. (1986); and Prabhakar et al. (1987).

However, according to Shukla et al. (1987), the number of branches was not affected by nitrogen.

2.1.1.3. Dry matter production

James et al.(1967) obtained increased total dry matter production in chillies due to application of nitrogen. Mohamed Kunju (1968) showed that, higher doses of nitrogen significantly increased the total weight of dry matter produced per plant. Rajendra Prasad and Subramaniam (1978) have experienced a higher dry matter production in chillies in vegetative and maturity phases by the soil application of N especially in early stages. Chougule and Mahajan (1979) observed that the dry matter content of leaves, branches and fruits were significantly influenced due to higher and medium doses of nitrogen application. A positive correlation between nitrogen application and total dry matter production was also observed by Joseph (1982), Dod et al. (1983), Paraminder Singh et al. (1986) and Manchanda and Bhopal Singh (1987).

2.1.1.4. Shoot-Root Ratio

James et al. (1967) observed that 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. According to Mohamed Kunju (1968), the shoot-root ratio increased significantly by graded doses of nitrogen.

2.1.2. Effect of nitrogen on time of flowering, yield attributes and yield

2.1.2.1. Time of flowering

Ivanic (1957) observed that nitrogen delayed flowering and prolonged the growing season in chillies. Gill et al. (1974) revealed that number of days to flowering was increased by nitrogen. Rajagopal et al. (1977) indicated that nitrogen influenced the duration to flowering, since it prolonged the vegetative phase. Rao and GulshanLal (1986) observed a significant increasing trend for number of days to 50% flowering with the increasing levels of nitrogen upto 150 kg/ha. However, Mohamed Kunju (1968) pointed out that there was no significant change in the earliness of flowering due to nitrogen. Khan and Suryanarayana (1977) found that nitrogen made little difference in the number of days to flowering. Chougule and Mahajan (1979) indicated that the days required for flowering initiation and 50% flowering were affected significantly only at higher dose of nitrogen ie., 200 kg N/ha.

2.1.2.2. No. of flowers/plant

James _et al_. (1967) found that the number of buds and flowers was significantly increased with the application of nitrogen. Mehrotra _et al_. (1968) observed that deficiency of nitrogen adversely affected the production of flowers. Mohamed Kunju (1968) reported that nitrogen increased significantly the flower production in chilli. Similar effect of nitrogen in increasing the number of flowers was also reported by Dass and Mishra (1972).

2.1.2.3. No. of pods/plant

The total number of pods produced per plant were significantly increased by increased dose of nitrogen (Mohamed Kunju, 1968). Gill _et al_. (1974) observed that number of fruits per plant was significantly influenced by varying levels of nitrogen. Khan and Suryanarayana (1977) summarising the results of the manurial experiments on chillies reported that pod number was highest with 120 kg

N/ha. Similar results were reported by Chougule and Mahajan (1979); Joseph (1982) and Shukla *et al*. (1987).

2.1.2.4. Setting percentage of fruits

Maynard (1962) observed an increasing trend in setting percentage by the application of nitrogen. According to Mohamed Kunju (1968), there was an increased fruit setting by the application of nitrogen at 75 kg/ha over a rate of 25 kg/ha. Significant increase in setting percentage by the application of graded doses of nitrogen was also reported by Joseph (1982).

2.1.2.5. Length and Girth of pods

A direct relationship between nitrogen application and fruit length was reported by Lal and Pundrik (1971). According to Chougule and Mahajan (1979), length of fruits was significantly increased due to higher and medium levels of nitrogen. According to Joseph (1982) application of graded doses of nitrogen up to 75 kg/ha increased the length and girth of pods. Dod *et al*. (1983) also observed an increase in length of fruits with increase in N levels.

However, according to Mohamed Kunju (1968), the length and girth of pods were not influenced by nitrogen.

2.1.2.6. 100 pod weight

The weight of 100 pods was increased by graded doses of nitrogen (Mohamed Kunju, 1968). Ramachandran and Subbiah (1980) observed that, the weight of 100 fruits increased generally with nitrogen. Joseph (1982) also reported similar effect of nitrogen on 100 pod weight.

2.1.2.7. Total yield of chillies

Mohamed Kunju (1968) observed significant increase in the yield of dry pods by the application of graded doses of nitrogen. Lal and Pundrik (1971) from their investigations concluded that increasing levels of nitrogen increased the yield of dry chillies from 35.6 q to 63.4 q. Iruthayaraj and Kulandaivelu (1973) observed that chilli responded to nitrogen upto 120 kg/ha. Selvaraj et al. (1973) showed that with the increase in nitrogen application from 35 kg/ha to 70 kg/ha, the yield increased by about 30%.

Alagai Pillai et al. (1977) indicated that nitrogen at 120 kg/ha produced significantly higher mean dry pod yield, registering a 80.6% increase over control. According to Joseph (1982), the yield of dry pods was significantly increased by the application of graded doses of nitrogen upto 112.5 kg/ha. According to Srinivas and Prabhakar (1982), nitrogen application increased the mean fruit yield upto 150 kg N/ha. Narasappa et al. (1985) revealed that the yield of green fruits rose with the nitrogen rate to a maximum of 170.7 q/ha at 150 kg N/ha and then declined to 157.4 q/ha at

250 kg N/ha. Hegde (1986) reported that nitrogen fertilization increased fruit fresh and dry weights upto 180 kg N/ha. Similar increasing trend in yield with the graded levels of nitrogen was reported by many workers (Paraminder Singh et al., 1986; Manchanda and Bhopal Singh, 1987; Prabhakar et al., 1987; Shukla et al., 1987 and Ramarao et al., 1988).

However, Rajagopal et al. (1979) revealed that with medium level of N in soil and application of farmyard manure, chilli did not respond to applied nitrogen.

2.1.3. Effect of nitrogen on fruit ascorbic acid content

Dass and Mishra (1972) observed that there was an increase in the fruit ascorbic acid content with nitrogen application. Coverelli (1976) found increased ascorbic acid content of fruits with increase in nitrogen application. Kopec and Stevlikova (1977) reported that the ascorbic acid content is affected by fertilization and was averaged around 160 mg/100 g fresh weight. Khan and Suryanarayana (1977) found that fruit ascorbic acid content was increased by nitrogen application to a maximum of 54.5 mg/100 g pod. Joseph (1982) revealed that incremental doses of nitrogen significantly increased the ascorbic acid content of fruits.

Dod et al. (1983) observed profound effect of nitrogen fertilization on the ascorbic acid content of fruits.

Paraminder Singh et al. (1986) showed that vitamin C content was increased with enhanced levels of nitrogen and the response was linear upto 90 kg N/ha. Manchanda and Bhopal Singh (1987) reported that vitamin C content in bell pepper increased significantly with incremental rates of nitrogen and ranged from 55.42 mg/100 g of fruit at 0 kg N to 97.12 mg/100 g of fruit at 160 kg N/ha.

However, Sinha (1975) showed that every increase in nitrogen dose decreased the vitamin C content of fresh chilli fruits.

2.2. Effect of phosphorus

2.2.1. Effect of phosphorus on growth characters

2.2.1.1. Height of plant

James et al. (1967) obtained increased height of plant with phosphorus application. Mohamed Kunju (1968) observed that phosphorus increased plant height significantly in the early stages. Joseph (1982) noted increased height of plants by application of graded doses of phosphorus.

However, Prabhakar et al. (1987) and Shukla et al. (1987) found that plant height was not influenced by phosphorus fertilization.

2.1.2. No. of branches/plant

Phosphorus application increased the number of branches per plant (James et al., 1967). Mehrotra et al. (1968) found that branching was significantly impaired in chilli crop by the deficiency of phosphorus. Mohamed Kunju (1968) observed the maximum number of branches with 60 kg phosphorus per hectare. Similar beneficial effects of phosphorus in increasing the plant height in chilli were reported by many workers (Chougule and Mahajan, 1979; Joseph, 1982).

However, Prabhakar et al. (1987) showed that P-fertilization did not affect the number of branches in chilli cv.G_3. Shukla et al. (1987) also revealed that number of branches was not affected by phosphorus.

2.2.1.3. Dry matter production

Higher doses of phosphorus significantly increased the total weight of dry matter produced by plant (Mohamed Kunju, 1968). According to Chougule and Mahajan (1979), the dry matter content of leaves, branches and fruits were significantly increased due to graded levels of phosphorus. Joseph (1982) also reported similar effect of phosphorus on dry matter production in chilli.

2.2.1.4. Shoot-Root Ratio

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

However, according to Mohamed Kunju (1968), there was a decrease in the shoot-root ratio due to increased application of phosphorus though it was not significant.

2.2.2. Effect of phosphorus on time of flowering, yield attributes and yield

2.2.2.1. Time of flowering

Gill et al. (1974) showed that phosphorus doses decreased the mean days required for flowering from 47.17 to 42.67 with 187.5 kg P_2O_5 per hectare. Covarelli (1976) observed that, phosphorus increased the number of earliest fruits in chillies. Khan and Suryanarayana (1977) also reported that number of days to flowering was reduced from 60 to about 53 and 45 by phosphorus at 45 and 90 kg/ha respectively. Joseph (1982) noted significant earliness in flowering at 60 kg phosphorus per hectare.

However, Mohamed Kunju (1968) reported no significant change in the earliness of flowering due to phosphorus application.

2.2.2.2. No. of flowers/plant

Mehrotra et al. (1968) found that deficiencies of phosphorus adversely affected flower production in chilli crop, whereby no flowers formed in phosphorus deficient plants. According to Mohamed Kunju (1968), phosphorus increased significantly, the flower production in chilli. Dass and Mishra (1972) observed linear response to phosphorus in flower production.

2.2.2.3. No. of pods/plant

Total number of pods produced per plant was significantly increased by increased doses of phosphorus. Gill et al. (1974) noted increased mean number of pods with phosphorus. From his experiments with chillies, Covarelli (1976) reported that phosphorus increased the number of pods per plant. Khan and Suryanarayana (1977) got the highest number of pods per plant with 90 kg P_2O_5 per hectare. Joseph (1982) also reported that higher doses of phosphorus significantly increased the number of pods per plant.

2.2.2.4. Setting percentage of fruits

Mohamed Kunju (1968) observed that, application of graded doses of phosphorus upto 40 kg/ha increased the setting percentage significantly, beyond which, the increase was not significant. Joseph (1982) also reported that setting percentage was significantly increased by the application of graded doses of phosphorus.

2.2.2.5. Length and Girth of pods

Lal and Pundrik (1971) observed that phosphorus exhibited a direct relationship with the fruit length and fruit weight. Khan and Suryanarayana (1977) reported that the length and girth of pods were maximum by the application of 90 kg P_2O_5 per hectare. Similar beneficial effects of phosphorus in increasing the length and girth of pods in chilli were also reported by Joseph (1982).

However, Mohamed Kunju (1968) showed that, length and girth of pods was not influenced by phosphorus.

2.2.2.6. 100 pod weight

Coverelli (1976) from his investigations with chillies reported that, phosphorus increased the 100 pod weight. According to Chougule and Mahajan (1979), the weight of 100 pods significantly increased with higher doses of phosphorus. Joseph (1982) also reported similar effect of phosphorus on 100 pod weight of chilli.

2.2.2.7. Total yield of chillies

Mohamed Kunju (1968) obtained increased yield of dry pods by the application of graded doses of phosphorus. Iruthayaraj and Kulandaivelu (1973) observed significant increase in yield of pods at 60 kg P_2O_5/ha. Khan and Suryanarayana (1977) showed that yield was maximum at 90 kg P_2O_5/ha. According to Chougule and Mahajan (1979), the total yield of green chilli was maximum at 120 kg P_2O_5/ha. Joseph

(1982) also showed that yield of dry pods increased significantly by increased levels of phosphorus.

However, many workers have shown that response of chilli to applied phosphorus is negligible. Selvaraj *et al*. (1973) reported that there was no significant increase in yield with phosphorus. Srinivas (1983) studied the response of green chilli to phosphorus fertilization and found that the response to P was not significant. Shukla *et al*. (1987) showed that there was no response of chilli to applied P.

2.2.3. Effect of phosphorus on fruit ascorbic acid content

According to Dass and Mishra (1972), phosphorus application significantly increased the fruit ascorbic acid content in chillies. Similar effects of phosphorus in increasing the vitamin C content of fresh fruits were also reported by Joseph (1982).

But, Khan and Suryanarayana (1977) showed that phosphorus did not affect the ascorbic acid content of chilli fruits.

2.3. Effect of potassium

2.3.1. Effect of potassium on growth characters

2.3.1.1. Height of plant

Significant increase in plant height due to application of potash has been reported by Ozaki et al. (1957). Joseph (1982) found that potassium exerted appreciable influence on plant height at the time of final harvest.

But a number of works in chilli crop showed that K exerted little effect in increasing the height of plant. According to Mohamed Kunju (1968), Potash had no influence in increasing the height of plants. Shukla et al. (1987) also showed that height of plants was not affected by potassium.

2.3.1.2. No. of branches/plant

Branching of chilli was significantly impaired by the deficiency of potash, whereby less number of branches were seen in potash deficient plants (Mehrotra et al., 1968). According to Paraminder Singh et al. (1986), potassium significantly increased the number of primary branches per plant.

Contrary to the above findings, Mohamed Kunju (1968) observed no significant difference in number of branches due to different levels of potassium. Similar results were reported by many workers (Chougule and Mahajan, 1979; Joseph, 1982).

2.3.1.3. Dry matter production

Khan and Suryanarayana (1977) from their studies on the effect of N, P and K on chilli var. NP.46.A, reported that the dry matter accumulation was maximum at 45 kg K_2O/ha. Joseph (1982) found that higher doses of potassium significantly increased the total dry matter yield per plant. However, Chougule and Mahajan (1979) indicated that dry matter content of leaves and branches was not affected by potassium.

2.3.1.4. Shoot-Root Ratio

Mohamed Kunju (1968) reported that there was no significant difference in the shoot-root ratio with graded levels of potassium. Chougule and Mahajan (1979) also showed that there was little effect of applied potassium on the shoot-root ratio of the plant.

2.3.2. Effect of potassium on time of flowering, yield attributes and yield

2.3.2.1. Time of flowering

Pimpini (1967) observed that application of 160 kg potash per hectare promoted earliness in chillies. In a study on the nutritional requirement of chilli in 2 seasons, Joseph (1982) observed that effect of potash on earliness of flowering was not significant in the first season, but in the second season, the effect was significant. However, Mohamed Kunju (1968) observed that application of different levels of potash had given no significant difference in time of flowering. Similar effects of potassium on the time of flowering were reported by a number of workers (Coverelli, 1976; Khan and Suryanarayana, 1977 and Chougule and Mahajan, 1979).

2.3.2.2. No. of flowers/plant

Deficiencies of potash adversely influenced the production of flowers in chillies (Mehrotra et al., 1968). Dass and Mishra (1972) reported that there was an increase in the number of flowers produced, with an increase in K level from 30-90 kg/ha.

However, Mohamed Kunju (1968) pointed out that, eventhough there was increased flower production by increased application of potassium, it was not statistically significant.

2.3.2.3. No. of pods/plant

Mohamed Kunju (1968) reported that the total number of pods produced per plant was significantly higher with higher doses of potash. Khan and Suryanarayana (1977) reported that pod number/plant was highest with 45 kg K_2O/ha. But Chougule and Mahajan (1979) observed that potash application failed to produce significant effect on the number of fruits per plant in chilli. Joseph (1982) also showed that higher doses of potash had not influenced the number of pods per plant.

2.3.2.4. Setting percentage of fruits

Mohamed Kunju (1968) observed that application of different levels of potash had no significant influence on setting percentage. Joseph (1982) also found that, potash had no significant influence on setting percentage.

2.3.2.5. Length and Girth of pods

According to Mohamed Kunju (1968), the length of girth of pods were not influenced by the application of potash. Khan and Suryanarayana (1977) reported that pod length and girth were highest with 90 kg K_2O per hectare. Joseph (1982), found that potash had no significant influence on length of pods, but it increased the girth of pods.

2.3.2.6. 100 pod weight

The weight of 100 pods was increased by graded doses of potash (Mohamed Kunju, 1968). Chougule and Mahajan (1979) reported that weight of 100 fruits was significantly influenced by higher doses of potash. Similarly Joseph (1982) observed that the dry weight of 100 pods was increased by graded doses of potassium.

2.3.2.7. Total yield of chillies

Khan and Suryanarayana (1977) reported that the yield of chilli was maximum at 90 kg K_2O/ha. Joseph (1982) observed that yield of dry pods was significantly higher at higher levels of potassium. Kadam et al. (1985) obtained highest yield of dry pods at 125 kg K_2O. Similar positive correlation between potassium application and yield of chilli was reported by many workers (Wankhade and Morey, 1986; Ramarao et al., 1988).

But Mohamed Kunju (1968) showed that the corresponding increase in yield by application of higher levels of potash was not statistically significant. Iruthayaraj and Kulandaivelu (1973) revealed that there was no response to applied potash. Shukla et al. (1987) also reported that yield was not affected by potassium application.

2.3.3. Effect of potassium on fruit ascorbic acid content

There was no effect of potassium on fruit ascorbic acid content (Khan and Suryanarayana, 1977). Joseph (1982) also observed that potash had no significant effect on fruit ascorbic acid content.

However, Dass and Mishra (1972) from their investigations reported that the vitamin C content of fresh fruits increased with increased levels of potassium application.

2.4. Effect of combined application of nutrients on growth, yield and quality

Dhulappanavar (1965) advocated application of phosphorus and potassium along with nitrogen with a view to maintain soil fertility and to obtain more yields in favourable season. Ramanathan (1965) showed that chilli needs balanced and complete NPK fertilization for increased yield. Pimpini (1967) observed that potash in combination with phosphorus increased fruit number per plant and average weight per fruit. Mohamed Kunju (1968) revealed that nitrogen in combination with phosphorus increased the height, number of pods per plant and setting percentage.

Lal and Pundrik (1971) observed that nitrogen, phosphorus and potash at 100, 90 and 50 kg/ha respectively, resulted in maximum fruit length and fruit weight. Gill et al. (1974) observed that the interaction effects of nitrogen and phosphorus were significant in promoting earliness, number of pods per plant and number of branches per plant. Subbiah et al. (1982) showed that nitrogen in combination with potassium tended to produce more yield in chillies.

2.5. Uptake of nitrogen, phosphorus and potassium

Vleck and Polach (1963) worked out the ratio of N, P_2O_5 and K_2O removed by chilli grown in gravel with a complete nutrient solution, as 1:0.92:2.05. James et al. (1967) found that application of phosphorus and nitrogen had a complimentary effect on the uptake of those nutrients. Spaldon and Ivanic (1968) reported that uptake of nitrogen, phosphorus and potassium increased with increasing rates of potassium.

Fernandes *et al.* (1973) estimated that a plant population of 25,000 removed 40.9 kg nitrogen, 3.8 kg phosphorus and 68.6 kg potassium per hectare. Ivanic and Strelec (1976) showed that increasing potassium rates increased nitrogen, phosphorus and potash uptake and improved their utilization. Rajendra Prasad and Subramaniam (1978) found that the uptake of K by the crop was highest followed by that of N and P at all stages of growth.

Joseph (1982) observed that, total uptake of nitrogen was significantly increased by increased levels of N, P and K. Similar trends were also noted in the uptake of P and K.

The review of literature on the effect of nitrogen, phosphorus and potassium on chilli presented in the foregoing section clearly reveals that, these nutrients have significant positive effects on growth, yield, quality and nutrient uptake in chillies.

MATERIALS AND METHODS

3. MATERIALS AND METHODS

A field experiment was conducted to study the effects of nitrogen, phosphorus, potassium and their interactions on the growth, yield, quality and nutrient uptake of vegetable chilli variety Jwala Sakhi, at the Instructional Farm attached to the College of Agriculture, Vellayani, during 1988. The details of the materials used and methods followed are presented in this chapter.

3.1. Materials

3.1.1. Experimental site

The experiment was conducted in the garden land at the Instructional Farm attached to the College of Agriculture, Vellayani. The Farm is situated at 8.5° north latitude and 76.9° east longitude, at an attitude of 29 m above mean sea level.

3.1.2. Soil

The soil of the experimental area was red loam, acidic in reaction, low in available nitrogen and potassium and medium in available phosphorus. The physical and chemical properties of the soil are presented in Table 1.

Table 1. Physical and chemical properties of the soil

Sl. No.	Parameter	Observation	Remarks
1.	Coarse sand (%)	13.60	
2.	Fine sand (%)	33.70	
3.	Silt (%)	28.10	
4.	Clay	24.60	
5.	Soil texture	Loam	
6.	pH	5.3	Acidic
7.	Available N (kg/ha)	210.38	Low
8.	Available P_2O_5 (kg/ha)	36.21	Medium
9.	Available K_2O (kg/ha)	88.23	Low

3.1.3. Cropping history of the field

The experimental area was lying fallow for 3 months before the experiment and prior to that it was under bulk crop of cucumber.

3.1.4. Meteorological parameters

The experimental site enjoys a humid tropical climate. The data on various weather parameters like rainfall, minimum and maximum temperatures and relative humidity during the cropping period are given in Appendix I and graphically presented in Fig. 1.

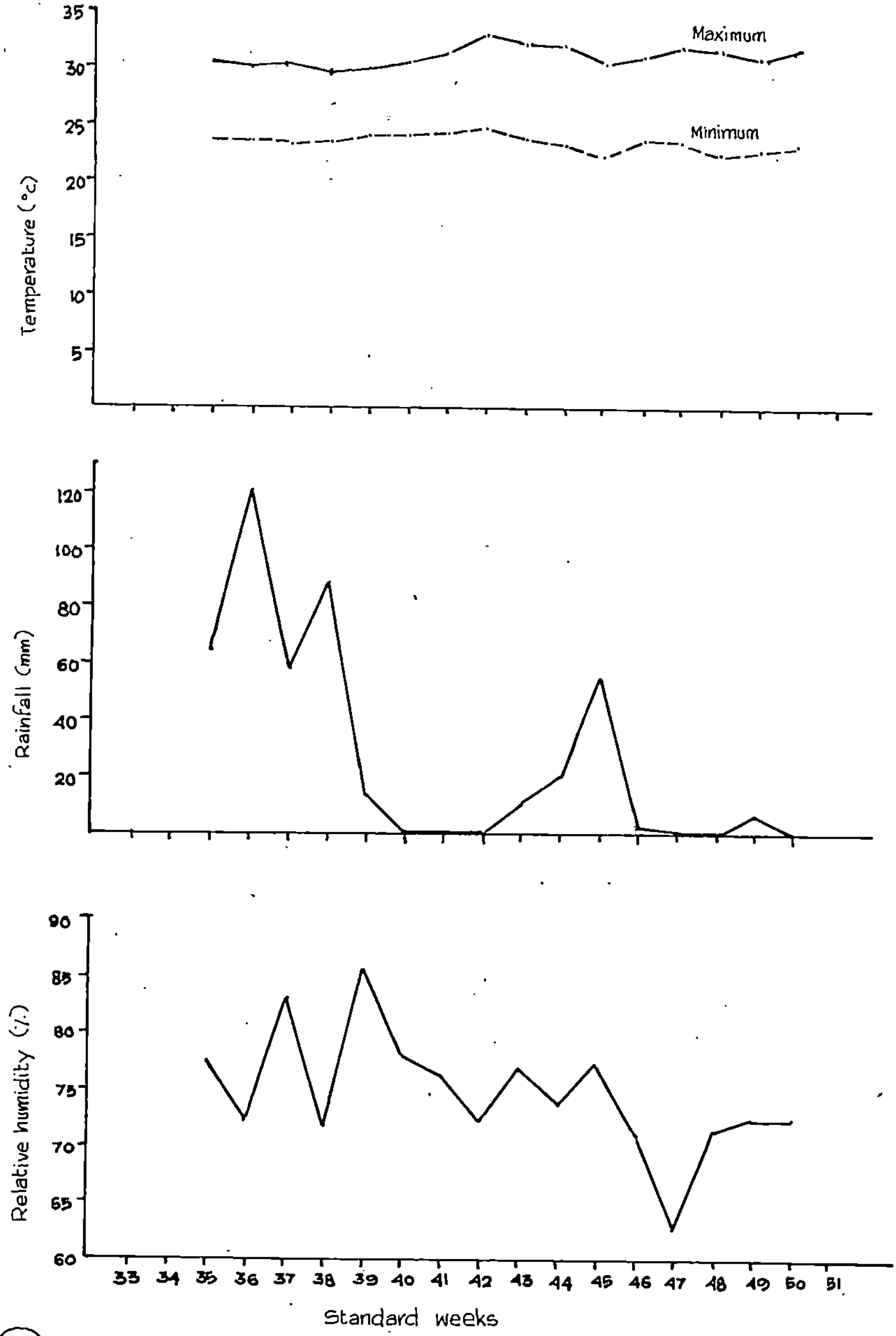

Fig 1 Weather conditions during the cropping period

In general, the weather conditions were favourable for the satisfactory growth of the crop.

3.1.5. Season

The field experiment was conducted during the period from 28-8-1988 to 10-12-1988.

3.1.6. Variety

The variety used was Jwala Sakhi, a newly released high yielding variety of vegetable chilli evolved by Kerala Agricultural University by crossing Vellanotchi, a popular local cultivar of South Kerala with Pusa Jwala. It has got high yield potential, ideal for culinary purposes and suited for high density planting.

The seed material was obtained from the Department of Plant Breeding, College of Agriculture, Vellayani.

3.1.7. Nursery

200 g of seeds were sown in well prepared raised nursery beds of size 1.2 m wide and 15 cm high with channels around them to facilitate the drainage of excess water. A basal dressing of powdered cattle manure at the rate of 1 kg/sq. meter was applied in the nursery beds.

The seeds were sown on 29-7-1988, The seedlings were irrigated every day. Hand weeding and plant protection measures were undertaken periodically as per KAU package of practices recommendations (Anon., 1986). The seedlings were ready for transplanting in 25-30 days.

3.1.8. Manures and fertilizers

A uniform dose of 20 t cattle manure per hectare was applied in the experimental area at the time of preparatory cultivation. The fertilizers used for the experiment were Urea (46% N), Superphosphate (16% P_2O_5) and Muriate of Potash (60% K_2O).

3.2. Methods

3.2.1. Design and Layout

The experiment was laid out as a $3^3 + 1$ partially confounded factorial design in Randomised Blocks with 2 replications. The higher order interactions NP^2K and NP^2K^2 were confounded in replication I and II respectively. The layout of the experiment is given in Figure 2. The details of the layout are given below.

No. of Treatments	-	28
No. of Blocks	-	6
No. of plots in a block	-	10
Total No. of plots	-	60
Gross plot size	-	2.8 x 2.40 m
Net plot size	-	2.1 x 1.6 m

→ N

Replication I	B_3	$n_3p_1k_1$	$n_1p_1k_3$	$n_0p_0k_0$	$n_2p_3k_1$	$n_3p_2k_2$	$n_2p_2k_3$	$n_1p_3k_2$	$n_3p_3k_3$	$n_1p_2k_1$	$n_2p_1k_2$
	B_1	$n_1p_3k_3$	$n_1p_1k_1$	$n_3p_3k_1$	$n_1p_2k_2$	$n_3p_2k_3$	$n_0p_0k_0$	$n_2p_3k_2$	$n_2p_1k_3$	$n_3p_1k_2$	$n_2p_2k_1$
	B_2	$n_3p_1k_3$	$n_2p_2k_2$	$n_1p_3k_1$	$n_3p_2k_1$	$n_2p_3k_3$	$n_2p_1k_1$	$n_1p_1k_2$	$n_0p_0k_0$	$n_1p_2k_3$	$n_3p_3k_2$
Replication II	B_2	$n_1p_3k_1$	$n_3p_2k_1$	$n_1p_2k_2$	$n_2p_2k_3$	$n_3p_3k_3$	$n_3p_1k_2$	$n_0p_0k_0$	$n_2p_3k_2$	$n_1p_1k_3$	$n_2p_1k_1$
	B_1	$n_3p_2k_2$	$n_0p_0k_0$	$n_2p_3k_3$	$n_3p_3k_1$	$n_3p_1k_3$	$n_2p_1k_2$	$n_1p_3k_2$	$n_2p_2k_1$	$n_1p_2k_3$	$n_1p_1k_1$
	B_3	$n_2p_3k_1$	$n_3p_2k_3$	$n_1p_1k_2$	$n_2p_1k_3$	$n_0p_0k_0$	$n_3p_3k_2$	$n_2p_2k_2$	$n_1p_3k_3$	$n_1p_2k_1$	$n_3p_1k_1$

Fig 2 Lay out plan of 3^3+1 partially confounded factorial in Randomised Block Design

Spacing	-	40 x 35 cm
No. of plants in gross plot	-	48
No. of plants in net plot	-	24
Replication	-	2

3.2.2. Treatments

The treatments consisted of 3 levels each of N, P_2O_5 and K_2O and their combinations with absolute control as detailed below.

(i) Levels of nitrogen

n_1 - 75 kg N/ha

n_2 - 100 kg N/ha

n_3 - 125 kg N/ha

(ii) Levels of phosphorus

P_1 - 40 kg P_2O_5/ha

P_2 - 60 kg P_2O_5/ha

P_3 - 80 kg P_2O_5/ha

(iii) Levels of potassium

k_1 - 25 kg K_2O/ha

k_2 - 45 kg K_2O/ha

k_3 - 65 kg K_2O/ha

(iv) Absolute control

$N_0P_0K_0$ - No fertilizer

The different treatment combinations were as follows.

$n_0p_0k_0$	$n_2p_2k_2$
$n_1p_1k_1$	$n_2p_2k_3$
$n_1p_1k_2$	$n_2p_3k_1$
$n_1p_1k_3$	$n_2p_3k_2$
$n_1p_2k_1$	$n_2p_3k_3$
$n_1p_2k_2$	$n_3p_1k_1$
$n_1p_2k_3$	$n_3p_1k_2$
$n_1p_3k_1$	$n_3p_1k_3$
$n_1p_3k_2$	$n_3p_2k_1$
$n_1p_3k_3$	$n_3p_2k_2$
$n_2p_1k_1$	$n_3p_2k_3$
$n_2p_1k_2$	$n_3p_3k_1$
$n_2p_1k_3$	$n_3p_3k_2$
$n_2p_2k_1$	$n_3p_3k_3$

3.2.3. Details of cultivation

3.2.3.1. Land preparation

The main field was dug twice and plots of 2.8 x 2.4 m were laid out with bunds of 40 cm width all around. Individual plots were again dug and perfectly levelled. Ridges were formed 40 cm apart and 30 days old seedlings were planted on the ridges at 35 cm apart on 28-8-1988. The plants were given uniform irrigation. Necessary shade was also provided for the first 4 days after transplanting.

3.2.3.2. Application of fertilizers

Fertilizers were applied as per the schedule of treatments. The entire dose of phosphorus and half of nitrogen and potash were given as basal dressing. One fourth of nitrogen and half of potash were applied 25 days after transplanting. The remaining quantity of nitrogen was applied one month after the first top dressing.

3.2.3.3. Maintenance of the crop

Gap filling was done on the 5th day after transplanting. The crop was hand weeded thrice at 25 days interval. The general stand of the crop was good. The crop was given irrigation periodically. Need based plant protection measures were undertaken to control pests and diseases.

3.2.3.4. Harvest

The crop was ready for first harvest 71 days after planting and subsequent harvests were made at an interval of 8-10 days. On the whole five pickings were taken.

3.3. Observations

3.3.1. Growth characters

3.3.1.1. Height of plant

This observation was taken from 10 plants at random in each treatment after eliminating border rows. The height of plants were measured from the base to the growing tip of the plants. Observations were recorded on the same plants at the 3 growth stages viz. 35th day, 70th day after planting and at final harvest.

3.3.1.2. No. of branches

The total number of branches per plant at final harvest was recorded from 10 plants at random in each treatment after eliminating border rows.

3.3.1.3. Dry matter production

The entire dry weights of shoot and fruits of 10 plants from the observational area were recorded. The samples were dried to constant weights in a hot air oven at a temperature of 70°C and then the dry weights were taken.

3.3.1.4. Shoot-root ratio

After the final harvest, plants were pulled out without damaging the roots. The dry weights of shoots and roots of

10 plants were recorded after drying in sun. From this the shoot-root ratio was calculated.

3.3.2. Time of flowering, yield attributes and yield

3.3.2.1. Time of 50% flowering

The number of days taken for 50% of the plant population to flower in each treatment was recorded.

3.3.2.2. No. of flowers produced per plant

Flower production on the 10 selected plants was recorded from the first flower opening till the flower production was ceased.

3.3.2.3. No. of pods per plant

The total number of pods on the 10 selected plants was recorded and the average worked out.

3.3.2.4. Setting percentage of fruits

This observation was calculated by dividing the total number of fruits formed on a plant with the total number of flowers produced in the same plant and it was taken in 10 selected observational plants in each treatment.

3.3.2.5. Length of pods

From the selected plants, 10 pods taken at random from the second harvest were measured and their average length calculated.

3.3.2.6. Girth of pods

Pods used for measuring length were used for recording the girth of pods. Girth was measured at the broadest part of the pods.

3.3.2.7. 100 pod weight

From each treatment 100 pods were drawn at random and their fresh weight recorded.

3.3.2.8. Total yield of chillies

The produce from each harvest was weighed and recorded for each treatment.

3.3.3. Ascorbic acid content of fruits

Variation in the quality of fresh fruits as influenced by the incremental doses of N, P and K was assessed by estimating the vitamin C content of fruits. It is expressed as mg/100 g of mature fresh fruits.

3.4. Chemical analysis

3.4.1. Soil analysis

Before the commencement of the trial, soil from the experiment site was taken and subjected to analysis for physical and chemical properties and fertility status in terms of available N, P and K.

After the experiment, the effect of individual treatment on the residual soil fertility was determined. Soil from each experiment plot was assayed for available N, P and K. The methods followed for the assay of various soil parameters are given in Table 2.

3.4.2. Plant analysis

The contents of total N, P and K in the stem, leaves and fruits of the plants in each treatment were determined separately in order to assess the nutrient uptake by the crop.

The plant samples collected from the observational area in each plot at the time of final harvest were separated into stem, fruits and leaves. They were dried to constant weight in an electric oven at 70°C, ground and passed through a 20 mesh sieve and subjected to acid extraction of total nutrients. Nitrogen, phosphorus and potassium were determined by the methods given in Table 2.

3.4.2.1. Uptake of nitrogen, phosphorus and potassium

The total uptake of nitrogen, phosphorus and potassium by the stem, leaves and fruits was calculated as the product of the per cent content of these nutrients in the plant samples and the respective dry weights and expressed in kg/ha.

Table 2. Analytical methods for soil and plant parameters

Sl. No.	Parameter	Method	Reference
I.	Soil analysis		
(i)	Mechanical analysis	International Pipette method	Piper, 1950
(ii)	pH	pH meter with glass electrode	Jackson, 1967
(iii)	Available N	Alkaline perman-ganometric method	Subbiah & Asija, 1956
(iv)	Available P_2O_5	Bray No. 1 extract	Bray & Kurtz, 1945
(v)	Available K_2O	Neutral normal ammonium acetate extract	Jackson, 1967
II.	Plant analysis		
(i)	Total N	Modified kjeldahl method	Jackson, 1967
(ii)	Total P	Vanado-molybdate yellow colour method by Spectro-nic 2000	Jackson, 1967
(iii)	Total K	Atomic Absorption Spectro photo-metry	Jackson, 1967
(iv)	Vitamin C	Titrimetric method	Paul Gyorgy & Pearson, 1967

3.5. Economics of cultivation

The economics of chilli cultivation was worked out based on the following factors.

	Rs.	Ps.
1. Cost of cultivation of chilli per hectare, excluding the cost of treatments	26200	00
2. Cost of 1 kg N	5	22
3. Cost of 1 kg P_2O_5	6	25
4. Cost of 1 kg K_2O	2	50
5. Price of 1 kg vegetable chilli	6	00

The net income and return per rupee invested were calculated as follows.

Net income (Rs./ha) : Gross income − Total expenditure

Net return per rupee invested (Rs.) : $\frac{\text{Net income}}{\text{Total expenditure}}$

3.6. Statistical analysis

The data relating to each character were analysed using the analysis of variance technique as applied to 3^3+1 partially confounded factorial experiment in RBD by suitably extending the technique of analysis of 3^3 design described by Panse and Sukhatme (1967). In case where the effects were found to be significant critical difference were calculated for effecting multiple comparisons among the means.

Response function models of different types were fitted to predict optimum response. It was found that the response pattern could satisfactorily be represented by squareroot polynomial response function of the form

$$Y = b_0 + b_1 \sqrt{N} + b_2 \sqrt{P} + b_3 \sqrt{K} + b_4 N + b_5 P + b_6 K + b_7 \sqrt{NP} + e$$

where Y is the predicted yield, N, P and K the fertilizer doses and 'e' the random component.

The economic dose was estimated by equating the partial derivatives into the respective input/output price ratios.

Path coefficient analysis was also attempted to identify the major yield components by way of decomposing the true correlation coefficient of each characters with yield into the direct effects of each character and the indirect effects through other characters.

RESULTS

4. RESULTS

The experimental data were subjected to statistical analysis to bring out the effects of nitrogen, phosphorus and potassium on the growth, yield, quality and nutrient uptake of vegetable chilli variety Jwalasakhi. The results obtained are presented under the following sections.

1. Growth characters
2. Time of 50% flowering, yield components and yield
3. Ascorbic acid content of fruits
4. Plant uptake of nutrients
5. Soil nutrient status
6. Correlation studies
7. Economics and optimum doses of nutrients

4.1. Growth characters

4.1.1. Height of plant

The data on mean height of plants at different stages of growth are presented in Table 3 and the analysis of variance in Appendix II.

The results showed that application of fertilizers has exerted significant influence on plant height.

The effect of nitrogen on plant height was found to be positive and significant. Application of nitrogen at

125 kg/ha was found to produce taller plants than those at 75 kg and 100 kg levels of nitrogen at all the three stages of observations.

Application of phosphorus also produced significant effect on the height of plants. At 35th day after planting, phosphorus at 80 kg/ha was found to be significantly superior to phosphorus at 40 kg/ha. However, the differences between 80 kg P_2O_5/ha and 60 kg P_2O_5/ha and 60 kg P_2O_5/ha and 40 kg P_2O_5/ha were not significant.

At 70th day after planting, the effect of phosphorus on plant height was not significant. At the time of final harvest, phosphorus at 80 kg P_2O_5/ha was found to be significantly superior to 40 kg P_2O_5/ha, but was on par with 60 kg P_2O_5/ha.

Application of graded doses of potassium did not influence the plant height significantly.

4.1.2. Number of branches

The mean number of branches per plant at the time of final harvest for various treatments are shown in Table 3 and the analysis of variance in Appendix II.

The effect of different treatments on number of branches was statistically significant. There was a progressive

Table 3. Effect of different levels of nitrogen, phosphorus and potassium on height, number of branches, drymatter production and shoot-root ratio

Levels of nutrients kg/ha	Height of plant (cm)			No. of branches at harvest	Dry-matter production per plant (g)	Shoot-root ratio
	35 DAP	70 DAP	Final harvest			
Nitrogen (N)						
75	31.11	44.00	48.94	55.56	48.68	4.32
100	34.67	51.72	53.00	78.56	80.30	4.74
125	36.72	55.72	61.56	81.94	80.74	5.12
'F' Test	S	S	S	S	S	S
Phosphorus (P_2O_5)						
40	33.33	49.44	54.16	67.17	67.12	4.85
60	34.56	50.61	56.94	74.11	71.48	4.73
80	34.61	51.39	57.39	74.77	71.13	4.61
'F' Test	S	NS	S	S	S	S
Potassium (K_2O)						
25	33.94	50.11	55.17	71.05	68.57	4.70
45	34.33	50.72	56.78	72.22	70.00	4.74
65	34.22	50.61	56.56	72.77	71.16	4.75
'F' Test	NS	NS	NS	NS	S	NS
SEm ±	0.44	0.73	0.65	0.75	0.51	0.03
CD (0.05)	1.28	3.68	1.87	2.17	1.48	0.18
Control ($n_0p_0k_0$)	18.33	35.83	42.33	34.66	38.94	3.75

S : Significant

NS : Not Significant

increase in the total number of branches per plant due to graded levels of nitrogen upto the highest level tried (125 kg N/ha). The differences among the various levels of nitrogen were statistically significant.

Application of phosphorus was found to have significant effect on the number of branches per plant. Phosphorus at 60 kg P_2O_5/ha and 80 kg P_2O_5/ha were significantly superior to the lowest level of 40 kg P_2O_5/ha. However, the effects of P_2O_5 at 60 and 80 kg/ha were statistically on par.

Application of potassium did not influence the total number of branches per plant.

4.1.3. Total dry matter production

The data on the mean total dry matter production per plant are shown in Table 3 and the analysis of variance in Appendix II.

Application of fertilizers had a profound influence in enhancing the total dry matter production per plant.

There was a progressive increase in the dry matter production due to successive levels of nitrogen upto 125 kg N/ha. The higher levels of N tried were significantly superior to the lowest level of nitrogen tried in the present study.

Application of phosphorus was found to have significant effect on dry matter production. Effects of P_2O_5 at 60 and 80 kg/ha were found to be more pronounced than that at 40 kg/ha. Phosphorus at 60 kg P_2O_5/ha produced the maximum dry matter which was on par with 80 kg P_2O_5/ha.

The response of potassium also was significant with 65 kg K_2O/ha, producing the maximum dry matter per plant. The levels 65 kg and 45 kg K_2O/ha were statistically on par in this respect. Similarly 45 and 25 kg K_2O/ha were also on par.

4.1.4. Shoot-Root Ratio

The data on mean shoot-root ratio are furnished in Table 3 and the analysis of variance in Appendix II.

Application of nitrogen had significantly influenced the shoot-root ratio. The ratio increased progressively with incremental doses of nitrogen.

Application of phosphorus was found to give a significant reduction in the shoot-root ratio, with the maximum shoot-root ratio at 40 kg P_2O_5/ha followed by 60 kg P_2O_5/ha.

The effect of potassium on shoot-root ratio was not statistically significant.

4.2. Time of 50% flowering, yield components and yield

4.2.1. Time of 50% flowering

The data on mean number of days taken for 50% flowering are given in Table 4 and the analysis of variance in Appendix III.

The influence of graded doses of nitrogen, phosphorus and potassium on time of 50% flowering was found to be statistically significant.

Time of 50% flowering was significantly delayed with graded levels of nitrogen. The differences among any pairs of means were statistically significant. Plants supplied with 125 kg nitrogen took about 36 days while those supplied with 75 kg N/ha took only 32 days.

Phosphorus also exerted significant influence on the number of days taken for 50% flowering of plants. Phosphorus at 60 kg and 80 kg P_2O_5/ha were significantly superior in inducing earliness. But the effects of 60 kg and 80 kg P_2O_5/ha were on par.

Similarly the effect of potassium also was significant in reducing the mean number of days required for 50% flowering. Potassium at 65 kg K_2O/ha induced earliness significantly. The differences due to potassium at 25 and 45 kg and 45 and 65 kg K_2O/ha were statistically not significant.

Table 4. Effect of different levels of nitrogen, phosphorus and potassium on time of 50% flowering, number of flowers, percentage fruit set, number of pods, length of pods and girth of pods

Levels of nutrients kg/ha	Time of 50% flowering (days)	No. of flowers per plant	Percentage fruit set	No. of pods per plant	Length of pods (cm)	Girth of pods (cm)
Nitrogen (N)						
75	31.67	121.53 (11.02)	51.80	62.71 (7.92)	8.36	5.36
100	33.50	156.37 (12.50)	57.20	89.81 (9.48)	9.33	5.78
125	36.33	154.26 (12.42)	55.93	86.21 (9.28)	8.91	5.59
'F' Test	S	S	S	S	S	S
Phosphorus (P_2O_5)						
40	34.72	136.97 (11.70)	53.73	73.64 (8.58)	8.81	5.54
60	33.44	146.97 (12.12)	55.21	81.28 (9.02)	8.98	5.63
80	33.33	146.95 (12.12)	55.99	82.52 (9.08)	8.81	5.56
'F' Test	S	S	S	S	NS	NS
Potassium (K_2O)						
25	34.67	142.76 (11.95)	54.92	78.53 (8.86)	8.83	5.49
45	33.83	143.33 (11.97)	54.97	79.21 (8.90)	8.83	5.59
65	33.00	144.68 (12.03)	55.05	79.55 (8.92)	8.93	5.64
'F' Test	S	NS	NS	NS	NS	NS
SEm ±	0.41	0.04	0.42	0.02	0.11	0.05
CD (0.05)	1.18	0.12	1.21	0.15	0.31	0.15
Control ($n_0p_0k_0$)	38.33	86.00	42.15	36.16	6.87	3.73

S : Significant

NS : Not Significant

4.2.2. Number of flowers per plant

The mean number of flowers produced per plant are shown in Table 4 and the analysis of variance in Appendix III.

The mean number of flowers produced per plant was influenced by the graded levels of nitrogen application. The maximum flower production was obtained with 100 kg N/ha followed by 125 kg level. The average number of flowers at 75 kg N/ha was significantly lesser than those at higher doses.

Phosphorus application also has resulted in an increase in the mean number of flowers produced per plant upto 60 kg P_2O_5/ha. Phosphorus at 60 kg and 80 kg P_2O_5/ha were significantly superior to 40 kg P_2O_5/ha. However, the difference due to 60 and 80 kg P_2O_5/ha was not statistically significant.

It is seen that the application of potassium has not resulted in any significant influence in the production of flowers in plants.

4.2.3. Percentage fruit set

The data on percentage fruit set are given in Table 4 and the analysis of variance in Appendix III.

Nitrogen application resulted in marked influence on the percentage fruit set, with 100 and 125 kg levels of nitrogen giving significantly higher percentage fruit set compared with 75 kg N/ha. The effects of nitrogen at 125 kg and 100 kg/ha were on par.

Setting percentage was increased with increasing levels of phosphorus also; the maximum being at 80 kg P_2O_5/ha. The effects of 80 kg and 60 kg P_2O_5/ha were on par.

Application of potassium did not produce any significant response on the setting percentage.

4.2.4. Number of pods per plant

The data on the mean number of pods per plant are given in Table 4 and graphical representation in Fig. 3 and analysis of variance in Appendix III.

There was significant increase in the total number of pods produced per plant due to the effects of nitrogen upto 100 kg N/ha. Maximum number of pods/plant (90) was obtained with 100 kg N/ha. The difference between the two higher levels of nitrogen was not significant. But, both differed significantly from the lower level.

Application of phosphorus also significantly increased the number of pods per plant. Phosphorus at 80 and 60 kg P_2O_5/ha were significantly superior to 40 kg level. However, the effects of 80 and 60 kg P_2O_5/ha were on par.

Potassium application did not exert any significant influence on this character.

4.2.5. Length of pods

Table 4 gives the data on mean length of pods and the analysis of variance is given in Appendix III.

Among the fertilizer nutrients, nitrogen significantly influenced the length of pods. The differences in length due to graded levels of phosphorus and potassium were statistically not significant. Application of nitrogen significantly increased the mean length of pods, with maximum length obtained at 100 kg N/ha. The effects of 100 and 125 kg N/ha were on par.

4.2.6. Girth of pods

The data on mean girth of pods are presented in Table 4 and the analysis of variance in Appendix III.

Application of nitrogen significantly increased the mean girth of pods. Nitrogen at 100 and 125 kg/ha were significantly superior to 75 kg N/ha in enhancing the girth of pods. However, the effects of 100 and 125 kg N/ha were on par.

Differences in mean girth of pods due to graded doses of phosphorus and potassium were statistically not significant.

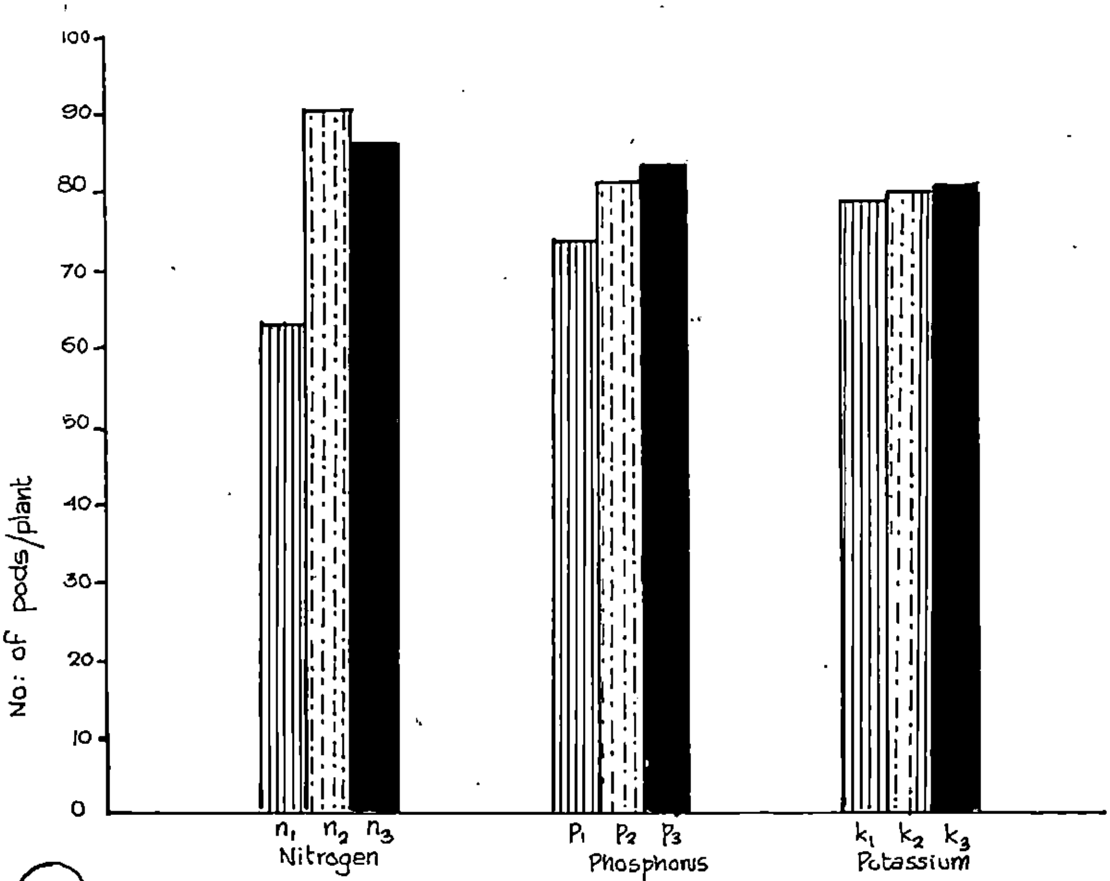

Fig 3 Number of pods per plant

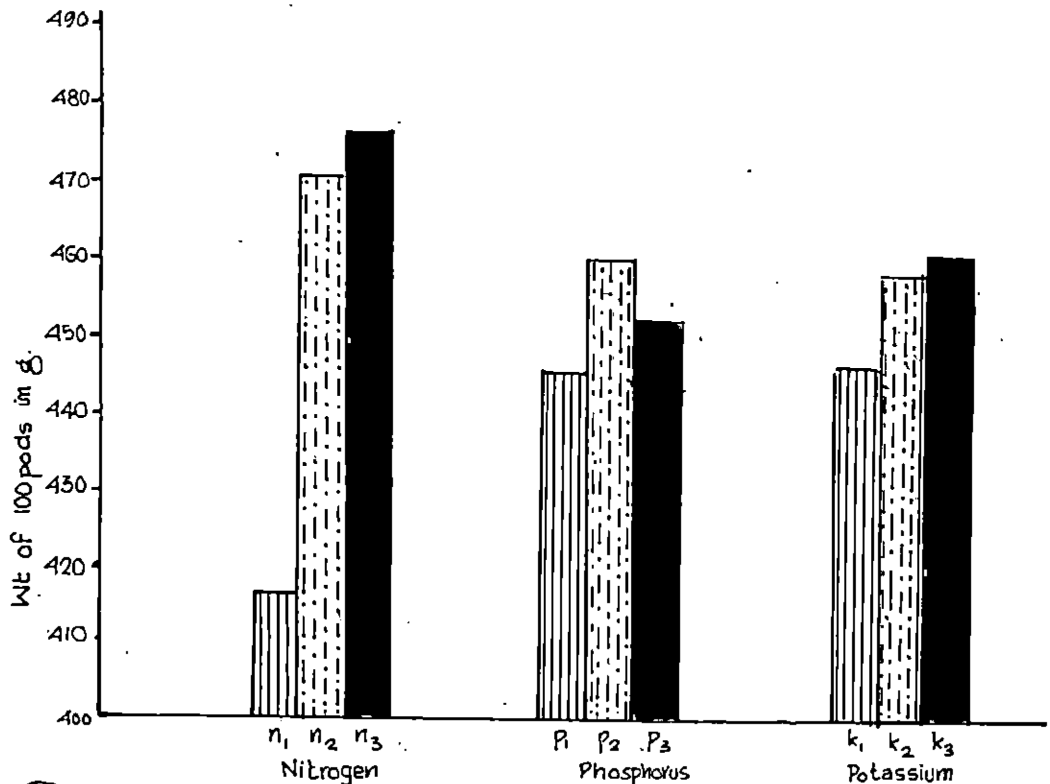

Fig 4 100 pod weight

4.2.7. 100 pod weight

The data on weight of 100 fresh pods are given in Table 5a and its graphical representation in Fig. 4 and the analysis of variance in Appendix IV.

The influence of nitrogen was significant in increasing the weight of 100 pods upto the highest level tried. Nitrogen at 125 kg/ha recorded the maximum fresh weight and the effects at 100 and 125 kg/ha were on par. Nitrogen at 75 kg/ha was significantly inferior to the two higher levels of nitrogen.

With respect to phosphorus, application of 60 kg P_2O_5/ha had a significant and positive response over its application at 40 and 80 kg P_2O_5/ha. The effects due to application of 80 and 40 kg P_2O_5/ha were statistically on par.

Significant effect was obtained by graded doses of potassium in this yield attribute, with 65 kg K_2O/ha registering the maximum weight per 100 pods. However, the difference due to 65 and 45 kg K_2O/ha was statistically not significant.

4.2.8. Yield of chilli

The summary of data on mean yields of fresh pods are

Table 5a. Effect of different levels of nitrogen, phosphorus and potassium on 100 pod weight, yield, ascorbic acid content and uptake of nitrogen, phosphorus and potassium by plant

Levels of nutrients (kg/ha)	100 pod weight (g)	Yield (t/ha)	Ascorbic acid content mg/100 g fresh fruit	Uptake of nitrogen (kg/ha)	Uptake of phosphorus (kg/ha)	Uptake of potassium (kg/ha)
Nitrogen (N)						
75	417.06	13.06	120.84	46.54	7.76	55.06
100	470.56	19.27	136.70	64.43	11.19	80.21
125	476.39	19.12	131.44	65.65	11.06	80.41
'F' Test	S	S	S	S	S	S
Phosphorus (P_2O_5)						
40	445.28	16.39	128.51	54.99	9.12	67.82
60	460.00	17.56	129.87	60.35	10.39	74.03
80	451.67	17.50	130.60	61.28	10.50	73.84
'F' Test	S	S	NS	S	S	S
Potassium (K_2O)						
25	446.39	16.57	129.79	56.88	9.79	68.00
45	457.61	17.39	129.19	59.68	10.17	72.70
65	460.00	17.48	130.01	60.06	10.06	74.99
'F' Test	S	S	NS	S	NS	S
SEm ±	2.78	0.13	1.33	0.52	0.16	0.31
CD (0.05)	8.04	0.37	3.84	1.51	0.48	0.90
Control ($n_0p_0k_0$)	325.83	7.67	70.05	25.02	4.62	35.02

S : Significant

NS : Not Significant

given in Table 5a and its graphical representation in Fig. 5 and the analysis of variance in Appendix IV.

Application of fertilizer nutrients significantly influenced the mean yield of chilli. The effect of nitrogen was profound in increasing the yield of chilli. Application of nitrogen at 100 and 125 kg/ha was significantly superior to 75 kg N/ha. Nitrogen at 100 kg/ha registered the highest yield of chilli and effects due to 100 and 125 kg N/ha were statistically on par.

Response of P_2O_5 was significant on the yield of chilli, with 60 kg P_2O_5/ha registering the maximum yield. The difference due to 60 and 80 kg P_2O_5/ha was not statistically significant. The lower level of P registered significantly inferior yield.

There was significant increase in yield due to application of potassium. The effects due to 45 and 65 kg K_2O/ha were significantly superior to the lower level. However, the increase in yield due to application of K_2O at 45 and 60 kg levels was statistically not significant.

Among the various interactions, combined effect of nitrogen and phosphorus alone was found to be significant (Table 5b); plants supplied with 100 kg of nitrogen and 60 kg P_2O_5/ha produced the maximum yield of chillies followed

Table 5b. Interaction effect of different levels of nitrogen and phosphorus on yield

		Nitrogen			Mean
		n_1	n_2	n_3	
	P_1	12.53	17.84	18.77	16.39
Phosphorus	P_2	13.33	20.01	19.33	17.56
	P_3	13.29	19.95	19.27	17.50
Mean		13.057	19.27	19.12	

SEm ± 0.22

CD (0.05) 0.63

by those supplied with 100 kg N and 80 kg P_2O_5/ha.

4.3. Ascorbic acid content of fruits

Table 5a gives the mean values of fruit ascorbic acid content and its graphical representation is given in Fig. 6 and the analysis of variance in Appendix IV.

Application of 100 and 125 kg N/ha significantly increased the fruit ascorbic acid content and the highest amount was recorded with 100 kg N/ha. The effects due to 100 and 125 kg N/ha were on par, and nitrogen at 75 kg/ha was significantly inferior to the higher doses.

The effects due to graded levels of phosphorus and potassium in the mean ascorbic acid content of fresh fruits were statistically not significant.

4.4. Nutrient uptake by plants

4.4.1. Uptake of nitrogen

The data on the total uptake of nitrogen by plants are presented in Table 5a, its graphical representation in Fig. 7 and the analysis of variance in Appendix IV.

There was a progressive increase in the total uptake of nitrogen by plants due to graded levels of nitrogen upto the highest level. However, the effects due to 125 and 100 kg

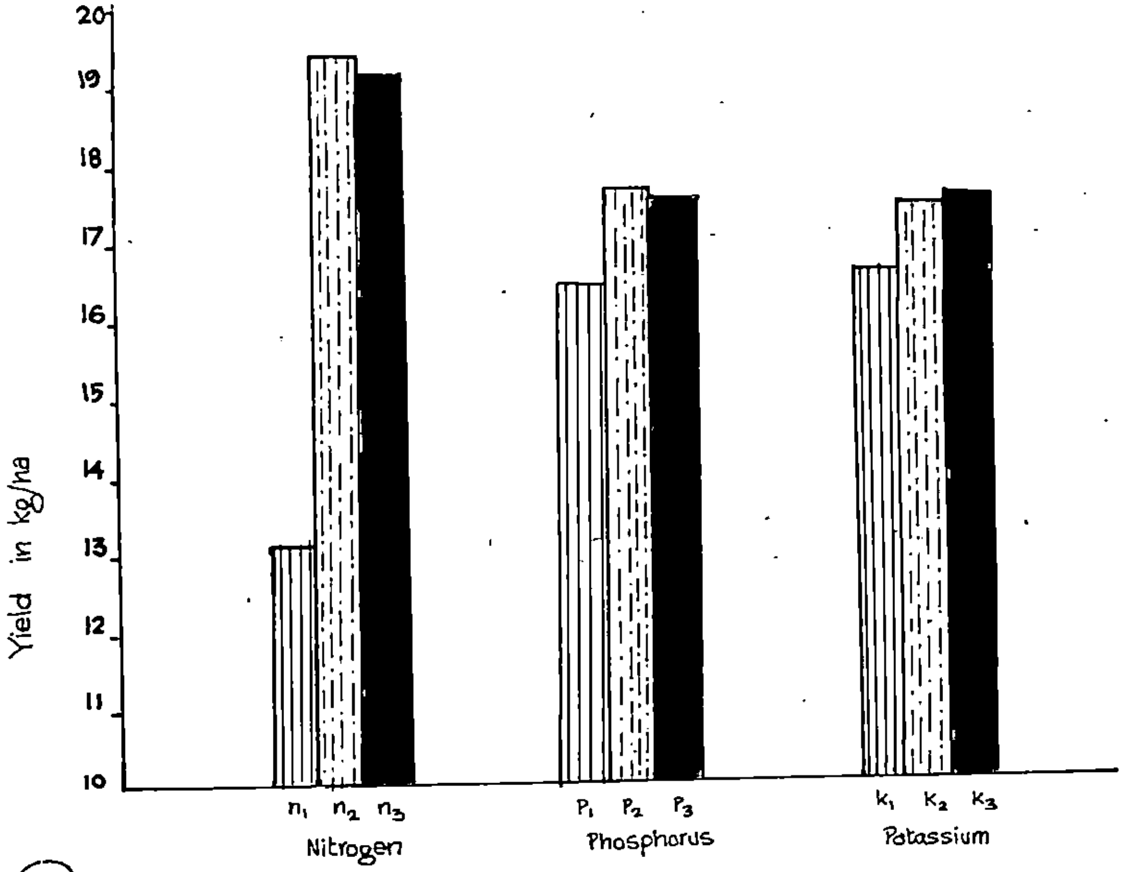

Fig 5

Yield of chilli pods

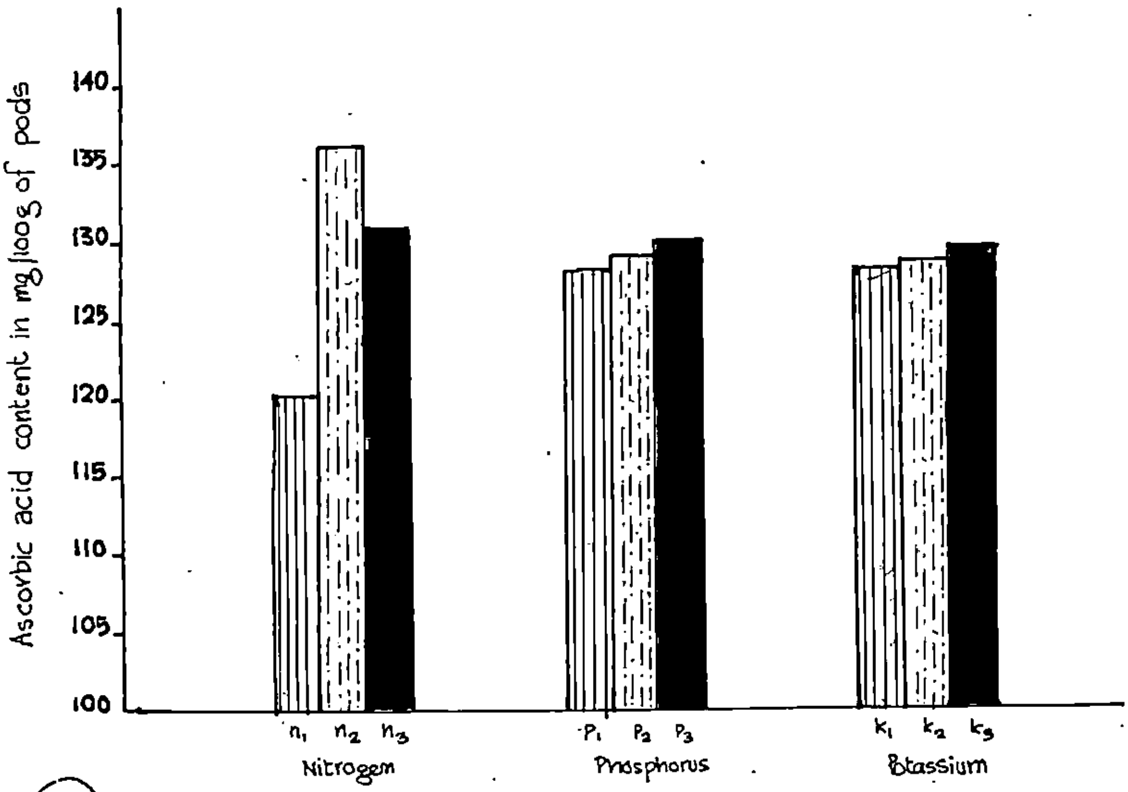

Fig 6

Ascorbic acid content of fruits

N/ha were statistically on par. Nitrogen at 75 kg/ha was significantly inferior in this respect.

Uptake of nitrogen increased with graded doses of phosphorus. Phosphorus application at 80 and 60 kg P_2O_5/ha significantly increased the nitrogen uptake compared with 40 kg P_2O_5/ha. However, the effects due to 80 and 60 kg P_2O_5/ha were statistically on par.

Potassium application also significantly influenced the total uptake of nitrogen by plants and the maximum uptake was recorded with 65 kg K_2O/ha. Application of 45 kg K_2O/ha was significantly superior to that at 25 kg K_2O/ha, and was on par with 65 kg K_2O/ha.

4.4.2. Uptake of phosphorus

The data on mean total uptake of phosphorus by plants are given in Table 5a and its graphical representation in Fig. 7 and the analysis of variance in Appendix IV.

Nitrogen application significantly increased the uptake of phosphorus by plants. Nitrogen at 100 and 125 kg/ha were significantly superior to 75 kg N/ha. Application of nitrogen at 100 kg/ha resulted in maximum phosphorus uptake and the difference due to 100 and 125 kg/ha was not statistically significant.

Application of higher doses of phosphorus significantly increased the uptake of phosphorus by plants. Phosphorus at 80 kg P_2O_5/ha recorded the highest total uptake and its effect was on par with 60 kg P_2O_5/ha. Uptake of phosphorus was significantly lesser when P_2O_5 was applied at 40 kg level.

The influence of potassium was not significant in this respect.

4.4.3. Uptake of potassium

The data on mean total uptake of potassium by plants are presented in Table 5a and its graphical representation in Fig. 7 and analysis of variance in Appendix IV.

The influence of nitrogen on the total uptake of potassium by plants was significant and there was a progressive increase in the uptake of potassium with incremental doses of nitrogen. But the effects of nitrogen at 100 kg/ha and 125 kg/ha levels were on par and the above two levels of nitrogen were significantly superior to 75 kg N/ha.

With respect to the effect of phosphorus on potassium uptake, the highest total uptake was noticed at 60 kg P_2O_5/ha. However, the effects of phosphorus at 60 and 80 kg P_2O_5/ha were on par which in turn were significantly superior to 40 kg P_2O_5/ha.

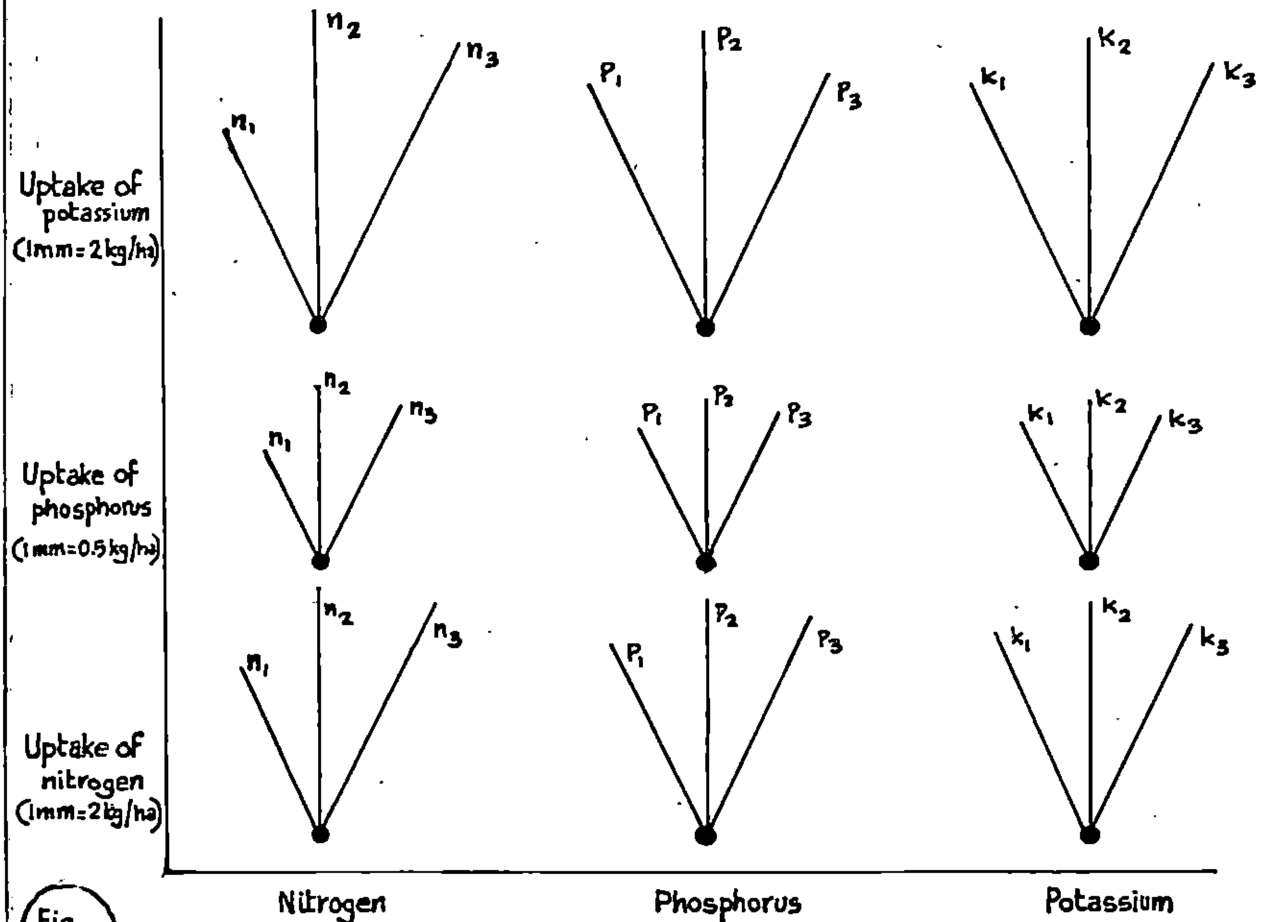

Fig 7 Uptake of nitrogen, phosphorus and potassium by plants

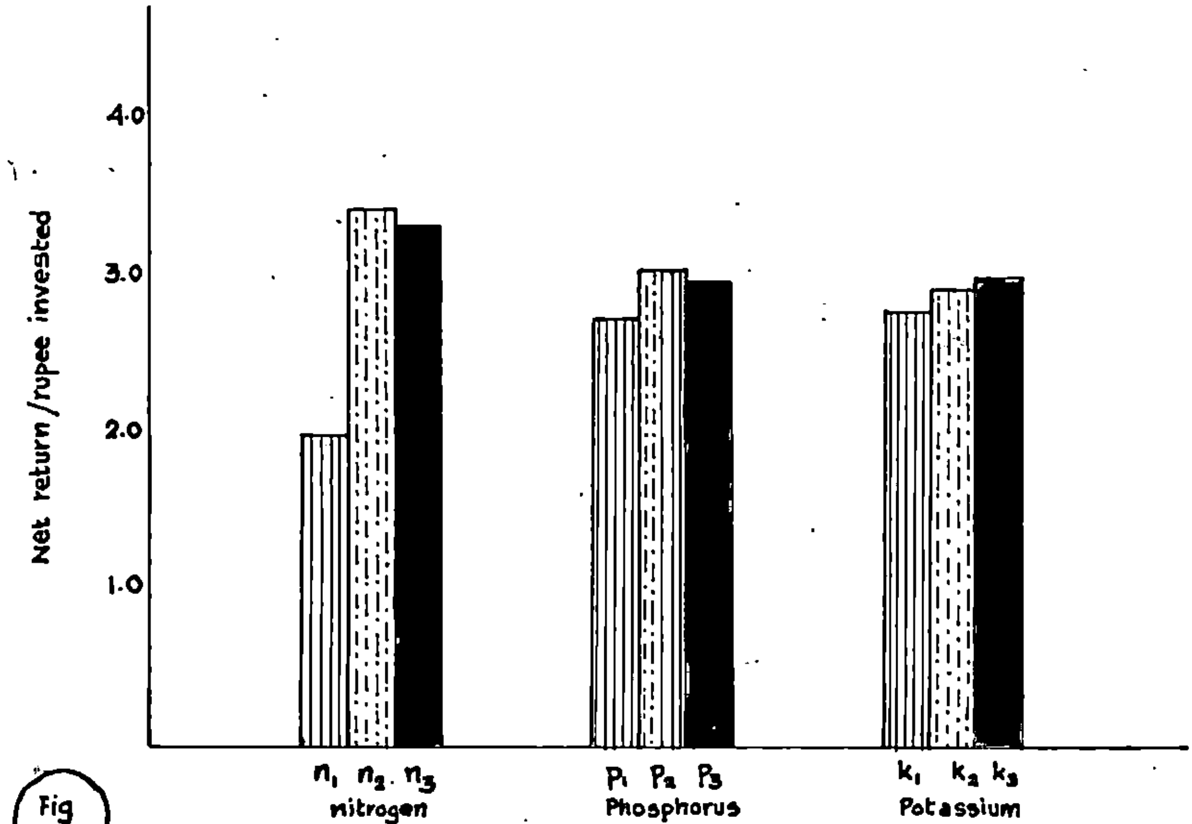

Fig 8 Net return per rupee invested on chilli

Plant uptake of K increased significantly with incremental dose of potassium. The highest total uptake was recorded at 65 kg K_2O/ha. The differences between all the three levels of potassium were statistically significant.

4.5. Soil nutrient status

Table 6a gives the data on the mean content of available nitrogen, available phosphorus and available potassium in soil after the experiment, and the analysis of variance is given in Appendix V.

Available nitrogen content after the experiment was reduced considerably in plots receiving no fertilizer. But the available nitrogen content in the treatment plots increased significantly when the soil received any of the fertilizer treatments. However, the effects due to graded doses of any of the fertilizer treatments were statistically not significant.

Similarly, though there was an increasing trend in the available phosphorus and potassium content of soil after the experiment, the various levels of nutrients did not exert any significant influence.

4.6. Correlation studies

Simple correlation studies were undertaken with a view

Table 6a. Effect of different levels of nitrogen, phosphorus and potassium on soil nutrient status and economics of cultivation

Levels of nutrients (kg/ha)	Soil nutrient status after the experiment			Economics of cultivation	
	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)	Net income (Rs.)	Net return per rupee invested (Rs.)
Nitrogen (N)					
75	281.22	49.33	105.06	52144.00	1.99
100	281.05	49.11	105.44	89384.00	3.41
125	282.67	49.06	106.17	88504.00	3.38
'F' Test	NS	NS	NS	S	S
Phosphorus (P_2O_5					
40	281.11	48.72	105.00	72094.00	2.75
60	276.33	49.89	106.67	79130.00	3.02
80	280.83	48.89	105.50		
'F' Test	NS	NS	NS	S	S
Potassium (K_2O)					
25	279.61	48.56	105.78	73174.00	2.79
45	280.67	49.50	106.11	78154.00	2.98
65	278.00	49.44	104.78	78704.00	3.00
'F' Test	NS	NS	NS	S	S
SEm ±	2.04	0.87	0.75	784.69	0.02
CD (0.05)	5.95	2.54	2.19	2277.16	0.08
Control ($n_0p_0k_0$)	196.50	33.76	87.15	20356.33	0.774

S : Significant

NS : Not Significant

Table 6b. Interaction effect of different levels of nitrogen and phosphorus on net income

		Nitrogen			Mean
		n_1	n_2	n_3	
	P_1	49094	80804	86384	72094
Phosphorus	P_2	53784	93864	89744	79130
	P_3	53554	93484	89384	78807
Mean		52144	89384	88504	

SEm ± 1359.13

CD (0.05) 3944.16

to elucidate the relationship of each of the various yield attributing characters and yield. The correlation coefficients of yield with five important characters viz. percentage fruit set, number of pods, length of pods, girth of pods and 100 pod weight were calculated. The results showed that all the correlation coefficients were statistically significant.

Path coefficient analysis was applied to decompose the correlation coefficients of yield with each of the yield contributing characters to the direct effects of each of the characters and indirect effects through other character. (Results are shonw in Table 7 and the diagramatic representation in Fig. 9).

The direct effects of number of pods, 100 pod weight and length of pods were positive and that of percentage fruit set and girth of pods were negative. The maximum direct effect (0.77) was contributed by the number of pods. The positive direct effect of number of pods was increased by other factors, especially by 100 pod weight thereby accounting for a highly significant correlation of 0.97. Though the direct effect of 100 pod weight was only 0.32 it was highly correlated to yield (0.94), mainly due to the indirect effect through number of pods (0.72). The direct effect of length of pods was positive (0.14) and enhanced by the 100 pod weight

Table 7. Path coefficient analysis : Direct and indirect effects of the yield components on yield

Percentage Fruit set	Length of pods	Girth of pods	100 pod weight	No. of pods	Correlation coefficient
-<u>0.06838</u>	0.12214	-0.15820	0.28746	0.72298	0.9060
-0.05763	<u>0.14492</u>	-0.14248	0.24394	0.63104	0.8198
-0.06115	0.11672	-<u>0.17690</u>	0.27728	0.65345	0.8094
-0.06120	0.11007	-0.15272	<u>0.32119</u>	0.72006	0.9374
-0.06442	0.11917	-0.15063	0.30137	<u>0.76741</u>	0.9729

Residual effect = 0.196547

(Diagonal values denote the direct effects)

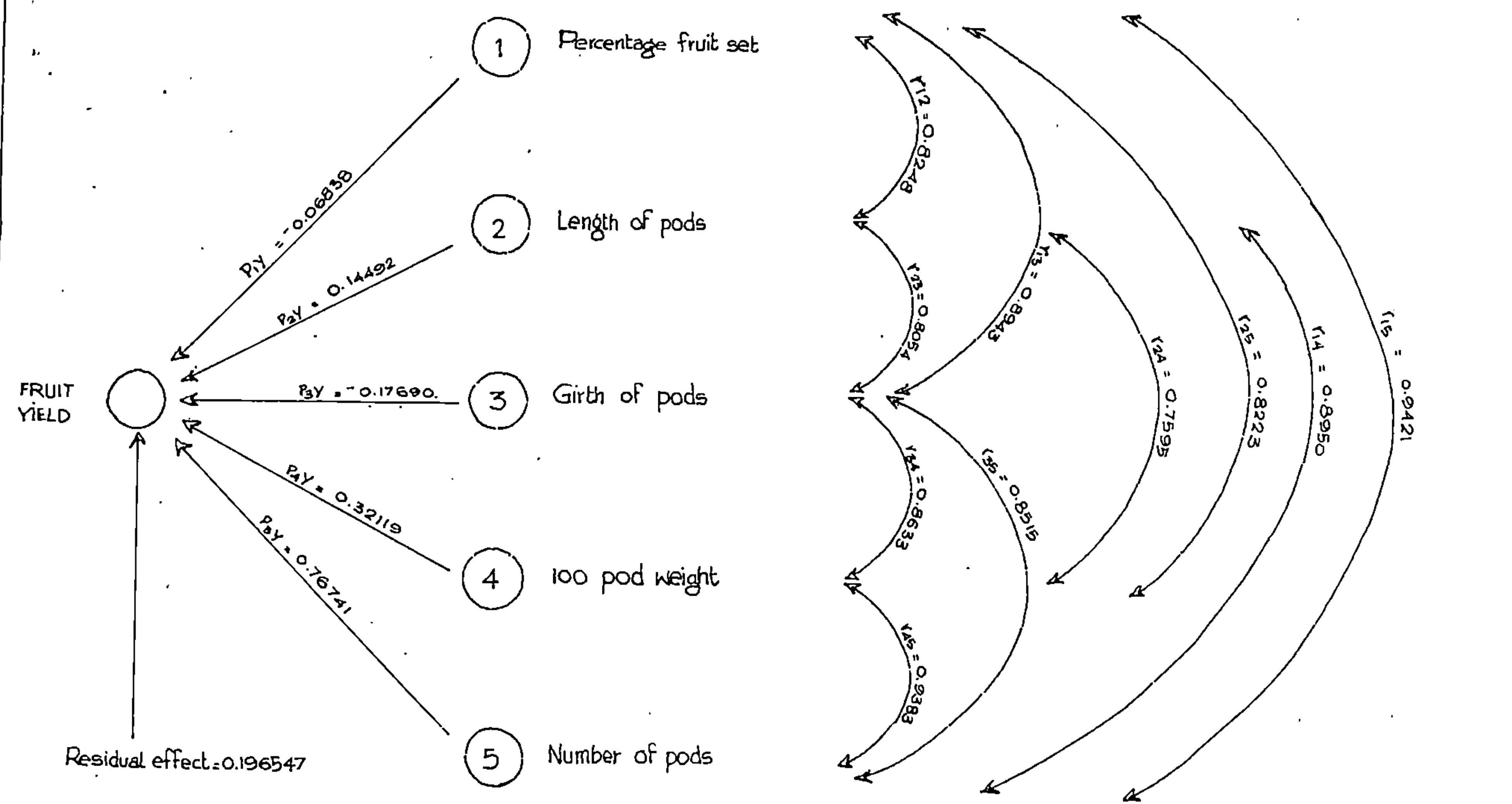

Fig 9 Path diagram on yield components of chilli

(0.25) and number of pods (0.63) but diminished by the girth of pods (0.14) and percentage fruit set (0.05), thereby accounting for a highly significant correlation of 0.82.

Percentage fruit set and girth of pods were also significantly correlated to yield, eventhough their direct effects were comparatively small and negative. The high correlation obtained was mainly due to the indirect effect through the number of pods and 100 pod weight.

The residual effect was negligibly small (0.196).

4.7. Economics and optimum doses of nutrients

4.7.1. Economics

4.7.1.1. Net income

The data on net income are shown in Table 6a and the analysis of variance in Appendix V.

Application of fertilizers significantly increased the net income from vegetable chilli cultivation. Nitrogen exerted significant influence in enhancing the net income from chilli. Nitrogen at 100 and 125 kg/ha was significantly superior to 75 kg N/ha. However, effects due to 100 and 125 kg/ha were statistically on par.

Phosphorus application significantly influenced the net income from chilli. Phosphorus at 40 kg P_2O_5/ha was significantly inferior to the higher doses. However, the effects due to 60 and 80 kg P_2O_5/ha were statistically on par. Phosphorus application at 60 kg P_2O_5/ha gave the maximum net income.

Application of potassium at 45 and 65 kg K_2O/ha significantly increased the net income from chilli compared with potassium at 25 kg K_2O/ha. Potassium application at 65 kg/ha resulted in maximum net incoem. However, the effects due to 65 and 45 kg K_2O/ha were on par.

Among the interaction effects, the combined effect of nitrogen and phosphorus was significant and a combination of 100 kg N/ha and 60 kg P_2O_5 gave the maximum net income (Table 6b).

4.7.1.2. Net return per rupee invested

The mean data on net return per rupee invested are presented in Table 6a and the graphical representation in Fig. 8 and analysis of variance in Appendix V.

As in the case of net income, net return per rupee invested was also increased due to the application of graded doses of nitrogen, phosphorus and potassium.

Nitrogen application at 100 and 125 kg/ha was significantly superior to 75 kg N/ha in increasing the net return per rupee invested in chilli cultivation. Application of nitrogen at 100 kg N/ha gave the maximum net return per rupee invested. However, the effects due to 100 and 125 kg N/ha were statistically on par.

With respect to phosphorus, application of 60 and 80 kg P_2O_5/ha was significantly superior to 40 kg P_2O_5/ha. The maximum net return per rupee invested was obtained with 60 kg P_2O_5, but the differences due to 60 and 80 kg P_2O_5/ha were statistically not significant.

Potassium application increased the net return per rupee invested upto 65 kg K_2O/ha. Application of 45 and 65 kg K_2O/ha was significantly superior to the lower level. The effects due to 45 and 65 kg K_2O/ha were statistically on par.

4.7.2. Optimum doses of nutrients

The quadratic response equation of the squareroot polynomial model, developed from the yield data is as follows.

$$Y = -221.95 + 39.84\sqrt{N} + 5.87\sqrt{P} + 2.14\sqrt{K} - 1.87\,N - 0.335\,P - 0.141\,K - 0.033\sqrt{NP}$$

The physical optimum doses of nitrogen, phosphorus and potassium were found to be 112:68:58 kg/ha respectively. The expected yield at this physical optimum was worked out to be 21.92 t/ha.

The economic doses of nitrogen, phosphorus and potassium were estimated at the prevailing market rates of Rs.6/- per kg of vegetable chilli, Rs.5.22 per kg of nitrogen, Rs.6.25 per kg of phosphorus and Rs.2.50 per kg of potassium. The economic doses of nitrogen, phosphorus and potassium can be fixed at 110:67:57 kg/ha respectively. The expected total yield at the economic doses of the nutrients was worked out to be 21.08 t/ha, fetching a net return of Rs.1,00,264/-.

DISCUSSION

5. DISCUSSION

An experiment was conducted at the Instructional Farm, College of Agriculture, Vellayani, during 1988 to study the effects of nitrogen, phosphorus and potassium on the growth, yield, quality and nutrient uptake of vegetable chilli variety Jwalasakhi. The results of the experiment are discussed in this chapter.

5.1. Growth characters

5.1.1. Height of plant

Application of nitrogen increased the height of plants at all the stages of observation. Increase in plant height is attributable to the rapid meristematic activity due to nitrogen as reported by Crowther (1935). Influence of N in increasing the vegetative growth of plants is a universally accepted fact. Significant increase in plant height due to incremental doses of nitrogen is in conformity with the results obtained by Joseph (1982), Paraminder Singh et al. (1986) and Rao and Gulshanlal (1986).

The results also indicated significant effect of phosphorus on the height of plants. Higher doses of phosphorus increased the plant height significantly in early stages. At the time of final harvest also, higher levels were superior in enhancing the plant height. The increase in height may be due to the higher rate of metabolic activity coupled with rapid cell division brought about by phosphorus (Bear, 1965). Its application at higher rates resulted in enhanced uptake of phosphorus and this might have resulted in increased utilization of nitrogen, leading to an increase in vegetative growth.

Potassium application did not significantly influence the plant height at any stage of observation. This might be due to the fact that the role played by potassium in increasing the vegetative growth is less marked than the other two major nutrients. Lack of response to potassium in increasing the plant height is in conformity with the results obtained by Mohamed Kunju (1968) and Shukla et al. (1987) in chilli.

5.1.2. Number of branches

The total number of branches produced per plant was significantly influenced by the application of incremental doses of nitrogen. Being a key element of plant growth, effect of nitrogen on vegetative growth is reflected on the number of branches produced by plant. Similar results of increased branching at higher levels of nitrogen have been reported by Joseph (1982), Paraminder Singh et al. (1986) and Rao and Gulshanlal (1986) in chilli.

Application of phosphorus significantly increased the number of branches per plant, upto 60 kg P_2O_5/ha. Since phosphorus is a constituent of cell nucleus, it is closely associated with cell division and meristematic activity (Bear, 1965). Its application at higher levels might have resulted in higher rates of availability of this nutrient leading to an increase in the number of branches per plant. Similar results have also been reported by Gill et al. (1974) and Joseph (1982).

Unlike nitrogen and phosphorus, application of potassium at graded levels did not influence significantly the total number of branches produced per plant. Lack of response to applied potassium in influencing the number of branches per plant is in conformity with the results obtained by Mohamed Kunju (1968), Chougule and Mahajan (1979), Joseph (1982).

5.1.3. Total dry matter production

There was significant influence of nitrogen, phosphorus and potassium on the total dry matter production per plant. The levels of 100 and 125 kg N/ha although on par were significantly superior to 75 kg N/ha. Increased doses of nitrogen have not only increased the plant height, but also increased the number of branches and number of fruits per plant, resulting in an increased dry matter production. Similar results in chilli have been reported earlier by Joseph (1982), Paraminder Singh et al. (1986) and Manchanda and Bhopal Singh (1987).

There was significant increase in total dry matter production upto 60 kg P_2O_5/ha. The increase in the total dry matter production by the application of higher doses of phosphorus may be due to the cumulative effect of phosphorus on plant height, number of branches per plant and number of pods per plant. Similar results have been reported by Chougule and Mahajan (1979) and Joseph (1982) in chilli.

Potassium application also resulted in significant increase in the total dry matter, with the maximum dry matter produced at 65 kg K_2O/ha. This may be due to the fact that higher levels of potassium enhanced higher uptake of nitrogen and resulted in more vigorous growth and higher yield of pods per plant. Joseph (1982) also reported similar effect of potassium on total dry matter production.

5.1.4. Shoot-Root Ratio

The shoot-root ratio was increased significantly by the application of nitrogen. Application of higher doses of nitrogen has given successively wider ratios indicating that shoot weight has been enhanced considerably by N nutrition as compared to root growth. Similar results have been reported earlier by James et al. (1967) and Mohamed Kunju (1968) in chilli.

Application of phosphorus has given a significant decrease in the shoot-root ratio. This may be attributed to better development of roots by increased doses of phosphorus application (Buckman and Brady, 1960).

The effect of potassium on shoot-root ratio was not statistically significant. Mohamed Kunju (1968) also reported similar influence of potassium on shoot-root ratio in chilli.

5.2. Time of 50% flowering, yield components and yield

5.2.1. Time of 50% flowering

Application of nitrogen at higher levels had significantly delayed the time of 50% flowering. Nitrogen at higher doses has a tendency to prolong the vegetative phase and delay the maturity of chilli crop (Joachim and Paul, 1939). The influence of nitrogen in increasing the time of 50% flowering is in conformity with the results obtained in chilli by Chougule and Mahajan (1979) and Rao and Gulshan Lal (1986).

Phosphorus application at higher levels induced earliness in flowering significantly. Phosphorus at 60 and 80 kg

P_2O_5/ha were significantly superior to 40 kg P_2O_5/ha. Similar results of inducing earliness to flowering in chilli due to the application of higher doses of phosphorus have also been reported by Khan and Suryanarayana (1977) and Joseph (1982).

Application of potassium also, significantly reduced the mean number of days taken for 50% flowering. This is in conformity with the results obtained by Pimpini (1967).

5.2.2. Number of flowers per plant

Application of nitrogen at 100 and 125 kg/ha significantly increased the mean number of flowers produced per plant. Plant supplied with higher doses of nitrogen might have prompted an increased number of flower buds. The result of the present investigation is in conformity with the results obtained by Mohamed Kunju (1968) and Dass and Mishra (1972) in this respect.

The number of flowers produced per plant increased significantly upto 60 kg P_2O_5/ha. An adequate supply of phosphorus in early stages of the plant growth is important in the initiation of flower primordia (Tisdale and Nelson, 1965). Mohamed Kunju (1968) also observed similar effect of phosphorus on the number of flowers produced per plant.

Application of potassium has not resulted in any significant influence on the mean number of flowers produced per plant.

5.2.3. Percentage fruit set

Percentage fruit set was increased significantly due to higher levels of nitrogen application. 100 and 125 kg N/ha were significantly superior to 75 kg N/ha. The effects of nitrogen at 100 and 125 kg/ha levels were on par. Similar observations have been made earlier by Mohamed Kunju (1968) and Joseph (1982).

Setting percentage increased with increased levels of phosphorus also with the maximum obtained at 80 kg P_2O_5/ha. The effect of 80 kg and 60 kg P_2O_5/ha were on par. The result obtained in the present study is in agreement with the earlier findings by Joseph (1982).

Application of potassium did not produce any significant influence on the setting percentage of chilli fruits. Similar results regarding the effect of potassium have been reported earlier by Mohamed Kunju (1968) and Joseph (1982).

5.2.4. Number of pods per plant

The number of pods produced per plant increased progressively with successive higher levels of nitrogen application.

This increase in the number of pods per plant by the application of higher doses of nitrogen was due to the increased production of flowers and high setting percentage observed at higher levels of nitrogen application (Table 4). Similar results of enhanced number of pods per plant by the application of higher doses of nitrogen have been reported by Joseph (1982), Subbiah (1983) and Shukla et al. (1987).

Application of phosphorus at 80 and 60 kg P_2O_5/ha was significantly superior to 40 kg P_2O_5/ha with respect to the number of pods per plant. Increased number of pods per plant at higher levels of phosphorus application was due to the significant influence of phosphorus in increasing the number of flowers produced per plant and setting percentage at higher levels of its application. Similar result has been reported in chillies by Chougule and Mahajan (1979) and Joseph (1982).

Application of potassium did not show any profound influence on the total number of pods produced per plant. It may be remembered that the influence of potassium on total number of flowers produced per plant and setting percentage was not significant as seen in Table 4. Therefore it is quite imperative that potassium could not influence the total number of pods/plant. This finding is in conformity with the results obtained by Covarelli (1976) and Joseph (1982).

5.2.5. Length of pods

Application of nitrogen was found to be significant in enhancing the length of pods. There was significant increase upto 100 kg N/ha in this respect. However, the effects due to 100 and 125 kg N/ha were statistically on par. Increased length of pods due to nitrogen application has been reported earlier by Khan and Suryanarayana (1977), Joseph (1982) and Dod et al. (1983).

The difference in length due to graded levels of phosphorus was statistically not significant. With respect to potassium also the effect was not statistically significant, though there was a slight increase in the mean length of pods at the highest level tried. The results obtained in the present study are in conformity with the findings by Mohamed Kunju (1968).

5.2.6. Girth of pods

Among the graded levels of nitrogen, phosphorus and potassium, application of nitrogen significantly increased the mean girth of pods. Nitrogen at 100 and 125 kg/ha although on par, were significantly superior to 75 kg N/ha. Similar effects of nitrogen on the girth of chilli pods have also been reported by Khan and Suryanarayana (1977) and Joseph (1982).

Differences in mean girth of pods due to graded doses of phosphorus and potassium were statistically not significant. This is in conformity with the result obtained by Mohamed Kunju (1968).

5.2.7. 100 pod weight

There was significant influence by nitrogen, phosphorus and potassium on 100 pod weight. Application of nitrogen gave a progressive increase in 100 pod weight with graded levels of nitrogen. Such an increase in pod weight can be attributed to the plumpiness of the fruits due to increased synthesis of carbohydrates at higher levels of nitrogen application. The result obtained in this investigation is in agreement with the findings of Mohamed Kunju (1968) and Joseph (1982).

100 pod weight increased significantly upto 60 kg P_2O_5/ha. Pimpini (1967) also noted that phosphorus in combination with potassium increased the average pod weight in chillies.

There was progressive increase in 100 pod weight with successive levels of applied potassium also. This may be due to the role of potassium in the formation and translocation of carbohydrates in plants as reported by Tisdale and Nelson (1965), thereby resulting in an increase in pod weight. Similar results have been observed earlier by Mohamed Kunju (1968) and Joseph (1982) in chillies.

5.2.8. Yield of chilli

Application of nitrogen, phosphorus and potassium significantly increased the yield of vegetable chilli. The influence of nitrogen was profound in increasing the yield. Application of nitrogen at 100 and 125 kg/ha was significantly superior to 75 kg N/ha. The effects due to 100 and 125 kg N/ha were statistically on par. In the present study it can be seen that nitrogen at higher levels has significantly increased the number of flowers produced, setting percentage, number of pods per plant and 100 pod weight (Table 4). The overall effects of these factors might have contributed to the observed significant yield increase with high levels of N. Similar results have been reported earlier by several research workers (Subbiah, 1983; Srinivas, 1983; Narasappa et al. 1985; Hegde, 1986; Paraminder Singh et al. 1986; Prabhakar et al. 1987; Shukla et al. 1987 and Ramarao et al. 1988).

There was significant increase in yield upto 60 kg P_2O_5/ha. Phosphorus at 40 kg P_2O_5/ha was significantly inferior to both 80 and 60 kg P_2O_5/ha. This can be attributed to the favourable effects of phosphorus on number of pods, percentage fruitset and 100 pod weight. Increase in yield due to phosphorus application was reported earlier by Khan and Suryanarayana (1977), Joseph (1982) and Prabhakar et al.(1987).

There was progressive increase in yield with graded doses of potassium. Application of potassium at 65 and 45 kg K_2O/ha was superior to 25 kg K_2O/ha. Potassium has shown significant influence on 100 pod weight. Potassium also had its influence on the uptake and utilization of nitrogen. These may be the probable reasons for the significant effect of potassium on the yield of chillies. The results are in conformity with the observations made by Subbiah (1983), Kadam et al. (1985) and Ramarao et al. (1988).

Among the various interactions, combined effect of nitrogen and phosphorus was significant. Plants supplied with 100 kg/ha N and 60 kg/ha P_2O_5 produced the maximum yield of 20.01 t/ha. Many research workers have reported increased yield of chilli by the application of nitrogen in combination with phosphorus (Lal and Pundrik, 1971; Gill et al. 1974 and Joseph, 1982).

5.3. Ascorbic acid content of fruits

Application of fertilizer nutrients exerted significant influence on fruit ascorbic acid content. Application of 100 and 125 kg N/ha significantly increased the ascorbic acid content of fresh fruits compared with 75 kg N/ha. However, the effects due to 100 and 125 kg N/ha were on par. This result is in agreement with the findings of Dod et al. (1983), Paraminder Singh et al. (1986) and Manchanda and Bhopal Singh (1987).

The differences due to graded levels of phosphorus and potassium in the mean fruit ascorbic acid content were not statistically significant. Similar results have been reported earlier by Khan and Suryanarayana (1977) and Joseph (1982).

5.4. Nutrient uptake by plants

5.4.1. Uptake of nitrogen

There was a progressive increase in the total uptake of nitrogen by plants due to graded levels of nitrogen application. The effects due to the application of 100 and 125 kg N/ha were on par which in turn were significantly superior to 75 kg N/ha. Similar results were also reported by James et al. (1967) and Joseph (1982).

The uptake of nitrogen increased with increase in the level of applied phosphorus. However, the difference due to 80 and 60 kg P_2O_5/ha was statistically not significant. The beneficial effects of higher levels of phosphorus in increasing the uptake of nitrogen have been reported earlier by James et al. (1967) and Joseph (1982).

Potassium application significantly increased the total uptake of nitrogen by plants, with the maximum uptake at 65 kg K_2O/ha. Similar results of increase in the uptake of nitrogen by the application of graded doses of potassium were reported by Ozaki and Hamilton (1954). Spaldon and Ivanic (1968), Ivanic and Strelec (1976) and Joseph (1982).

5.4.2. Uptake of phosphorus

The various fertilizer treatments significantly influenced the total uptake of phosphorus by plants. Nitrogen application at 100 and 125 kg/ha was significantly superior to 75 kg N/ha in enhancing the uptake of phosphorus. Increased uptake of phosphorus with increasing levels of applied nitrogen has also been reported by James et al. (1967) and Joseph (1982).

Application of phosphorus significantly increased the uptake of phosphorus by plants. Phosphorus at 80 kg P_2O_5/ha recorded the highest total uptake. Increased uptake of phosphorus with increasing levels of applied phosphorus was reported earlier by James et al. (1967) and Joseph (1982).

The influence of potassium on the total uptake of phosphorus by plant was not significant.

5.4.3. Uptake of potassium

Application of fertilizers significantly increased the total uptake of potassium by plants. There was a progressive increase in the uptake of potassium with incremental doses of nitrogen. Increased uptake of potassium with increasing levels of applied nitrogen has also been reported by Ozaki and Hamilton (1954) and Joseph (1982).

Potassium uptake increased with increasing levels of phosphorus upto 60 kg P_2O_5/ha. Phosphorus has got a favourable effect on the uptake of applied potassium. Similar result has been reported earlier by Joseph (1982).

Application of graded doses of potassium significantly increased the potassium uptake by plants. The highest total uptake was with 65 kg K_2O/ha. The beneficial effects of higher levels of potassium application in increasing its uptake were reported earlier by many workers (Spaldon and Ivanic, 1968; Ivanic and Strelic, 1976 and Joseph, 1982).

5.5. Soil nutrient status

The data on soil analysis after the experiment clearly showed that application of nitrogen, phosphorus and potassium had significant influence on the soil nutrient contents after the experiment.

In plots receiving no fertilizer, there was considerable reduction in available nitrogen content after the experiment. This reduction in available nitrogen status from 210.38 kg/ha to 196.50 kg/ha can be mainly attributed to the uptake and utilization of nitrogen by the crop. On the contrary, the available nitrogen content in the treatment plots increased significantly when the soil received any of the fertilizer treatment. However, the effects due to graded doses of any of the fertilizer treatments were statistically not significant. The different doses of nutrients applied might not be sufficient enough to increase the N status of the soil after meeting the crop requirement of the nutrient.

The available phosphorus content of the soil in the fertilizer treatments increased considerably after the experiment, although the effects due to graded doses of any of the fertilizer nutrients were not significant.

The available potassium content of the soil remained more or less the same, after the experiments in plots which received no fertilizer treatment. But it increased significantly due to various fertilizer treatments. However, the effects due to graded levels of any of the nutrients were statistically not significant.

The results of soil analysis however, indicates the superiority of nitrogen, phosphorus and potassium fertilization in improving the available nutrient status of the soil.

5.6. Correlation studies

The results of correlation studies clearly showed that, the correlation coefficients of yield with the yield attributing characters (percentage fruitset, number of pods, length of pods, girth of pods and 100 pod weight) were statistically significant.

The path coefficient analysis indicated that, the direct effects of number of pods per plant, 100 pod weight and length of pods were positive and that of percentage fruitset and girth of pods were negative.

The maximum direct effect (0.77) was contributed by the number of pods/plant and its total correlation with yield was high (0.97), exerted through the indirect effects of other factors, especially through 100 pod weight. Many research workers have shown that the number of fruits is the principal yield attribute in chilli (Singh et al. 1972; Lee, 1976; Mishra et al. 1976 and Gill et al. 1977).

The enhanced correlation of 100 pod weight to the yield obtained in this study was mainly due to the indirect effects of number of pods and length of pods and this is in conformity with the result obtained by Rocchella et al. (1976) in chillies.

The direct and positive correlation of fruit length with yield obtained in this study is in agreement with the findings of Chang (1977) in chillies.

From the above result, it is clear that number of pods and 100 pod weight are the major contributing factors to yield in chilli followed by length of pods. The 20% value estimated for residue reveals that 80% of the variation in yield can be explained through the five factors studied.

5.7. Economics and optimum doses of nutrients

5.7.1. Economics

5.7.1.1. Net income

Application of nitrogen significantly influenced the net income from chilli cultivation. When the level of nitrogen increased from 75 to 100 kg/ha, net income rose from Rs.52,144/- to Rs.89,384/-. But nitrogen application beyond 100 kg N/ha slightly lowered the net income, eventhough the differences were statistically not significant.

Phosphorus application exerted significant influence on net income from chilli. Application of 60 kg P_2O_5/ha gave the maximum net income of Rs.79,130/-. It was significantly higher than the net income obtained with 40 kg P_2O_5/ha (Rs.72,094/-). However, application of phosphorus beyond 60 kg P_2O_5/ha resulted in a slight decrease in the net income, though the differences were statistically not significant.

The net income from chilli increased with graded levels of potassium also. Application of 25 kg K_2O/ha was significantly inferior to the higher doses in influencing the net income. Potassium application at 65 kg K_2O/ha gave the maximum net return of Rs.78,704/-. However, it was on par with the effect of 45 kg K_2O/ha in this respect.

5.7.1.2. Net return per rupee invested.

Fertilizer nutrients exerted profound influence on the net return per rupee invested. By increasing the level of nitrogen from 75 to 100 kg/ha, the net return per rupee invested increased from 1.99 to 3.41 clearly indicating the beneficial effect of nitrogen in increasing the returns from chilli. However, application of nitrogen beyond 100 kg N/ha, slightly reduced the net return per rupee invested, though the effects were statistically on par.

Application of phosphorus upto 60 kg P_2O_5/ha significantly increased the net return per rupee invested. From 2.75 at 40 kg P_2O_5/ha, it rose to 3.02 at 60 kg P_2O_5/ha. However, phosphorus application beyond 60 kg P_2O_5/ha decreased the net return per rupee invested though the differences were statistically not significant.

With respect to potassium, application of 65 kg K_2O/ha resulted in maximum net return of Rs.3/- per rupee invested. The result clearly indicates the influence of potassium in enhancing the net returns from chilli. However, the response was statistically not significant beyond 45 kg K_2O/ha.

5.7.2. Optimum doses of nutrients

From the present study it has been revealed that nitrogen, phosphorus and potassium @ 112:68:58 kg/ha respectively were required for maximum yields and a dose of 110:67:57 kg/ha for economic optimum yields of approximately 21 t/ha, fetching a net return of more than Rs.1 lakh.

At present no specific nutrient recommendations have been evolved for chillies for the State of Kerala. There is only a general recommendation for solanaceous vegetables as a whole. The economic doses of nitrogen, phosphorus and potassium for vegetable chilli obtained in the present study are much higher than the current recommendation for solanaceous vegetables as a whole (75:40:25 kg/ha). This brings to light the importance of increasing the nutrient application for obtaining maximum productivity from such a crop which can give yields as high as 21 t/ha which more than compensates the cost of additional fertilizers.

SUMMARY

6. SUMMARY

A field experiment was conducted at the Instructional Farm of the College of Agriculture, Vellayani, during the period from August to December 1988, to study the effects of graded doses of nitrogen, phosphorus and potassium on the growth, yield, quality and nutrient uptake of vegetable chilli, variety Jwalasakhi. The soil of the experimental field was red loam, acidic in reaction, low in available nitrogen and potassium and medium in available phosphorus. The treatments were three levels each of nitrogen (75, 100 and 125 kg N/ha), phosphorus (40, 60 and 80 kg P_2O_5/ha) and potassium (25, 45 and 65 kg K_2O/ha) with control. The experimentment was laid out as a 3^3+1 partially confounded factorial in RBD, confounding NP^2K and NP^2K^2 in replications 1 and 2 respectively. The results of the experiment are summarised below.

1. Plant height increased due to graded doses of nitrogen and phosphorus whereas potassium application exerted no appreciable influence on plant height.

2. Number of branches produced per plant increased with successive levels of nitrogen. Phosphorus application significantly increased the number of branches upto 60 kg P_2O_5/ha. Potassium had no significant influence on branching.

3. Higher doses of nitrogen, phosphorus and potassium significantly increased the total drymatter production per plant. However, the effects due to nitrogen was more pronounced than that of phosphorus and potassium.

4. Graded doses of nitrogen progressively increased the shoot-root ratio while phosphorus application significantly decreased this aspect. Potassium did not influence the shoot-root ratio significantly.

5. Number of days taken for 50% flowering increased significantly with successive levels of nitrogen. But phosphorus application at higher doses resulted in significant earliness in flowering. Significant earliness in flowering was obtained with 65 kg K_2O/ha also.

6. Nitrogen and phosphorus application significantly increased the mean number of flowers produced per plant. Potassium had no significant influence in this respect.

7. Number of pods produced per plant was significantly increased with graded doses of nitrogen. Higher doses of phosphorus also significantly increased the total number of pods per plant. Application of graded doses of potassium had no significant influence on the number of pods produced per plant.

8. Application of higher doses of nitrogen and phosphorus significantly increased the percentage fruit set. Potassium had no significant influence on setting percentage.

9. Nitrogen application significantly increased the mean length of pods upto 100 kg N/ha. Phosphorus and potassium had no significant influence on length of pods.

10. Girth of pods increased significantly with higher doses of nitrogen, but was not influenced by phosphorus or potassium.

11. 100 pod weight increased significantly upto 100 kg N/ha, though the maximum weight was obtained with 125 kg N/ha. Phosphorus application increased the 100 pod weight significantly upto 60 kg P_2O_5/ha. Higher doses of potassium also resulted in significant increase in 100 pod weight.

12. Yield of chilli increased significantly with nitrogen application upto 100 kg N/ha. There was significant increase in yield upto 60 kg P_2O_5/ha. A combination of 100 kg N/ha and 60 kg P_2O_5/ha produced the maximum yield of chilli. Higher doses of potassium also significantly increased the mean yield.

13. Application of nitrogen significantly increased the mean ascorbic acid content of fresh fruits upto 100 kg N/ha. Phosphorus and potassium had little influence on the ascorbic acid content of chilli pods.

14. The total uptake of nitrogen by plant was significantly increased by higher doses of all the three nutrients tried.

15. Higher doses of nitrogen and phosphorus significantly increased the total uptake of phosphorus by plant. But the effect of potassium was not significant.

16. The total uptake of potassium was significantly influenced by graded doses of all the three nutrients. The effect due to nitrogen was significant upto 100 kg N/ha. Phosphorus also gave the maximum uptake at 60 kg P_2O_5/ha. Potassium application significantly increased its uptake upto 65 kg K_2O/ha

17. Application of fertilizers significantly increased the mean content of available nitrogen, available phosphorus and available potassium in soil after the experiment as compared to control. But the effects due to graded doses of nitrogen, phosphorus or potassium were not significant in the treatment plots.

18. Number of pods and 100 pod weight were the important yield contributing factors in chilli, followed by length of pods.

19. Application of nitrogen significantly increased the net income from chilli upto 100 kg/ha, beyond which the effect was not significant. Phosphorus application increased the net income upto 60 kg P_2O_5/ha, beyond which it declined slightly. A combined application of 100 kg N/ha and 60 kg P_2O_5/ha gave the maximum net income from chillies. In the case of potassium, the maximum net income was obtained with 65 kg K_2O/ha.

20. The net return per rupee invested was increased with nitrogen application upto 100 kg N/ha beyond which it decreased slightly. Phosphorus application upto 60 kg P_2O_5/ha significantly increased the net return per rupee invested. In the case of potassium, application of 45 and 65 kg K_2O/ha significantly increased the net return per rupee invested.

21. The physical optimum doses of nitrogen, phosphorus and potassium were estimated to be 112:68:58 kg/ha respectively with the expected yield of 21.9 t/ha.

22. The economic optimum doses of nitrogen, phosphorus and potassium were estimated to be 110:67:57 kg/ha respectively with the expected total yield of 21.08 t/ha, fetching a net return of Rs.1,00,264/-.

Future line of work

The present study has revealed that 112:68:58 kg/ha N, P and K respectively were the optimum doses of nutrients for maximum yield, while economic optimum were obtained at 110:67:57 kg/ha of N, P and K respectively. However, in partially shaded coconut garden conditions and homesteads, where this vegetable is commonly grown in our State, the nutrient recommendation may vary from the results obtained from the present study which was conducted in the open. This needs further investigation.

Moreover, in the present study, the nutrient requirements were assessed at constant closer spacing of 40 x 35 cm. The optimum spacing for this newly released variety has not yet been worked out. In this context, it would be worthwhile to estimate the nutrient requirements in relation to plant density studies.

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* Original not seen

APPENDICES

Appendix-I

Meteorological data during the cropping period

Standard weeks	Period From	Period To	Rainfall mm	Maximum Temperature °C	Minimum Temperature °C	Relative humidity %
35	27-8-1988	2-9-'88	65.2	30.2	23.6	77.57
36	3-9-'88	9-9-'88	121.2	30.0	23.5	72.57
37	10-9-'88	16-9-'88	58.0	30.1	23.3	83.00
38	17-9-'88	23-9-'88	89.3	29.4	23.21	71.93
39	24-9-'88	30-9-'88	14.9	29.8	24.1	85.29
40	1-10-'88	7-10-'88	0.0	30.6	24.1	77.86
41	8-10-'88	14-10-'88	0.0	31.3	24.2	76.56
42	15-10-'88	21-10-'88	0.0	32.8	24.6	72.43
43	22-10-'88	28-10-'88	11.6	31.9	23.5	77.14
44	29-10-'86	4-11-'88	20.6	31.8	23.0	74.07
45	5-11-'88	11-11-'88	55.3	30.1	22.2	77.50
46	12-11-'88	18-11-'88	2.9	30.9	23.6	71.14
47	19-11-'88	25-11-'88	0.0	31.7	23.5	63.07
48	26-11-'88	2-12-'88	0.0	31.3	22.2	71.71
49	3-12-'88	9-12-'88	6.4	30.7	22.7	72.64
50	10-12-'88	16-12-'88	0.0	31.2	22.9	72.36

Appendix-II

Analyses of variance of height, number of branches, drymatter production and shoot-root ratio

Source	DF	Mean squares					
		Height of plant			No. of branches at harvest	Drymatter production per plant	Shoot-root ratio
		35 days after planting	70 days after planting	At harvest			
Blocks	5	7.256	10.615	3.256	50.775**	12.150	0.0191
N	2	145.05**	639.132**	761.054**	3710.57**	6084.016**	2.860**
P	2	9.388*	17.242	54.990**	319.812**	105.812**	0.268**
K	2	0.7226	1.906	13.718	13.921	30.156**	0.015
N x P	4	13.278*	9.851	8.445	11.765	6.320	0.013
P x K	4	1.277	1.714	4.695	11.171	13.031*	0.0050
N x K	4	2.77	1.601	7.281	1.960	6.335	0.0048
NPK	2	3.5	0.132	1.718	3.640	9.234	0.018
NP^2K	2	6.037	4.925	1.371	3.441	12.394	0.030
NPK^2	2	3.388	1.796	3.390	1.421	3.218	0.0118
NP^2K^2	2	1.815	6.371	2.257	7.710	2.859	0.033
Trt V contrl	1	1353.75**	1158.67**	1033.359**	7533.84**	5180.313**	5.190**
Error	27	95.40	9.686	7.557	10.141	4.743	0.024

* Significant at 5% level

** Significant at 1% level

Appendix-III

Analyses of variance of time of 50% flowering, number of flowers, percentage fruitset, number of pods, length of pods and girth of pods

Source	DF	Mean square					
		Time of 50% flowering	No. of flowers per plant	Percentage fruitset	No. of pods per plant	Length of pods	Girth of pods
Blocks	5	17.496**	0.375**	24.340**	0.3010**	1.573**	0.3005**
N	2	99.50**	12.445**	143.765**	12.987**	4.282**	0.7883**
P	2	10.722**	1.055**	23.671**	1.38**	0.172	0.0455
K	2	12.50**	0.031	0.093	0.015	0.053	0.113
N x P	4	0.221	0.059	0.914	0.052*	0.087	0.048
P x K	4	0.221	0.0089	0.421	0.0052	0.129	0.051
N x K	4	1.0	0.0063	0.468	0.0032	0.029	0.019
NPK	2	0.722	0.0112	0.148	0.0034	0.117	0.088
NP^2K	2	2.481	0.0137	0.058	0.013	0.013	0.024
NPK^2	2	0.054	0.0148	0.312	0	0.028	0.0065
NP^2K^2	2	0.037	0.017	0.843	0.0039	0.307	0.0097
Trt V contrl	1	109.351**	39.691**	888.968**	44.85**	21.560**	18.33**
Error	27	3.020	0.0310	3.131	0.015	0.206	0.047

* Significant at 5% level

** Significant at 1% level

Appendix-IV

Analyses of variance of 100 pod weight, yield, ascorbic acid content of fruits, and uptake of nitrogen, phosphorus and potassium by plant

Source	DF	Mean squares					
		100 pod weight	Yield	Ascorbic acid content of fruits	Uptake of nitrogen	Uptake of phosphorus	Uptake of potassium
Blocks	5	456.6*	4.349**	4.412	10.7656	0.927	10.162**
N	2	192.50**	225.967**	1175.689**	2061.258**	68.032**	3827.42**
P	2	1197.50**	7.867**	20.218	207.210**	10.512**	224.656**
K	2	950.50**	4.620**	3.312	54.234**	0.690	228.359**
N x P	4	67.50	1.528**	7.75	2.992	0.416	6.398
P x K	4	28.75	0.644	1.328	3.839	0.123	0.960
N x K	4	51.00	0.374	0.468	2.753	0.112	3.39
NPK	2	14.50	0.688	0.6875	0.1875	0.098	2.20
NP^2K	2	200.25	0.0053	4.312	14.175	0.453	1.078
NPK^2	2	50.00	0.096	0.656	0.664	0.047	1.609
NP^2K^2	2	86.00	0.2836	2.078	4.10	0.260	0.570
Trt V contrl	1	896.29**	484.45**	19189.06**	6187.25**	156.418**	7343.21**
Error	27	139.24	0.287	31.785	4.890	0.487	1.762

* Significant at 5% level

** Significant at 1% level

Appendix-V

Analyses of variance of soil nutrient content after the experiment and economics of cultivation

		Mean squares				
		Soil nutrient content after the experiment			Economics of cultivation	
Source	DF	Available nitrogen	Available phosphorus	Available potassium	Net income	Net returns per rupee invested
Blocks	5	234.27*	32.871**	6.575	44252672**	0.0618**
N	2	152	0.390	5.718	2117785600**	3.092**
P	2	129.95	7.167	6.156	56422400**	0.085**
K	2	32.25	5.054	8.656	83075200**	0.048**
N x P	4	107.25	6.804	5.218	5199872**	0.0072*
P x K	4	86.87	2.972	1.843	2900992*	0.0042
N x K	4	205.50	0.111	9.718	1607686	0.0025
NPK	2	151.75	5.554	6.875	6545408**	0.0019
NP^2K	2	26.00	16.777	15.43	281600	0.0006
NPK^2	2	53.25	4.167	9.375	385024	0.0006
NP^2K^2	2	102.00	2.111	2.10	1027072	0.0016
Trt V contrl	1	20089.00**	735.843**	1694.50**	4414550000**	6.2253**
Error	27	75.574	13.794	10.288	972800	0.0028

* Significant at 5% level

** Significant at 1% level

ABSTRACT

A field experiment was conducted at the Instructional Farm of the College of Agriculture, Vellayani during the period August to December 1988 to study the effects of graded doses of nitrogen, phosphorus and potassium on the growth, yield and quality of vegetable chilli variety 'Jwala Sakhi'. The soil of the experimental field was red loam, acidic in reaction, low in available nitrogen and potassium and medium in available phosphorus. The treatments consisted of factorial combinations of 3 levels each of nitrogen (75, 100 and 125 kg N/ha), phosphorus (40, 60 and 80 kg P_2O_5/ha) and potassium (25, 45 and 65 kg K_2O/ha) with absolute control. The experiment was laid out as a 3^3+1 partially confounded factorial in Randomised Block Design confounding NP^2K and NP^2K^2 in replication 1 and 2 respectively. An abstract of the resul. is given below.

Application of nitrogen and phosphorus had profound influence on all growth characters like plant height, number or branches, drymatter production, shoot-root ratio and number of days taken for 50% flowering. Application of potassium exerted significant influence only on drymatter production and number of days taken for 50% flowering among the growth characters.

Yield attributes such as number of flowers, number of pods, percentage fruit set, length of pods, girth of pods and 100 pod weight were significantly increased by the application of nitrogen. Phosphorus application also significantly influenced the yield attributes except length and girth of pods. Influence of potassium was significant only for 100 pod weight. The mean yield of chilli increased with the application of all the three nutrients.

Application of nitrogen significantly increased the ascorbic acid content of fresh fruits upto 100 kg N/ha. Phosphorus and potassium had little influence in this respect.

Uptake of nitrogen was found to be influenced by higher doses of all the three nutrients. Phosphorus uptake was significantly influenced by nitrogen and phosphorus and phosphorus and potassium application significantly increased the potassium uptake by plant.

The influence of graded levels of nutrients was not significant in enhancing the content of available nitrogen, phosphorus or potassium in soil after the experiment.

Number of pods and 100 pod weight were found to be the important yield contributing factors followed by length of pods.

The net income and net return per rupee invested were significantly influenced by all the three nutrients and application of 110 kg N, 67 kg P_2O_5 and 57 kg K_2O per ha was found to be the economic optimum doses of the nutrients.