NUTRIENT MANAGEMENT IN SNAKE GOURD
(*Trichosanthes anguina* L.)
UNDER PARTIAL SHADE

By

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THESIS
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Department of Agronomy
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DECLARATION

I hereby declare that this thesis entitled "Nutrient management in snake gourd (Trichosanthes anguina L.) under partial shade" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

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CERTIFICATE

Certified that this thesis entitled "Nutrient management in snake gourd (*Trichosanthes anguina* L.) under partial shade" is a record of research work done independently by Sri. Abdul Haris, A. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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INTRODUCTION

INTRODUCTION

Vegetables are considered important to man in many ways. They contribute substantially to the nutritive quality of human diet by providing proteins, carbohydrates, minerals and vitamins. Vegetables are also known as a cheap source of nutrition to human beings. In India, vegetable crops occupy less than two per cent of the total cropped area, producing nearly 45 million tonnes, as against a national requirement of about 98 million tonnes (Anon, 1988). In Kerala, the present rate of vegetable consumption is only 29 gram/day/head as against a requirement of 150 gram/day/head.

Inclusion of vegetables in the farming systems will ensure higher yields per unit area with increased supply of calorie value, proteins, vitamins and minerals ensuring a balanced diet to common man and higher income to small and marginal farmers and generate more employment. Hence, there is ample scope for scientific research for increasing productivity of vegetable crops in our country.

Believed to be native of Indian subcontinent, snake gourd (Trichosanthes anguina) occupies a pride of place among vegetables particularly in South India, where it is most commonly grown in the home gardens (Choudhury, 1987). In Kerala, snake gourd is cultivated during summer. It is grown for their immature fruits and is a source of vitamins, minerals, carbohydrates and proteins. Cultivation of this crop is found to be highly remunerative.

Kerala is unique in having a homestead farming system of small operational holdings with coconut palms and a variety of crops wherein vegetable cultivation forms an integral part. Earlier studies conducted revealed that the total amount of light that infiltrates to the ground through a coconut canopy is as much as 50 per cent in palms aged 40 years and increase further with increase in age of palms. Except in gardens of eight to twenty five year old palms, the light infiltration to the ground is enough to satisfy the requirements of intercrops (Nair, 1979). However, suitable technologies and research results for vegetables cultivated under homestead conditions are not available.

Balanced use of fertilizers is one of the important means of increasing productivity per unit area. The present fertilizer recommendation for snake gourd in the state is based on trials conducted in the open situation and as such is not suitable for homestead condition, where this crop is intercropped in coconut gardens under partial shade.

Considering all these factors, the present study was undertaken with the following objectives.

1. To determine the N, P_2O_5 and K_2O requirements of snake gourd under partial shade condition in coconut gardens

2. To investigate the uptake of major nutrients in snake gourd crop

3. To study the economics of cultivation of snake gourd under different fertilizer schedule.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Snake gourd is one of the major vegetable crops of Kerala and is widely cultivated in the homesteads. However, experimental evidences on the nutritional requirements of this crop under homestead situations are meagre. The research work carriedout on the influence of nitrogen, phosphorus and potassium and shade on the growth, yield, quality and nutrient uptake of snake gourd and other cucurbits are briefly reviewed and presented below.

2.1. Influence of nutrients and shade on growth characters

2.1.1. Nitrogen

Locasio *et al*. (1972) reported that the length of vine was significantly increased under higher doses of nitrogen application in water melon. Wilcox (1973) observed optimum growth of musk melon when ammonium nitrate was applied at the rate of 80-90 kg/ha. Ogunremi (1978) reported increase in number of leaves in water melon with graded doses of nitrogen upto 72 kg/ha. Randhawa *et al*. (1981) reported optimum plant growth in musk melon with a nitrogen level of 50 kg/ha. Increased number of branches and growth promotion in long melon by nitrogen application was reported by Ray Choudhury *et al*. (1982). Singh *et al*. (1983) recorded maximum length of vine with 75 kg N/ha in round melon. Mangal *et al*. (1987) reported that there was no increase in length of musk melon vines beyond 60 kg N/ha and growth of vine was significantly poor when nitrogen application was not made. Increase in the dry matter production with increase in nitrogen levels upto 120 kg/ha in water melon was reported by Hegde (1987).

For a successful crop of bitter gourd, Katyal (1977) suggested 50 t/ha of farmyard manure and 100 kg/ha of ammonium sulphate. George Thomas (1984) reported increased leaf area index and dry matter production upto 60 kg N/ha in bitter gourd. Das *et al*. (1987) observed that higher rates of nitrogen application resulted in increasing vine length, number of vine per plant and number of nodes per vine in pointed gourd.

Mc Collum and Miller (1971) observed maximum dry matter production at 91 kg N/ha in pickling cucumbers. Rajendran (1981) reported in pumpkin, significant increase in leaf area index at 30 and 60 days after sowing (DAS) and increased total dry matter at 60 DAS and at harvest with increasing level of nitrogen.

2.1.2. Phosphorus

According to Piazza and Venturi (1971) application of phosphorus increased all the growth characters like vine length, number of vines per plant and number of nodes per vine over control in musk melon. Randhawa *et al*. (1981) reported optimum plant growth in musk melon with 37.5 kg P_2O_5/ha. In round melon, maximum length of vine was observed with 30 kg P_2O_5/ha (Singh *et al*., 1983).

George Thomas (1984) reported increased leaf area index and dry matter production upto 30 kg P_2O_5/ha in bitter gourd. In pointed gourd, phosphorus application increased vine length, number of vines per plant and number of nodes per vine (Das *et al*., 1987).

Mc Collum and Miller (1971) observed maximum dry matter production at 48 kg P_2O_5/ha in pickling cucumbers. Rajendran (1981) reported in pumpkin, significant increase in leaf area index at 30 and 60 DAS and increased total dry matter at 60 DAS and at harvest with increasing levels of phosphorus.

2.1.3. Potassium

Mc Collum and Miller (1971) observed maximum dry matter production at 91 kg K_2O/ha in pickling cucumbers. Pettiet (1971) observed beneficial effect of potassium application on growth in pickling cucumbers. Penny *et al*. (1976) observed a markedly poor growth of cucumber in potassium deficient than in full nutrient solution. Rajendran (1981) reported that total dry matter content was not significantly influenced by potassium application in pumpkin.

Randhawa et al. (1981) reported optimum growth of musk melon with 37.5 kg K_2O/ha.

2.1.4. Shade

Sansamma George (1982) observed decreased plant height in red gram and no marked effect on grain cowpea and black gram due to shading. Krishnankutty (1983) reported significant effect of shading on the height of vegetable cowpea at 60 DAS. He further observed that the dry weight of all the stages of crop was much lower for vegetable cowpea grown under shade than that in the open.

Rajesh Chandran (1987) reported increase in vine length, leaf number and plant dry matter production with nitrogen 30 kg/ha and P_2O_5 60 kg/ha when vegetable cowpea was grown in the open and also as an intercrop in coconut garden.

Thus the foregoing review reveals that the major nutrients profoundly influence the growth of cucurbitaceous vegetables. However, research results on the effect of major nutrients and partial shade on the growth of snake gourd are meagre under the agroclimatic conditions of Kerala.

2.2. Influence of nutrients and shade on yield and yield attributes

2.2.1. Nitrogen

Hall (1949) had demonstrated in small gherkin that increased nitrogen supply reduced the male to female flower ratio from 6:1 to 4.58:1. Enhanced female flower production with increased nitrogen supply was observed in cucurbits and reported by a number of workers (Brantley and Warren, 1958, 1960a, 1960b; Pustgarvi, 1961).

Padda et al. (1968) obtained most profitable yield by the application of 56 kg N/ha in musk melon. Jassal et al. (1970) observed significant increase in fruit weight and yield by nitrogen application in musk melon. Bhosale et al. (1978) observed that nitrogen nutrition is important in the productivity of water melon and highest yield was reported with 100 kg N/ha. Ogunremi (1978) studied the response of water melon to nitrogen and reported highest fruit number per unit area and fruit size with 48 kg N/ha. Randhawa et al. (1981) reported highest number of fruits per vine, fruit weight per vine and fruit quality in musk melon from plots receiving nitrogen at the rate of 50 kg/ha. Singh et al. (1983) reported maximum number of fruits and maximum diameter of fruits in round melon at 75 kg N/ha. Deshwal and Patil (1984) observed maximum weight of fruits from vines treated with 70 kg N/ha in water melon. Srinivas and Doijode (1984) reported progressive increase in fruit weight in musk melon with increase in nitrogen levels upto 100 kg/ha. They also reported increase in fruit yield upto 180 kg/ha.

Pandey and Singh (1973) found that nitrogen at 50 or 100 kg/ha increased pistillate and staminate flowers, fruits as well as yield without affecting the female to male flower ratio in bottle gourd.

Highest fruit yield in bitter gourd was reported with a nitrogen level of 50 kg/ha (Anon, 1980; 1981; 1984). George Thomas (1984) reported that the bitter gourd crop responded well to nitrogen at 60 kg/ha along with 18 t/ha of farmyard manure, producing maximum yield and net returns. He also reported increase in mean number of fruits produced per plant and mean length and weight of fruits upto 60 kg N/ha. Lingaiah et al. (1988) reported nitrogen at 80 kg/ha recorded highest yield in bitter gourd in costal regions of Karnataka.

Ito and Saito (1958) reported that in cucumber abundant nitrogen arrested female flower production, followed by luxuriant growth and numerous staminate flowers. Parikh and Chandra (1969) reported that maximum and minimum number of female and male flowers were produced at the level 80 kg N/ha and higher nitrogen rates delayed the appearence of first female flower in cucumber. Cantliffe(1977) observed an increase of pistillate flowers per plant upto a nitrogen dose of 67 kg/ha in pickling cucumbers.

Sundararajan and Muthukrishnan (1975) reported that nitrogen at 40 kg/ha recorded highest yield in Co-2 pumpkin. William (1978) found significant yield increase in cucumber with nitrogen upto 280 kg/ha. John *et al*. (1988) observed that the yield of pumpkin increased with nitrogen application upto 202 kg/ha and 67 kg/ha under irrigated and dry conditions respectively.

Sharma and Shukla (1972) found economic production of pumpkin at nitrogen level of 103 kg/ha and 96 kg/ha during summer and rainy season crops respectively. Sreenivasan and Chockalingam (1973) showed that for pumpkin and snake gourd the optimum doses of nitrogen were 80 kg/ha and 40 kg/ha respectively. Rajendran (1981) showed that the response of nitrogen was quadratic in the case of pumpkin and the economic level was workedout to be 71 kg/ha.

2.2.2. Phosphorus

Piaza and Venturi (1971) reported that application of phosphorus exerted major influence in increasing fruit number per plant in musk melon. Randhawa *et al*. (1981) reported the highest number of fruits per vine, fruit weight per vine and fruit quality in musk melon from plots receiving 37.5 kg P_2O_5/ha. Singh *et al*. (1983) reported the maximum number and diameter of fruits in round melon with 30 kg P_2O_5/ha. Deshwal and Patil (1984) observed in water melon that P_2O_5 at 35 kg/ha gave significant increase in weight of fruit. Srinivas and Doijode (1984) reported that phosphorus application resulted in increased percentage of perfect flowers and significant increase in yield over no phosphorus application in musk melon. Application of 60 kg P_2O_5/ha increased fruit yield by 75 per cent in musk melon (Prabhakar, 1985).

Phosphorus at the rate of 25 kg/ha produced the maximum yield in bitter gourd in the open conditions (Anon, 1981; 1984). George Thomas (1984) reported that 30 kg P_2O_5/ha increased the mean number of fruits produced per plant and mean length and weight of fruits. Lingaiah et al. (1988) reported that 30 kg P_2O_5/ha recorded the highest yield of bitter gourd in coastal regions of Karnataka.

Bishop et al. (1969) showed that in cucumber, phosphorus played a major role in yield increase than nitrogen and potash. Sundararajan and Muthukrishnan (1975) reported that 40 kg P_2O_5/ha recorded the highest yield in pumpkin.

Sreenivasan and Chockalingam (1973) found that the optimum phosphorus requirement for pumpkin was 60 kg/ha and for snake gourd 30 kg/ha. Rajendran (1981) workedout linear response of applied phosphorus in the case of pumpkin and recommended 50 kg P_2O_5/ha as optimum dose.

2.2.3. Potassium

Randhawa *et al*. (1981) reported highest number of fruits per vine and fruit weight per vine with 37.5 kg K_2O/ha in musk melon. Deshwal and Patil (1984) reported that application of 50 kg K_2O/ha significantly increased the weight of fruits of water melon. Increase in the percentage of perfect flowers in musk melon by potassium application was reported by Srinivas and Doijode (1984). Prabhakar (1985) observed that application of 60 kg K_2O/ha increased fruit yield by 16 per cent over no potassium treatment and this was attributed to the increase in fruit weight by potassium application.

Highest fruit yield in bitter gourd was recorded with 50 kg K_2O/ha in various trials conducted at KAU (Anon, 1980; 1981). 25 kg K_2O/ha produced highest yield in bitter gourd (Anon, 1984). George Thomas (1984) reported that 60 kg K_2O/ha produced maximum number of fruits per plant and length and weight of fruits. Lingaiah *et al*. (1988) reported that treatments which received 80:30:0 kg N, P_2O_5 and K_2O/ha recorded the highest yield in bitter gourd.

Sundararajan and Muthukrishnan (1975) reported that 80 kg K_2O/ha recorded highest yield in Co-2 pumpkin.

Sreenivasan and Chockalingam (1973) found that the optimum potassium requirement for pumpkin was 60 kg/ha and for snake gourd, was 30 kg/ha.

2.2.4. Shade

Considerable reduction in yield of vegetable cowpea due to shading was observed by Krishnankutty (1973) and the yield under 25, 50 and 75 per cent shade levels were 39.9, 19.45 and 13.48 per cent respectively to those grown in the open. He also observed delay in flowering, decrease in number of pods per plant and weight of pods per plant with increasing shade intensities.

Rajesh Chandran (1987) reported that the highest yield and net return were obtained from vegetable cowpea raised in the open than those under partial shade. It was observed that plants raised under partial shade took more days for flowering and picking and the duration of flowering was more in plants grown in the open.

The foregoing review reveals that the major nutrients profoundly influence the yield and yield attributes of cucurbitaceous vegetables. However, research results on the effect of major nutrients and partial shade on the yield and yield attributes of snake gourd are meagre under the agroclimatic conditions of Kerala.

2.3. Influence of nutrients and shade on nutrient content and uptake

2.3.1. Nitrogen

In musk melon, Jassal *et al*. (1972) observed that the percentage of nitrogen in the plant tissues was highest at its highest level of application. Wilcox (1973) observed that optimum leaf nitrogen content in relation to yield in musk melon was over 4.5 per cent during plant growth. Laske (1979) reported that domestic cucumber planted at the rate of 1.2 plants/m^2 removed the equivalent of 500 kg N/ha during the growing season. Tesi et al. (1981) reported that with adequate nitrogen application, the uptake of nitrogen by summer squash was 170.5 kg/ha. Hegde (1987) reported increased nitrogen uptake in water melon with nitrogen application upto 180 kg/ha.

George Thomas (1984) reported that fertility levels significantly increased the percentage of nitrogen in plant parts of bitter gourd in all stages of growth except in vines at final harvest.

Tayel et al. (1965) reported that application of nitrogen fertilizers increased nitrogen content of cucumber plants. It was also observed that the total nitrogen absorbed by the plants per unit area increased with nitrogen fertilization. From a study of leaf nitrogen content during different stages of growth it was found that cucumber required higher nitrogen content from the time of flower bud formation (Grozdova, 1970). Aleksandrova (1971) observed significant increase in leaf nitrogen content by increasing nitrogen rates in cucumber. Mc Collum and Miller (1971) reported that the total uptake of nitrogen by pickling cucumber was 100 kg/ha and the estimated nitrogen removal by harvested fruits was 44.5 kg/ha. Nitrogen fertilizers increased the leaf nitrogen content and fruit accumulation of nitrates in cucumber (Novotorova and Pavlova, 1986).

2.3.2. Phosphorus

Locascio (1967) observed an increase in tissue phosphorus content due to applied phosphorus in water melon. Jassal et al. (1972) observed that percentage of phosphorus in the plant tissue was highest at its highest level of application. Tesi et al. (1987) reported that with adequate phosphorus application, the uptake of phosphorus was 71.2 kg/ha in summer squash.

Grozdova (1970) reported that the need for phosphorus by cucumber increased during flower bud formation, decreased slightly during flowering and rose again during fruiting period. Mc Collum and Miller (1971) reported that the total uptake of phosphorus by pickling cucumber was 13.34 kg/ha and the estimated phosphorus removal by harvested fruits was 6.7 kg/ha.

2.3.3. Potassium

Fiskell and Breland (1967) observed that the leaf potassium content decreased sharply with increase in yield in water melon. Tesi et al. (1981) reported that with adequate potassium application, the uptake of potassium by summer squash was 394.4 kg/ha.

Mc Collum and Miller (1971) reported that the total uptake of potassium by pickling cucumber was 161.2 kg and the estimated potassium removal by harvested fruits were 61.1 kg/ha.

2.3.4. Shade

The nitrogen and phosphorus contents in vegetable cowpea grown in the open or under partial shade did not differ significantly (Krishnankutty, 1983). He also reported that the uptake of nitrogen and phosphorus was more with the plant grown under full light and less with those grown under high shade.

Rajesh Chandran (1987) reported that the uptake of nitrogen, phosphorus and potassium was much higher in vegetable cowpea raised in the open compared to that raised under partial shade.

Thus, it can be seen from the review that the uptake and utilization of major nutrients in cucurbitaceous vegetables are greatly influenced by the addition of increasing levels of nutrients. They are also found to be very sensitive to shade, under which condition there is a general reduction of uptake, translocation and utilization of nutrients. Information on this aspect, as far as snake gourd is concenred, is lacking under the homestead conditions of Kerala.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation was undertaken with the objective of finding out the nitrogen, phosphorus and potassium requirements of snake gourd under partially shaded conditions. Further the uptake of major nutrients by the crop was investigated along with study of the economics of cultivation under different fertilizer schedules. The field experiment was conducted during the period from March to July, 1988. The materials used and the methods adopted for the present study are briefly described below.

3.1. Materials

3.1.1. Experimental site

The experiment was conducted at the Instructional Farm, College of Agriculture, Vellayani. The farm is located at 8.5^{o}N latitude and 76.9^{o}E longitude at an altitude of 29 M above mean sea level.

3.1.2. Soil

The soil of the experimental area is red loam. The data on the physico-chemical properties of the soil are given below.

A. Mechanical composition

Constituent	Content in soil (%)	Method used
Coarse sand	13.80	Bouyoucos Hydrometer method (Bouyoucos 1962)
Fine sand	33.50	
Silt	28.00	
Clay	24.70	
Textural class	Sandy clay loam	

B. Chemical composition

Constituent	Content in soil	Rating	Method used
Total nitrogen	2400 kg/ha		Modified Microkjeldahl method (Jackson 1973)
Available nitrogen	225 kg/ha	Low	Alkaline potassium permanganate method (Subbaiah and Asija, 1956)
Available P_2O_5	38.49 kg/ha	Medium	Bray colorimetric method (Jackson 1973)
Available K_2O	80 kg/ha	Low	Ammonium acetate method (Jackson 1973)
Organic carbon	0.729%	High	Walkley and Black rapid titration method (Jackson 1973)
pH	5.2	Acidic	1:2 soil solution ratio using pH meter

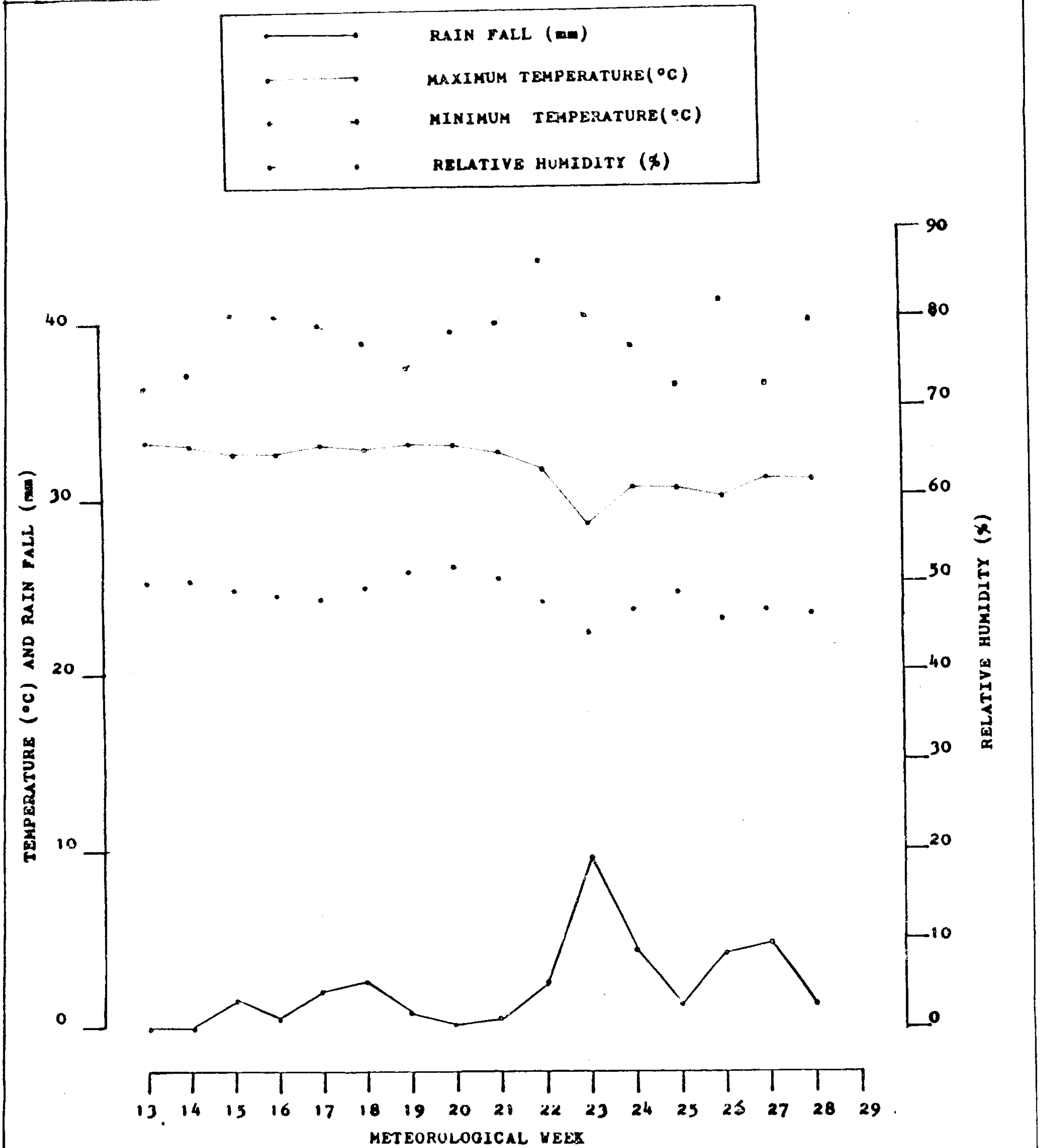


Fig.1 Weather data during cropping period.(25-3-1988 to 14-7-1988)

3.1.3. Cropping history of the field

The experimental site was a coconut garden with palms of over 50 years age with an average light infiltration of about 60 per cent to the ground. No crops had been grown in the interspaces of the palms for one year prior to the present investigation and before which it had been intercropped with guinea grass.

3.1.4. Season

The experiment was conducted during the period from March to July, 1988.

3.1.5. Weather conditions

Details of the meteorological observations during the entire cropping season were collected from the meteorological observatory of the department of Agronomy and presented as weekly averages in Appendix I and in Fig.1.

3.1.6. Light intensity measurement

This was done using a LI-188 B LI-COR integrating quantum/radiometer/photometer using a LI-COR LI-210 SB photometric sensor.

3.1.7. Cultivar used

The cultivar used for the study was TA-19. This is a high yielding snake gourd line released from

Snake gourd cv. TA-19

College of Horticulture, Vellanikkara. The cultivar has a duration of about 110 days. It produces medium sized stout fruits with dark green colour having white striations (Plate 1).

3.1.8. Source of seed material

Good seeds were procured from the Department of Olericulture, College of Horticulture, Vellanikkara, Trichur.

3.1.9. Fertilizers

Urea, superphosphate and muriate of potash were used as the source of nitrogen, phosphorus and potassium respectively. Chemical analysis of the fertilizers showed the following compositions.

Urea	-	46% N
Super phosphate	-	16% P_2O_5
Muriate of potash	-	60% K_2O

3.2. Methods

3.2.1. Design and layout

The experiment was laidout as a $3^3 + 1$ confounded factorial experiment in randomised block design with two replications. The higher order interactions NP^2K and NP^2K^2 were partially confounded in replications I and II respectively.

The details of the layout are as follows.

Plot size	- $16m^2$
Number of plants per plot	- 8
Spacing	- 2x2 m
Number of blocks	- 6
Replication	- 2
Number of plots per block	- 10
Total number of plots	- 60

The procedure followed for allocation of various treatments to different plots was in accordance with Yates (1964). The layout plan is shown in Fig.2.

3.2.2. Treatments

Treatments consisted 27 combinations of nitrogen, phosphorus and potassium at three levels each along with one absolute control per block.

3.2.2.1. Levels of nitrogen

n_1 = 50 kg N/ha

n_2 = 70 kg N/ha

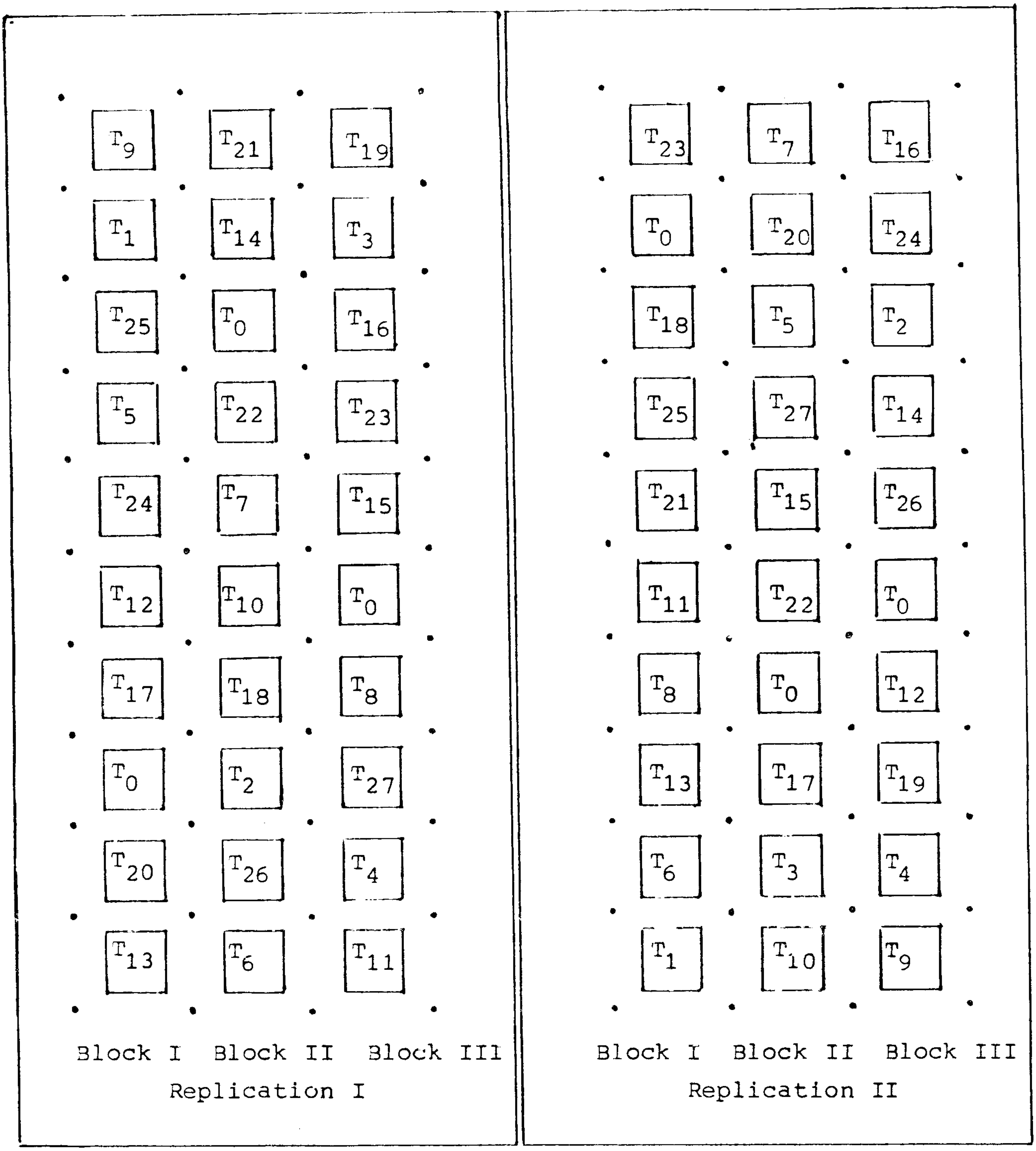
n_3 = 90 kg N/ha

3.2.2.2. Levels of phosphorus

p_1 = 15 kg P_2O_5/ha

p_2 = 25 kg P_2O_5/ha

p_3 = 35 kg P_2O_5/ha



● Coconut palm

Fig.2. Lay out plan - $3^3 + 1$ confounded factorial experiment in RBD.

3.2.2.3. Levels of potassium

k_1 = 25 kg K_2O/ha

k_2 = 50 kg K_2O/ha

k_3 = 75 kg K_2O/ha

3.2.2.4. Control

No application of N, P and K fertilizers

3.2.2.5. Treatment combinations

T_0 - $n_0p_0k_0$	T_{10} - $n_2p_1k_1$	T_{19} - $n_3p_1k_1$
T_1 - $n_1p_1k_1$	T_{11} - $n_2p_1k_2$	T_{20} - $n_3p_1k_2$
T_2 - $n_1p_1k_2$	T_{12} - $n_2p_1k_3$	T_{21} - $n_3p_1k_3$
T_3 - $n_1p_1k_3$	T_{13} - $n_2p_2k_1$	T_{22} - $n_2p_2k_1$
T_4 - $n_1p_2k_1$	T_{14} - $n_2p_2k_2$	T_{23} - $n_3p_2k_2$
T_5 - $n_1p_2k_2$	T_{15} - $n_2p_2k_3$	T_{24} - $n_3p_2k_3$
T_6 - $n_1p_2k_3$	T_{16} - $n_2p_3k_1$	T_{25} - $n_3p_3k_1$
T_7 - $n_1p_3k_1$	T_{17} - $n_2p_3k_2$	T_{26} - $n_3p_3k_2$
T_8 - $n_1p_3k_2$	T_{18} - $n_2p_3k_3$	T_{27} - $n_3p_3k_3$
T_9 - $n_1p_3k_3$		

3.2.3. Field culture

3.2.3.1. Land preparation

The experimental field was dug twice, stubbles removed, clods broken and the field was laidout into blocks and plots. Pits of 60 cm diameter and 30 to 45 cm depth were taken in each plot at a spacing of 2 x 2 m. The pits were half filled with a mixture of top soil and dried and powdered cowdung before planting.

3.2.3.2. <u>Manure and fertilizer application</u>

Organic matter as cowdung was applied at the rate of 25 t ha^{-1} to all the plots including control plots as basal dressing, based on package of practices of Kerala Agricultural University (Anon, 1986). Cowdung was applied in a powdered form after drying in the sun. Nitrogen, phosphorus and potash were applied to all the plots except control plots in the form of urea, super phosphate and muriate of potash in the stipulated doses as per treatments. Entire quantity of phosphorus and potassium and 50 per cent ni[illegible] were applied as basal dose one day prior to sowing. The remaining quantity of nitrogen was applied as two equal doses at 30 days after sowing (DAS) and 60 DAS.

3.2.3.3. <u>Seeds and sowing</u>

Plumby seeds selected for planting were soaked in water overnight before sowing. Four seeds were planted per pit.

3.2.3.4. <u>After cultivation</u>

At 15 DAS the plant population in each pit was limited to two. 1.5 m long sticks were fixed in each pit and the plants were allowed to trail on it. At 20 DAS pandals of height 1.8 m were erected around each plot seperately. Care was taken to trail the vines on the pandal regularly. Regular weeding operations were carried out to keep the plots weed free for the entire cropping period. Pot irrigation was done on alternate days for the entire cropping period.

3.2.3.5. Plant protection

After fruit set the fruits were covered with paper bags to increase mechanical protection against fruit flies. Malathion 0.2% suspension containing jaggery at 10 g/l was sprayed at fortnightly intervals after fruit set against attack of fruit flies. To prevent downy mildew mancozeb 0.2% was sprayed once in a month.

3.2.3.6. Harvesting

The crop was harvested at weekly intervals from 60 DAS. Totally six harvests were done over the entire cropping period. The fruits were harvested at vegetable maturity judged by visual observations.

3.2.4. Measurement of light intensity

Light intensity was measured in kilolux at the 50 per cent flowering stage at 11 AM, 1.30 PM and 4 PM and the averages of the three readings were recorded.

The percentage of shade available in each plot was calculated as follows.

$$\frac{L_1 - L_2}{L_1} \times 100$$

where L_1 = Light intensity in the open condition

L_2 = Light intensity in shaded condition

3.2.5. Biometrical observations

The sample plants were maintained in each treatment and the following observations were recorded.

3.2.5.1. Days for opening of first female flower

The number of days taken for opening of the first female flower was recorded from two plants.

3.2.5.2. Node at which the first female flower appeared

Node at which the first female flower appeared was counted from the cotyledonous node in two plants.

3.2.5.3. Internodal length

Internodal length was measured at 50 per cent flowering. Two plants from opposite pits were selected and length of ten consecutive internodes were measured leaving about first twenty internodes from the base and the mean internodal length was calculated and expressed in cm.

3.2.5.4. Sex ratio

The sex ratio was calculated based on observations taken at 50 per cent flowering and expressed as number of male flowers to female flower.

3.2.5.5. Yield per plot

Fruits are harvested at vegetable maturity and yield/ha was worked out.

3.2.5.6. Fruits per plant

Fruits per plant was obtained from total fruits per plot.

3.2.5.7. Fruit weight

Weight of a single fruit was obtained from weight of fruits per plot which was expressed in grams.

3.2.5.8. Length of fruit

Ten fruits from second and third harvests were randomly selected from each plot and the length of the fruit from the stalk end to the tip was measured and expressed in cm.

3.2.5.9. Girth of fruit

Ten fruits from second and third harvests were selected randomly from each plot and girth at the middle of the fruit was measured and expressed in cm.

3.2.5.10. Fruit set

This was worked out by dividing the total number of fruits harvested per plot by the total number of female flowers produced per plot. Fruit set was expressed as percentage.

3.2.5.11. Length of main vine

Total length of main vine was measured in cm when cropping was completed. Average length of two plants was taken.

3.2.5.12. Total dry matter production

The fruits at each harvest and the vines at final harvest were separately chopped and oven dried to constant weight at 80°C. The total dry weight of plants was recorded and expressed in grams per plant.

3.2.5.13. Harvest index

Harvest index was worked out from the data on dry matter production by the fruits and vines as follows.

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} = \frac{\text{Fruit yield}}{\text{Fruit yield + Vine yield}}$$

3.2.6. Chemical analysis

3.2.6.1. Plant analysis

The whole plant was analysed for nitrogen, phosphorus and potassium at the final harvest. One fruit from each harvest was selected at random from each plot. The plant samples were taken at final harvest from each plot. The plant and fruit samples were chopped and separately dried in an air oven at 80^{o}C till constant weights were achieved. Fruit samples at different harvests from the same plot were bulked. The samples were then ground to pass through a 0.5 mm mesh in a Wiley mill. The required quantity of samples were then weighed out accurately in an electronic balance and analysis were carried out.

3.2.6.1.1. Total nitrogen content

Total nitrogen content was estimated by modified micro-kjeldahl method as given by Jackson (1973) and the values were expressed in percentages.

3.2.6.1.2. Uptake of nitrogen

This was calculated by multiplying the nitrogen content of the plant or the fruits as the case may be with the total dry weight of the plant or fruits. The uptake values were expressed in kg/ha. Uptake of nitrogen by whole plant was determined by adding uptake values for plants and fruits.

3.2.6.1.3. Total phosphorus content

Phosphorus content was estimated colorimetrically (Jackson, 1973) by wet digestion of the sample using

2:1 mixture of nitric acid and perchloric acid. The colour was developed by vanado-molybdo phosphoric yellow colour method and read in Bausch and Lamb spectronic 2000 spectrophotometer.

3.2.6.1.4. Uptake of phosphorus

This was estimated by multiplying the phosphorus content and dry weight of the plants or fruits as the case may be. The values were expressed in kg/ha. The uptake of phosphorus by whole plant was determined by summing up the products thus obtained.

3.2.6.1.5. Total potassium content

Total potassium content in plants was estimated by the flame photometric method in a Perkin Elmer 3030 Atomic absorption sepctrophotometer after wet digestion of the sample using diacid mixture.

3.2.6.1.6. Uptake of potassium

This was calculated by multiplying the dry weights and potassium content of plants or fruits as the case may be. The uptake values were expressed in kg/ha. Uptake of potassium by whole plant was determined by adding the uptake values for plants and fruits.

3.2.6.1.7. Protein content of the fruits

The percentage of protein was calculated by multiplying the percentage of nitrogen in the fruits by the factor 6.25 (Simpson *et al.*, 1965).

3.2.6.2. Soil analysis

Soil samples were taken from the experimental area before and after the experiment. The air dried soil samples were analysed for available nitrogen, available phosphorus and available potash contents. Available nitrogen content was estimated by alkaline potassium permanganate method (Subbaiah and Asija, 1956). Available phosphorus content was estimated by Bray's colorimetric method (Jackson, 1973) and available potassium was estimated by ammonium acetate method (Jackson, 1973).

3.2.7. Economics of cultivation

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

		Rs. Ps.
1. Cost of 1 kg N	:	5.33
2. Cost of 1 kg P_2O_5	:	6.25
3. Cost of 1 kg K_2O	:	2.91
4. Cost of 1 ton FYM	:	230.00
5. Cost of cultivation of snake gourd per ha excluding the cost of treatment	:	24495.00
6. Price of 1 kg snake gourd	:	2.75

The net income and return per rupee invested were calculated as follows (Johl and Kapur, 1981).

Net income (Rs/ha) = Gross income - Cost of cultivation

$$\text{Net return per rupee invested} = \frac{\text{Net income}}{\text{Cost of cultivation}}$$

3.2.9. Statistical analysis

Data on shade intensity were first analysed by employing the technique of analysis of variance. The effect of shade was found to be insignificant (See Appendix II) and hence it could be assumed that all plots received almost uniform intensity of sunlight. Consequently analysis of covariance was not resorted to and the entire data were analysed by the technique of analysis of variance and then the statistical significance was tested by F test (Cochran and Cox, 1965). In cases where the effects were found to be significant, critical difference was calculated by using standard techniques.

To analyse the nature of response of nitrogen on the yield of snake gourd, the relevant sum of square of nitrogen was partitioned into leniar and quadratic orthogonal components and significance of each component tested as described by Snedecor and Cochran (1967). Appropriate response model was fitted to represent the response pattern.

The data were analysed using Keltron Versa IWS computer system.

RESULTS

RESULTS

The data on the observations were statistically analysed and the results are given below.

4.1. Growth characters

4.1.1. Days taken for opening of first female flower

The data on number of days taken for the opening of first female flower are given in Table 1 and the analysis of variance in Appendix III.

The levels of nitrogen and phosphorus had significant effect on this character. With increase in the level of nitrogen from n_1 to n_3, the number of days taken for the appearence of first female flower increased (46.54 to 50.75). Among the different levels of phosphorus the number of days taken for the opening of the first female flower also increased (47.82 to 49.36). However, p_1 and p_2 were found to be on par and so also p_2 and p_3. However, the different levels of potassium did not exert any influence. The number of days taken for opening the first female flower in the case of control was still lower (45).

4.1.2. Node at which first female flower appeared

The data on the node at which first female flower appeared are given in Table 1 and the analysis of variance in Appendix III.

Table 1. Effect of nitrogen, phosphorus and potassium on the days taken for the opening of first female flower and the node at which first female flower appeared

Treatments	Days taken for opening of first female flower	Node at which first female flower appeared
n_1	46.54	22.08
n_2	48.33	23.78
n_3	50.75	24.36
'F' test	S	S
p_1	47.82	23.67
p_2	48.44	22.86
p_3	49.36	23.69
'F' test	S	NS
k_1	48.33	23.47
k_2	48.72	23.14
k_3	48.57	23.61
'F' test	NS	NS
SE m$\pm$	0.37	0.46
CD (0.05)	1.07	1.34
Control	45.00	23.33
Treatment Vs control	S	NS

S Significant NS Not significant

The levels of nitrogen alone had pronounced influence on this characters. Among the levels of nitrogen n_3 recorded the maximum node number (24.36) followed by n_2 and n_1. However, the difference between n_2 and n_3 was not significant. Different levels of phosphorus and potassium had no significant influence on this character.

4.1.3. Internodal length

The data on the internodal length are given in Table 2 and the analysis of variance in Appendix IV.

The levels of nitrogen had significant influence on this characters. As the level of nitrogen increased from n_1 to n_3, internodal length increased from 18.35 cm to 20.34 cm. However, the different levels of phosphorus and potassium did not show any significant influence on this character. The control recorded significantly lower internodal length than other treatments.

4.1.4. Length of main vine at harvest

The data on the length of main vine at final harvest are given in Table 2 and analysis of variance in Appendix IV.

The treatments did not show any significant effect on this character. There was a marginal increase in the

Table 2. Effect of nitrogen, phosphorus and potassium on internodal length, length of main vine and total dry matter production

Treatments	Internodal length (cm)	Length of main vine (m)	Total drymatter production (g/plant)
n_1	18.35	9.33	331.41
n_2	19.37	9.41	346.52
n_3	20.34	10.18	381.78
'F' test	S	NS	S
p_1	19.33	9.44	343.07
p_2	19.18	9.44	367.98
p_3	19.54	10.04	348.65
'F' test	NS	NS	NS
k_1	19.07	9.65	346.89
k_2	19.69	9.68	356.79
k_3	19.29	9.59	356.03
'F' test	NS	NS	NS
SE m$\pm$	0.26	-	9.48
CD (0.05)	0.77	NS	27.66
Control	17.53	8.75	326.09
Treatment Vs control	S	NS	S

S Significant NS Not significant

length of main vine with increase in the levels of nitrogen, phosphorus and potassium though not significant.

4.1.5. Total dry matter production

The data on the total dry matter production at harvest are appended in Table 2 and the analysis of variance in Appendix IV.

The different levels of nitrogen exhibited significant effect on this character. As the level of nitrogen increased from n_1 to n_3 total dry matter production enhanced with n_3 level recording maximum dry matter production (381.78 g/plant). However, n_1 and n_2 levels were on par. Phosphorus and potassium had no significant effect on this character. A slight increase in the dry matter production was noticed upto p_2 (25 kg P_2O_5/ha) and k_2 (50 kg K_2O/ha) level, though not significant.

The control plants recorded significantly lower total dry matter production than the treated plants.

4.2. Yield and yield attributes

4.2.1. Sex ratio

The data on sex ratio at 50 per cent flowering are given in Table 3 and the analysis of variance in Appendix V.

Table 3. Effect of nitrogen, phosphorus and potassium on the sex ratio, fruit set, yield and harvest index

Treatments	Sex ratio (male to female)	Fruit set (%)	Yield (kg/ha)	Harvest index
n_1	16.32	20.07 (4.48)	13086.79	0.64
n_2	14.34	20.88 (4.57)	14011.62	0.65
n_3	21.15	21.90 (4.68)	15124.34	0.64
'F' test	S	NS	S	NS
p_1	15.36	20.88 (4.57)	13665.82	0.65
p_2	16.93	21.25 (4.61)	14626.29	0.64
p_3	19.52	20.70 (4.55)	13930.65	0.65
'F' test	S	NS	NS	NS
k_1	17.05	21.25 (4.61)	14145.50	0.66
k_2	16.51	21.34 (4.62)	14292.09	0.65
k_3	18.24	20.25 (4.50)	13785.15	0.63
'F' test	NS	NS	NS	NS
SE m$\pm$	0.79	-	437.49	-
CD (0.05)	2.29	NS	1276.41	NS
Control	19.38	15.52 (3.94)	9620.92	0.65
Treatment Vs control	NS	S	S	NS

S Significant NS Not significant

Figures in parentheses are transformed values ($\sqrt{x}$)

The levels of nitrogen and phosphorus had significant effect on this character. Among the various levels of nitrogen, n_3 level recorded the maximum sex ratio (21.15 male per female) followed by n_1 and n_2 and n_1 and n_2 were found to be on par. As the level of phosphorus increased, sex ratio also increased from 15.36 to 19.51 male/female. However, p_1 and p_2 were found to be on par. Potassium had no significant effect on this character.

The absolute control recorded a sex ratio of 19.38.

4.2.2. Fruit set

The data on fruit set are given in Table 3 and the analysis of variance in Appendix V.

The different levels of nitrogen, phosphorus and potassium had no significant effect on fruit set. However, a progressive increase in the fruit set was noticed upto n_3, p_2 and k_2 level, though not statistically significant.

The control plants registered significantly lower percentage fruit set than the treated plants.

4.2.3. Yield per plot

The data on yield per plot are given in Table 3 and the analysis of variance in Appendix VI.

The various levels of nitrogen had significant effect on this character. As the level of nitrogen enhanced from n_1 to n_3, a linear increase in yield from 13.086 tonnes/ha to 15.124 tonnes/ha was noted. However, n_1 and n_2 were on par and so also n_2 and n_3. Phosphorus and potassium levels influenced the yield upto p_2 and k_2 level, though not significant. None of the interactions were found to exhibit significant effect on this character.

The control had significantly lower yield as compared to other treatments (9.620 tonnes/ha).

4.2.4. Harvest index

The data on harvest index are given in Table 3 and the analysis of variance in Appendix V.

The various levels of nitrogen, phosphorus and potassium did not show significant effect on harvest index.

4.2.5. Fruit weight

The data on fruit weight are given in Table 4 and the analysis of variance in Appendix VII.

The different levels of nitrogen had significant effect on this character. A progressive increase in weight of fruit was observed as the level of nitrogen increased. The maximum weight of 599.69 g was recorded by n_3 level.

Table 4. Effect of nitrogen, phosphorus and potassium on fruit weight, length of fruit, girth of fruit and number of fruits per plant

Treatments	Fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	Number of fruits per plant
n_1	487.24	59.16	19.89	6.35 (2.52)
n_2	535.50	61.04	20.58	6.71 (2.59)
n_3	599.69	59.44	19.87	7.08 (2.66)
'F' test	S	NS	NS	NS
p_1	522.71	58.66	19.66	6.61 (2.57)
p_2	536.34	59.19	20.10	6.92 (2.63)
p_3	563.37	61.79	20.57	6.66 (2.58)
'F' test	NS	NS	NS	NS
k_1	539.33	59.61	20.07	6.81 (2.61)
k_2	543.67	59.53	19.99	6.86 (2.62)
k_3	539.43	60.49	20.27	6.40 (2.53)
'F' test	NS	NS	NS	NS
SE m$\pm$	12.68	-	-	-
CD (0.05)	36.78	NS	NS	NS
Control	445.18	55.10	18.43	4.62 (2.15)
Treatment Vs control	S	S	S	S

S Significant NS Not significant

Figures in parentheses are transformed values ($\sqrt{x}$)

Neither the levels of phosphorus nor the levels of potassium had any significant effect on this character. There was a slight increase in the weight of fruits with increasing level of phosphorus (522.71 g to 563.37 g) though not significant. Among the different levels of potassium, the weight of fruit recorded an increase upto k_2 level, was not significant.

The absolute control recorded a significantly lower fruit weight as compared to other treatments.

4.2.6. Length of fruit

The data on length of fruit are given in Table 4 and the analysis of variance in Appendix VII.

The different levels of nitrogen, phosphorus and potassium had no significant effect on this character. However, the length of fruit showed an increasing trend upto n_2, p_3 and k_3 levels, though not significant control plants recorded significantly lower fruit length than the treated plants.

4.2.7. Girth of fruit

The data on girth of fruit are given in Table 4 and the analysis of variance in Appendix VII.

The different levels of nitrogen, phosphorus and potassium had no significant effect on fruit girth. But there was an increasing trend among the levels with n_2, p_3 and k_3 registering the maximum values of 20.58 cm, 20.57 cm and 20.27 cm respectively. The control recorded a significantly lower fruit girth than the other treatments (18.43 cm).

4.2.8. Number of fruits per plant

The data on number of fruits per plant are given in Table 4 and the analysis of variance in Appendix VII.

The levels of nitrogen, phosphorus and potassium did not record statistically significant effect on number of fruits per plant. However, the values showed an increasing trend upto n_3, p_2 and k_2 levels though not significant. The control plants recorded significantly lower number of fruits than the treated plants (4.62).

4.3. Qualitative characters

4.3.1. Protein content of fruit

The data on protein content of fruit are given in Table 5 and the analysis of variance in Appendix VIII.

Levels of nitrogen had significant influence on protein content of fruit. As the nitrogen level increased the protein content increased with n_3 level recording the maximum (15.14%) protein content. However, n_2 and n_3 were

Table 5. Effect of nitrogen, phosphorus and potassium on the protein content, nitrogen content, phosphorus content and potassium content of fruit

Treatments	Protein content (%)	Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)
n_1	13.22	2.12	0.46	2.24
n_2	15.06	2.40	0.46	2.23
n_3	15.14	2.42	0.49	2.25
'F' test	S	S	NS	NS
p_1	14.00	2.24	0.38	2.25
p_2	14.53	2.32	0.47	2.23
p_3	14.89	2.37	0.56	2.24
'F' test	NS	NS	S	NS
k_1	14.44	2.31	0.47	2.05
k_2	14.36	2.30	0.47	2.22
k_3	14.62	2.33	0.45	2.45
'F' test	NS	NS	NS	S
SE m$\pm$	0.34	0.05	0.02	0.04
CD (0.05)	0.99	0.16	0.05	0.11
Control	12.35	1.98	0.42	1.97
Treatment Vs control	S	S	NS	S

S Significant NS Not significant

found to be on par. The levels of phosphorus and potassium did not influence this character. The protein content in the case of control was significantly lower than the other treatments.

4.4. Analysis of plant samples

4.4.1. Total nitrogen content of fruit

The data on the total nitrogen content of fruit are given in Table 5 and the analysis of variance in Appendix VIII.

The levels of nitrogen had significant influence on nitrogen content of fruit. The nitrogen content of fruit increased with increasing level of nitrogen with n_3 recording maximum, but n_2 and n_3 were found at par. The levels of phosphorus and potassium had no significant influence on this character. The control had significantly lower nitrogen content than the other treatments.

4.4.2. Total phosphorus content of fruit

The data on total phosphorus content of fruit are given in Table 5 and the analysis of variance in Appendix VIII.

The levels of phosphorus had significant influence on the phosphorus content of fruit. As the level of phosphorus increased, the phosphorus content of fruit increased with p_3 registering maximum value. Levels of nitrogen and potassium had no significant influence on this character.

4.4.3. Total potassium content of fruit

The data on the total potassium content of fruit are given in Table 5 and the analysis of variance in Appendix VIII.

Levels of potassium had significant effect on this character. The potassium content of fruit increased progressively with incremental doses of potassium. The effect due to graded doses of nitrogen and phosphorus was not significant. Control recorded significantly lower value than the other treatments.

4.4.4. Total nitrogen content of plant

The data on the total nitrogen content of plant are given in Table 6 and the analysis of variance in Appendix IX.

Levels of nitrogen and potassium had significant influence on this character. Among the levels of nitrogen n_2 recorded the maximum value followed by n_3 and n_1. However, n_3 and n_2 were on par. Among the levels of potassium k_2 recorded maximum plant nitrogen content

Table 6. Effect of nitrogen, phosphorus and potassium on the nitrogen, phosphorus and potassium content of plants

Treatments	Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)
n_1	1.71	0.53	0.93
n_2	2.14	0.66	1.18
n_3	2.10	0.60	1.16
'F' test	S	NS	S
p_1	1.92	0.43	1.06
p_2	2.06	0.62	1.14
p_3	1.98	0.72	1.07
'F' test	NS	S	NS
k_1	1.75	0.59	0.74
k_2	2.12	0.62	1.14
k_3	2.09	0.57	1.40
'F' test	S	NS	S
SE m±	0.06	0.04	0.03
CD (0.05)	0.19	0.11	0.10
Control	1.51	0.42	0.68
Treatment Vs control	S	S	S

S Significant NS Not significant

followed by k_3 and k_1, but k_3 and k_2 were on par. Levels of phosphorus had no significant effect on this character.

Control plants recorded lower nitrogen content than the treated plants.

4.4.5. Total phosphorus content of plant

The data on the total phosphorus content of plant are given in Table 6 and the analysis of variance in Appendix IX.

Levels of phosphorus had significant effect on the phosphorus content of plant. As the level of phosphorus increased, phosphorus content of plant also increased. However p_2 and p_3 were found to be on par.

Levels of nitrogen and potassium had no significant effect with phosphorus content of plant. Control recorded significantly lower value than the other treatments.

4.4.6. Total potassium content of plant

The data on the total potassium content of plant are given in Table 6 and the analysis of variance in Appendix IX.

Levels of nitrogen and potassium had significant influence on this character. Among the levels of nitrogen

n_2 recorded the maximum value followed by n_3 and n_1. However, n_2 and n_3 were found to be on par. As the level of potassium increased from k_1 to k_3 the potassium content increased with k_3 registering maximum value. Control recorded a significantly lower potassium content than the other treatments.

4.4.7. Nitrogen uptake by fruits

The data on the nitrogen uptake by fruits are given in Table 7 and analysis of variance in Appendix X.

Levels of nitrogen had significant effect on the nitrogen uptake by fruits. With increase in the level nitrogen from n_1 to n_3 nitrogen uptake increased with n_3 recording the maximum value. However n_2 and n_3 were found at par.

Levels of phosphorus and potassium had no significant effect with respect to nitrogen uptake by fruit. Control recorded significantly lower uptake value than the other treatments.

4.4.8. Phosphorus uptake by fruits

The data on the phosphorus uptake by fruits are given in Table 7 and the analysis of variance in Appendix X.

Table 7. Effect of nitrogen, phosphorus and potassium on the nitrogen, phosphorus and potassium uptake by fruits

Treatments	Nitrogen uptake (kg/ha)	Phosphorus uptake (kg/ha)	Potassium uptake (kg/ha)
n_1	16.75	3.63	17.65
n_2	20.19	3.87	18.84
n.	21.93	4.42	20.36
'F' test	S	S	S
p_1	18.26	3.09	18.35
p_2	20.55	4.12	19.67
p_3	20.06	4.71	18.82
'F' test	NS	S	NS
k_1	19.55	4.10	17.51
k_2	19.96	4.07	19.16
k_3	19.37	3.75	20.17
'F' test	NS	NS	S
SE m$\pm$	0.76	0.18	0.66
CD (0.05)	2.20	0.52	1.94
Control	11.09	2.38	11.09
Treatment Vs control	S	S	S

S Significant NS Not significant

Levels of nitrogen and phosphorus exhibited significant effect on the phosphorus uptake by fruits. Phosphorus uptake increased with increasing level of nitrogen with n_3 recording the maximum value. However, n_1 and n_2 were on par. As the level of phosphorus increased, uptake of phosphorus by fruits increased with p_3 registering the maximum value. Levels of potassium had no significant effect on this character. Control recorded significantly lower uptake value than the other treatments.

4.4.9. Potassium uptake by fruit

The data on the uptake of potassium by fruit are given in Table 7 and analysis of variance in Appendix X.

Levels of nitrogen and potassium exhibited significant effect on the potassium uptake by fruits. As the levels of nitrogen and potassium were increased the potassium uptake increased with n_3 and k_3 respectively registering the maximum values. Among the levels of nitrogen n_1 and n_2 were found to be on par and so were n_2 and n_3. The effect of potassium between k_1 and k_2 and between k_2 and k_3 were not significant. However, the different levels of phosphorus did not exert an influence in this character. Control recorded still lower uptake value than the other treatments.

4.4.10. Nitrogen uptake by whole plant

The data on the nitrogen uptake by whole plant are given in Table 8 and the analysis of variance in Appendix XI.

The levels of nitrogen, phosphorus and potassium exhibited significant effect on the nitrogen uptake by whole plant. As the levels of nitrogen increased nitrogen uptake increased with n_3 recording the maximum value (42.83 kg/ha). However n_2 and n_3 were found to be on par.

Among the levels of phosphorus p_2 recorded the maximum value (40.33) followed by p_3 and p_1. However, p_1 and p_3 were on par.

Among the levels of potassium k_2 recorded the maximum uptake value (39.40 kg/ha) followed by k_3 and k_1. However, k_2 and k_3 were on par. Control recorded significantly lower nitrogen uptake value (19.87 kg/ha) than the other treatments.

4.4.11. Phosphorus uptake by whole plant

The data on the phosphorus uptake by whole plant are given in Table 8 and the analysis of variance in Appendix XI.

The levels of nitrogen and phosphorus exhibited significant effect on the phosphorus uptake by whole plant.

Table 8. Effect of nitrogen, phosphorus and potassium on the nitrogen, phosphorus and potassium uptake by whole plant

Treatments	Nitrogen uptake (kg/ha)	Phosphorus uptake (kg/ha)	Potassium uptake (kg/ha)
n_1	31.40	8.09	26.04
n_2	39.37	9.77	29.44
n_3	42.83	10.34	31.83
'F' test	S	S	S
p_1	35.41	6.93	27.94
p_2	40.33	10.04	30.65
p_3	35.86	11.24	28.71
'F' test	S	S	NS
k_1	34.97	9.27	24.27
k_2	39.40	9.73	29.80
k_3	39.23	9.20	33.23
'F' test	S	NS	S
SE m$\pm$	1.28	0.43	1.03
CD (0.05)	3.74	1.25	2.99
Control	19.87	4.74	15.13
Treatment Vs control	S	S	S

S Significant NS Not significant

Phosphorus uptake increased with increasing levels of nitrogen and phosphorus with n_3 (10.34 kg/ha) and p_3 (11.24 kg/ha) respectively registering the maximum values. Among the levels of nitrogen n_2 and n_3 were at par and so were p_2 and p_3 among the levels of phosphorus. The different levels of potassium did not exert any significant influence with respect to this parameter. Control recorded significantly lower phosphorus uptake value (4.74 kg/ha) than the other treatments.

4.4.12. Potassium uptake by whole plant

The data on the potassium uptake by which plant are given in Table 8 and the analysis of variance in Appendix XI.

Levels of nitrogen and potassium exerted significant influence on the potassium uptake by whole plant. Potassium uptake increased with increasing levels of nitrogen and potassium with n_3 and k_3 respectively registering the maximum values of 31.83 kg/ha and 33.23 kg/ha. Among the levels of nitrogen n_2 and n_3 were found to be on par. The different levels of phosphorus did not exert an influence in this parameter.

Control plants recorded significantly lower potassium uptake value (15.13 kg/ha) than the treated plants.

4.5. Soil analysis

4.5.1. Available nitrogen content of soil after the experiment

The data on the available nitrogen content of soil after the experiment are given in Table 9 and the analysis of variance in Appendix XII.

The levels of nitrogen and phosphorus had significant influence on the available nitrogen content of soil. Available nitrogen in soil increased with increasing levels of nitrogen and phosphorus with n_3 and p_3 respectively registering the maximum values. Among the levels of nitrogen n_2 and n_3 were on par. Among the levels of phosphorus p_1 and p_2 and p_2 and p_3 were found at par.

Levels of potassium had no significant effect with respect to available nitrogen in soil. Control plots recorded significantly lower available nitrogen content than the other treatments after the experiment.

4.5.2. Available phosphorus content of soil after the experiment

The data on the available phosphorus content of soil after the experiment are given in Table 9 and the analysis of variance in Appendix XII.

Table 9. Effect of nitrogen, phosphorus and potassium on the available nitrogen, available phosphorus and available potassium in the soil after the experiment

Treatments	Available nitrogen (kg N/ha)	Available phosphorus (kg P_2O_5/ha)	Available potassium (kg K_2O/ha)
n_1	389.82	49.80	124.44
n_2	435.56	49.26	121.61
n_3	450.80	49.72	130.83
'F' test	S	NS	NS
p_1	407.25	42.36	122.89
p_2	422.49	48.96	122.89
p_3	446.44	57.47	131.11
'F' test	S	S	NS
k_1	422.49	49.33	110.22
k_2	424.67	49.29	124.61
k_3	429.02	50.16	142.06
'F' test	NS	NS	S
SE m$\pm$	9.75	0.41	2.70
CD (0.05)	28.45	1.19	7.88
Control	346.27	40.58	100.00
Treatment Vs control	S	S	S

S Significant NS Not significant

Levels of phosphorus exerted significant influence on this parameter. With increase in the level of phosphorus available phosphorus in the soil increased with p_3 registering the maximum value.

Levels of nitrogen and potassium did not exert significant influence with respect to this parameter. Control plots recorded significantly lower available phosphorus content than the other treatments after the experiment.

4.5.3. Available potassium content of soil after the experiment

The data on the available potassium content of the soil are given in Table 9 and the analysis of variance in Appendix XII.

Levels of potassium exhibitied significant influence on this parameter. As the level of potassium increased the available potassium content of soil increased with k_3 registering the maximum value.

Levels of nitrogen and phosphorus had no significant influence with regard to this parameter. The control plots recorded a significantly lower available potassium content after the experiment than the treated plots.

4.6. Economics

4.6.1. Net profit

The data on the net profit in rupee from the crop are given in Table 10 and the analysis of variance in Appendix XIII.

Levels of nitrogen exhibited significant influence with respect to net profit. As the level of nitrogen increased from n_1 to n_3 net profit also increased from Rs.10213.12 to Rs.15868.44, but n_1 and n_2 levels were on par and so were n_2 and n_3 levels.

None of the levels of phosphorus and potassium recorded any significant effect. Control recorded a significantly lower net profit (Rs.1418.28) than the other treatments.

4.6.2. Net return per rupee invested

The data on the net return per rupee invested are given in Table 10 and the analysis of variance in Appendix XIII.

Levels of nitrogen had significant effect with respect to net return per rupee invested. As the level of nitrogen increased net return per rupee invested also increased from Rs.0.41 to Rs.0.62, but n_1 and n_2 were at par and so were n_2 and n_3 levels.

Table 10. Effect of nitrogen, phosphorus and potassium on the net profit and net return per rupee invested

Treatments	Net profit (Rs)	Net return per rupee invested (Rs)
n_1	10213.12 (101.06)	0.41 (0.64)
n_2	12712.56 (112.75)	0.50 (0.71)
n_3	15868.44 (125.97)	0.62 (0.79)
'F' test	S	S
p_1	11483.27 (107.16)	0.46 (0.68)
p_2	14457.66 (120.24)	0.58 (0.76)
p_3	12629.26 (112.38)	0.50 (0.71)
'F' test	NS	NS
k_1	13384.18 (115.69)	0.53 (0.73)
k_2	13497.79 (116.18)	0.53 (0.73)
k_3	11644.57 (107.91)	0.46 (0.68)
'F' test	NS	NS
SE m$\pm$	(6.20)	(0.04)
CD (0.05)	(18.00)	(0.11)
Control	1418.28 (37.66)	0.06 (0.24)
Treatment Vs control	S	S

S Significant NS Not significant

Figures in parentheses are transformed values ($\sqrt{x}$)

None of the levels of phosphorus and potassium recorded any significant effect with respect to net return per rupee invested.

Control recorded significantly lower net return per rupee invested than the other treatments (Rs.0.06).

DISCUSSION

DISCUSSION

The results of the experiment conducted to study the nitrogen, phosphorus and potassium requirements of snake gourd under partial shade condition are discussed here under.

5.1. Growth characters

Nitrogen levels had significant influence on the days taken for the opening of first female flower (Table 1). As the level of nitrogen increased from 50 kg/ha to 90 kg/ha, the number of days taken for the opening of first female flower increased from 46.54 to 50.75. Nitrogen is considered the Kingpin in crop nutrition and one of the main functions of nitrogen is to promote vegetative growth in crops (Tisdale *et al*. 1985). As the levels of nitrogen increased, vegetative growth was increased which might have adversely affected the production of female flowers. Increased nitrogen application delayed flowering in cucumber (Parikh and Chandra, 1969).

Phosphorus also had significant influence in this character. With increasing level of phosphorus from 15 kg P_2O_5/ha to 35 kg P_2O_5/ha, the number of days taken for opening the first female flower increased from 47.82 to 49.36. However, there was no significant difference between 15 kg P_2O_5/ha and 25 kg P_2O_5/ha and also 25 kg P_2O_5/ha and 35 kg P_2O_5/ha. The different levels of potassium did not exert any significant influence in this character. In the control plots plants came to flowering much earlier than the treated plots. The first female flower appeared 45 days after sowing in the control plots. This supports the general view that fertilizer application will increase vegetative growth and that it will result in delay in the reproductive attributes of the crop.

Nitrogen levels had significant influence on the node at which first female flower appeared (Table 1). With increase in the level of nitrogen from 50 kg N/ha to 90 kg N/ha, the node at which first female flower appeared increased from 22.08 to 24.36. However, the application of 70 kg N/ha and 90 kg N/ha were on par. The influence of nitrogen on the development of vegetative parts of plants is well established. This inturn might have resulted in female flowers appearing at higher nodes with increasing levels of nitrogen. Neither the levels of phosphorus nor the levels of potassium had significant effect on this character.

Nitrogen exhibited positive influence on the internodal length (Table 2) measured at 50 per cent flowering (60 days after sowing). Internodal length was increased from 18.35 to 20.34 cm with increase in the level of nitrogen from 50 kg/ha to 90 kg/ha. The levels of phosphorus and potassium did not exert any significant influence on this parameter. As far as snake gourd is concerned internodal length is considered as an indication of vegetative growth and it was observed that there was increase in this character with increase in the level of nitrogen. The vegetative parts are definitely the photosynthetic factory of the plants and the length of vines decides the total number of leaves produced, flowering and yield. So the importance of nitrogen affecting this character is very important. Internodal length increased with maximum amount of nitrogen. A number of workers studied and demonstrated the dominant role of nitrogen in vegetative growth of vegetables wherein a marked increase in vegetative growth of cucurbitaceous vegetables by higher levels of nitrogen application was reported by Das et al. (1987) and Mangal et al. (1987). The control plants had significantly lower internodal length indicating the cumulative effect of fertilizer nutrients in increasing internodal length.

Table 2 further revealed that the different levels of nitrogen, phosphorus and potassium did not have significant influence with regard to length of main vine at final harvest. However, there was marginal increase in length of main vine with the highest levels of nitrogen, phosphorus and intermediate level of potassium. The comparatively decreased availability of nutrients especially nitrogen towards final stages of the crop and its poor utilisation at the later stages of the crop may probably be the cause for lack of response.

Further, partial shade might have also affected these characters though the shade was more or less uniform for all the treatments. Shade has got a significant influence in the growth and development of crops. Shading has been reported to affect plant height in many vegetables especially those adapted to open conditions. Significant negative influence of shading on the height of vegetable cowpea was reported by Krishnankutty (1983).

An appraisal of Table 2 reveals that nitrogen levels had significant influence on the dry matter production. As the level of nitrogen increased, dry matter production also increased from 331.41 g/plant to 381.78 g/plant. However, the influence of 50 kg N/ha and 70 kg N/ha were found to be on par. Levels of phosphorus and potassium had no significant effect on this parameter.

According to Russel (1973), as the nitrogen supply increases the extra protein produced allows the plant leaves to grow larger and hence to have more surface area available for photosynthesis, which results in better nitrogen use efficiency of plants and enhanced growth.

This might have led to an increased assimilation, high productivity and increased dry matter production. This increase in the dry matter accumulation and distribution through higher leaf area index, leaf area duration and crop growth rate was reported by Hegde (1988) in water melon.

The control plots recorded a significantly lower dry matter production than the treatments indicating that as the level of nutrients decreases, it affects the growth and subsequently the dry matter production. Higher the level of nutrient availability, higher the buildup of dry matter production.

5.2. Yield and yield attributes

Levels of nitrogen and phosphorus had significant influence on the sex ratio in snake gourd (Table 3). Among the levels of nitrogen, highest level of 90 kg N/ha recorded the maximum value of 21.1 male flowers per female flower. The lower levels 50 kg N/ha and 70 kg N/ha were on par. The sex ratio increased with increasing levels of phosphorus with the highest level (35 kg P_2O_5/ha) recording maximum value of 19.5 male flowers per female flower.

The incremental fertilizer doses increased the production of male and female flowers, but not to the same extent. This is in conformity with the findings of Ito and Saito (1958). Accordingly, abundant nitrogen arrested female flower production, caused luxuriant growth followed by numerous staminate flowers.

Fruit set was also not significantly influenced by nitrogen, phosphorus and potassium (Table 3). There were marginal increase in fruit set upto 90 kg N/ha and 25 kg P_2O_5/ha, but were not significant. The control plots recorded a significantly lower fruit set (15.52) than the plots receiving fertilizer treatments indicating that the higher levels of fertilizers increased the fruit set in snake gourd although it did not have significant difference.

The levels of nitrogen had significant influence on the yield per plot (Table 3 and Fig.3). With increase in nitrogen level from 50 kg N/ha to 90 kg N/ha, there was a linear increase in yield from 13086.79 kg/ha to 15124.34 kg/ha. However, the levels, 50 kg N/ha and 70 kg N/ha were on par and so were the levels of 70 kg N/ha and 90 kg N/ha. This linear response of nitrogen was proved by trend analysis studies of nitrogen by partitioning the relevant sum of squares into linear and quadratic orthogonal componants (Appendix VI) and significance of each componant tested as described by Snedecor and Cochran (1967).

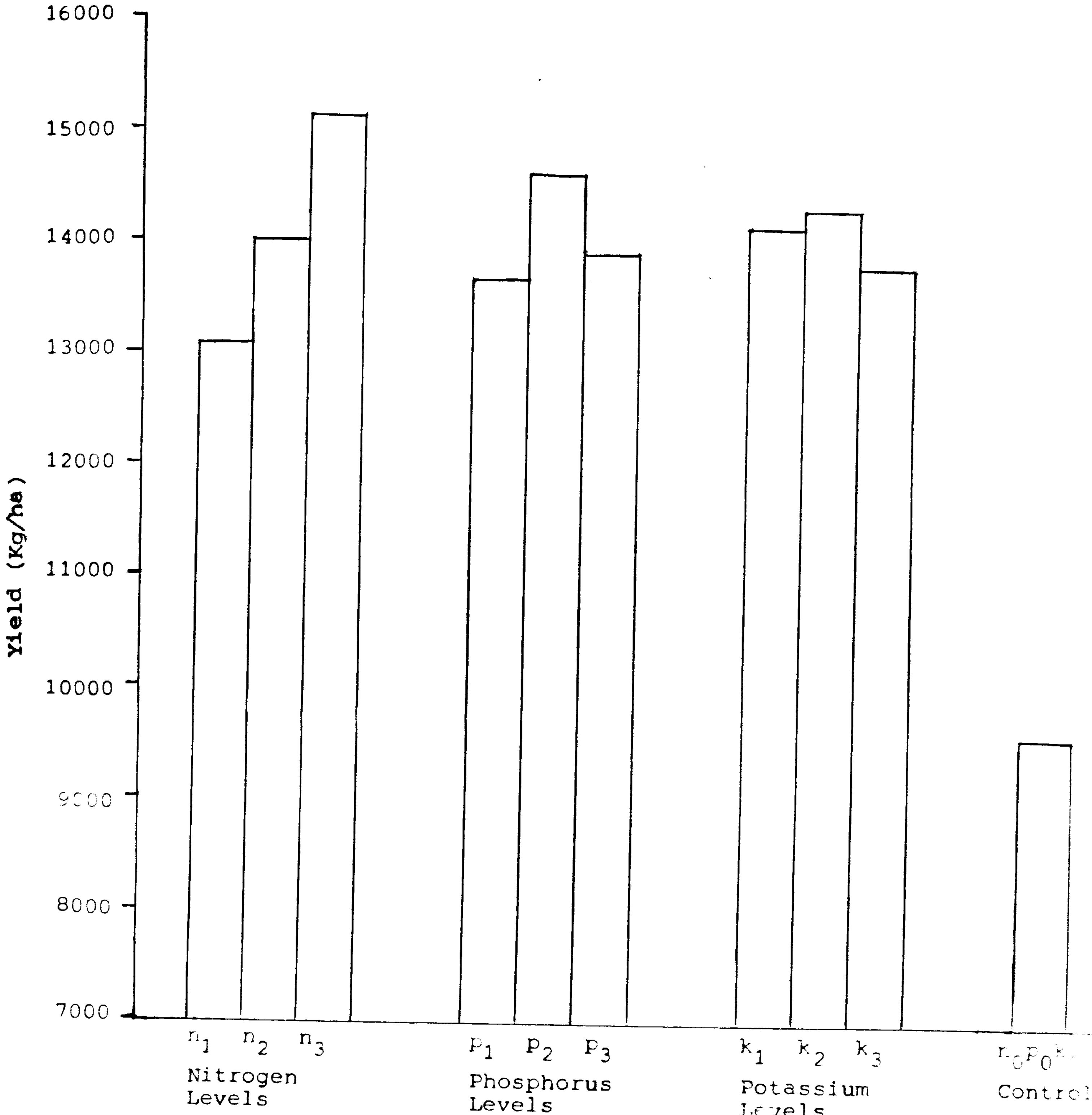


Fig.3. Effect of different levels of nitrogen, phosphorus and potassium on yield.

A linear regression equation was fitted for the response of nitrogen which is as follows.

$$Y = 10508.56 + 50.9384\ N\ (R^2 = 99.72\%)$$

From this equation the response line for nitrogen was traced(Fig.4). As nitrogen shows a linear response an optimum dose could not be fixed. The highest dose may be taken as optimum dose until further conclusive results are obtained.

The effects of phosphorus and potassium were not significant. In the case of phosphorus, there was an increasing trend upto medium level of 25 kg P_2O_5/ha but the lowest dose of 15 kg P_2O_5/ha can be considered sufficient as it was on par with the higher doses. Since the effect of different levels of potassium was statistically not significant the lowest dose of 25 kg K_2O/ha can be considered sufficient, until such time further investigations are undertaken. The control recorded the lowest yield of 9620.92 kg/ha.

The yield of any crop is a complex competitive character resulting from different factors, the more important being the yield per plant and the number of plants per unit area (Tanaka et al., 1964). The yield per plant is controlled by its genetic potential and the environmental conditions to which it is subjected during its life cycle. This inturn affects the nutrients taken

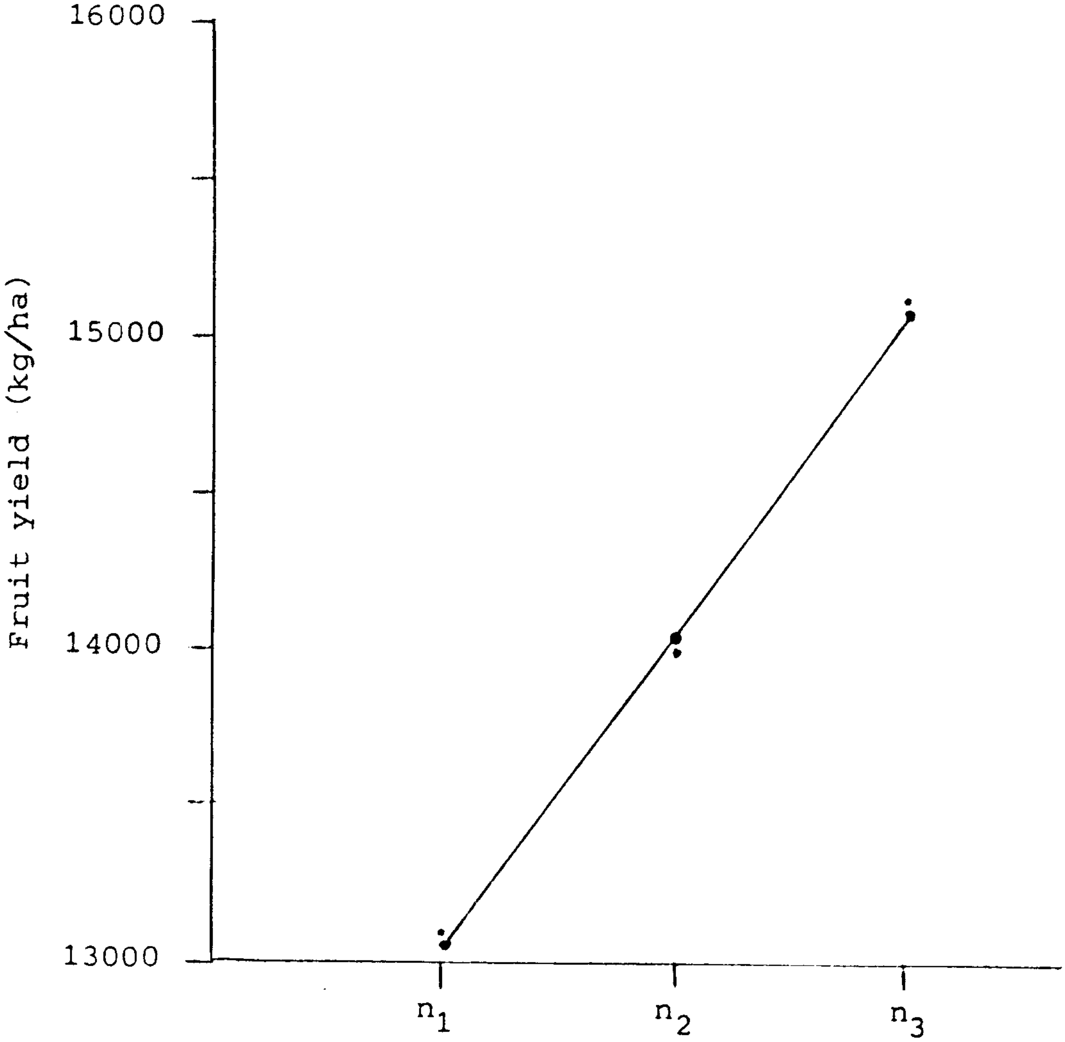


Fig.4. Response line for nitrogen.

up by the plants. Yield is the fixed expression of all the yield attributing characters like number of fruits per plant, fruit weight, length and girth of fruits etc. An increase in the application of major nutrients might have increased the above attributes in the present investigation though it did not reach the level of significance in some cases. The favourable influence of nutrients applied as those yield attributes can be ascribed to the increased availability and uptake of plant nutrients required for the production of flowers and the growth and development of fruits. This has resulted in the better growth and yield of the crop showing inter-relationship between yield and nutrient uptake. The general trend of increasing yield under graded levels of nutrients has been reported by Padda et al. (1969) in musk melon, Sharma and Shukla (1972) and Hegde (1987) in water melon.

None of the levels of nitrogen, phosphorus and potassium produced significant influence, with regard to harvest index (Table 3). The data (Table 3 and 4) indicate that the application of nitrogen, phosphorus and potassium increased the yield attributes like, weight of fruit, length of fruit, girth of fruit and number of fruits per plant, though the increases were marginal in some cases. A corresponding increase in vegetative characters was recorded with increasing levels of nutrients (Table 2). Nitrogen played a selective role so that the vegetative characters were improved only to the extent required. Thus the harvest index values, though comparatively higher had not showed any significant influence with the levels of nutrients.

The levels of nitrogen exhibited significant influence on fruit weight (Table 4). There was a progressive increase in the weight of fruit from 487.24 g to 599.69 g when the level of nitrogen was increased from 50 kg N/ha to 90 kg N/ha. Neither the levels of phosphorus nor the levels of potassium had any significant effect on fruit weight. Control plants recorded significantly lower fruit weight (445.18 g) than treated plants signifying the importance of nutrients on these characters. Nitrogen being the promotee of vegetative characters might have produced increased amounts of photosynthates which were translocated to the fruit effecting higher fruit weight. Similar trend was reported by Jassal et al. (1970) in musk melon, Deshwal and Patil (1984) in water melon and Srinivas and Doijode (1984) in musk melon.

The data on the fruit length and girth (Table 4) showed that none of the levels of nitrogen, phosphorus and potassium had any significant influence on fruit length and fruit girth. Fruit length showed only marginal increase (from 59.16 to 61.04 cm) upto 70 kg N/ha and from 58.66 to 61.79 cm upto 35 kg P_2O_5/ha and 59.61 to

60.49 cm upto 75 kg K_2O/ha. Fruit girth showed slight increase upto 70 kg N/ha (20.58 cm) and 35 kg P_2O_5/ha (20.57 cm). The control plants registered significantly lower fruit length (55.10 cm) and fruit girth (18.43 cm) than the treated plants. This indicates that though the length and girth of fruits are varietal characters, the application of fertilizer nutrients are required for their full expression.

It is seen from Table 4 that none of the levels of nitrogen, phosphorus and potassium exhibited significant influence on fruits per plant, though it had an increasing trend with respect to levels of nitrogen (6.35 to 7.08). The control recorded a significantly lower number of fruits per plant (4.62) than the treatments. This indicates that application of fertilizer containing major nutrients had profound influence on the number of fruits produced. Increased availability and uptake of plant nutrients are required for production of flowers and for growth and development of fruits. The linear response obtained for yield with respect to nitrogen suggests that inadequacy of nutrients may be the reason for not getting significant results with respect to levels of nitrogen. Higher number of fruits per plant with increased rates of application of nitrogen was reported by Ogunremi (1978) and Singh _et al_. (1983).

5.3. Quality character

Increasing levels of nitrogen application significantly increased the protein content of fruit with 90 kg/ha recording the maximum value (Table 5). This might be due to the favourable effect of nitrogen on protein synthesis. The effect of 70 kg N/ha and 90 kg N/ha were on par indicating that the protein content had not increased beyond a certain level. Neither the levels of phosphorus nor the levels of potassium had any significant effect on the protein content of fruits. However, the control plots recorded a significant reduction in protein content of fruits as compared to fertilizer treatments.

5.4. Nutrient content and uptake studies

The nitrogen, phosphorus and potassium contents of fruits were significantly increased by the respective levels of nitrogen, phosphorus and potassium (Table 5). The control registered significantly lower mean nutrient content than the treatment in all cases except in the case of phosphorus content of fruits which indicates that application of fertilizer nutrients definitely increased the nutrient content of fruit. Similar results have been reported by Tayel *et al*. (1965) and Novotorova and Pavlova (1986) in cucumber.

The data (Table 6) further revealed that nitrogen, phosphorus and potassium contents of plants were significantly influenced by the application of the respective nutrients. In all the cases the control recorded significantly lower nutrient content than the treatments.

In the case of nitrogen content of plants, the levels of nitrogen and potassium had significant influence with 70 kg N/ha and 50 kg K_2O/ha recording maximum content. However, the level 70 kg N/ha was on par with 90 kg N/ha and so were levels 50 kg K_2O/ha and 75 kg K_2O/ha. Phosphorus content progressively increased with levels of phosphorus, but the levels 25 kg P_2O_5/ha and 35 kg P_2O_5/ha were on par. In the case of potassium content of plants, levels of nitrogen and potassium exhibited significant influence with 70 kg N/ha and 75 kg K_2O/ha recording the maximum contents. This indicates that the application of fertilizer nutrients definitely increased the nutrient content of plants. Similar observations were made by Aleksandrova (1971) in cucumber and Jassal et al. (1972) in musk melon.

Application of different levels of nutrients might have promoted growth of plants and activity of roots and hence helped better absorption and translocation of the nutrients to plant parts and to fruits. This could be the reason for higher amounts of these nutrients in plant parts.

An appraisal of Table 7 revealed that levels of nitrogen exhibited significant influence on the nitrogen uptake by the fruits. Nitrogen uptake by the fruits increased with increasing level of nitrogen with 90 kg/ha recording the maximum uptake. Phosphorus uptake by the fruits was significantly affected by the levels of nitrogen and phosphorus. There was a progressive increase with the nitrogen and phosphorus levels with the highest levels recording the maximum phosphorus uptake. The potassium uptake too increased as the levels of nitrogen and potassium were increased with the highest levels of each registering the maximum uptake values. The control plots registered significantly lower uptake values than the respective treatments.

The data (Table 8) further revealed that control plots recorded significantly lower mean uptake values than the treatments in the case of nitrogen, phosphorus and potassium uptake by the whole plant.

Nitrogen uptake by the whole plant (Table 8 and Fig.5) increased as the level of nitrogen increased with 90 kg N/ha recording maximum value of 42.83 kg/ha. Nitrogen uptake showed an increasing trend upto medium level of phosphorus (40.33 kg/ha). With the levels of potassium too, nitrogen uptake significantly increased upto 50 kg K_2O/ha (39.40 kg/ha). Phosphorus is essential for the development of root system and potassium exerts

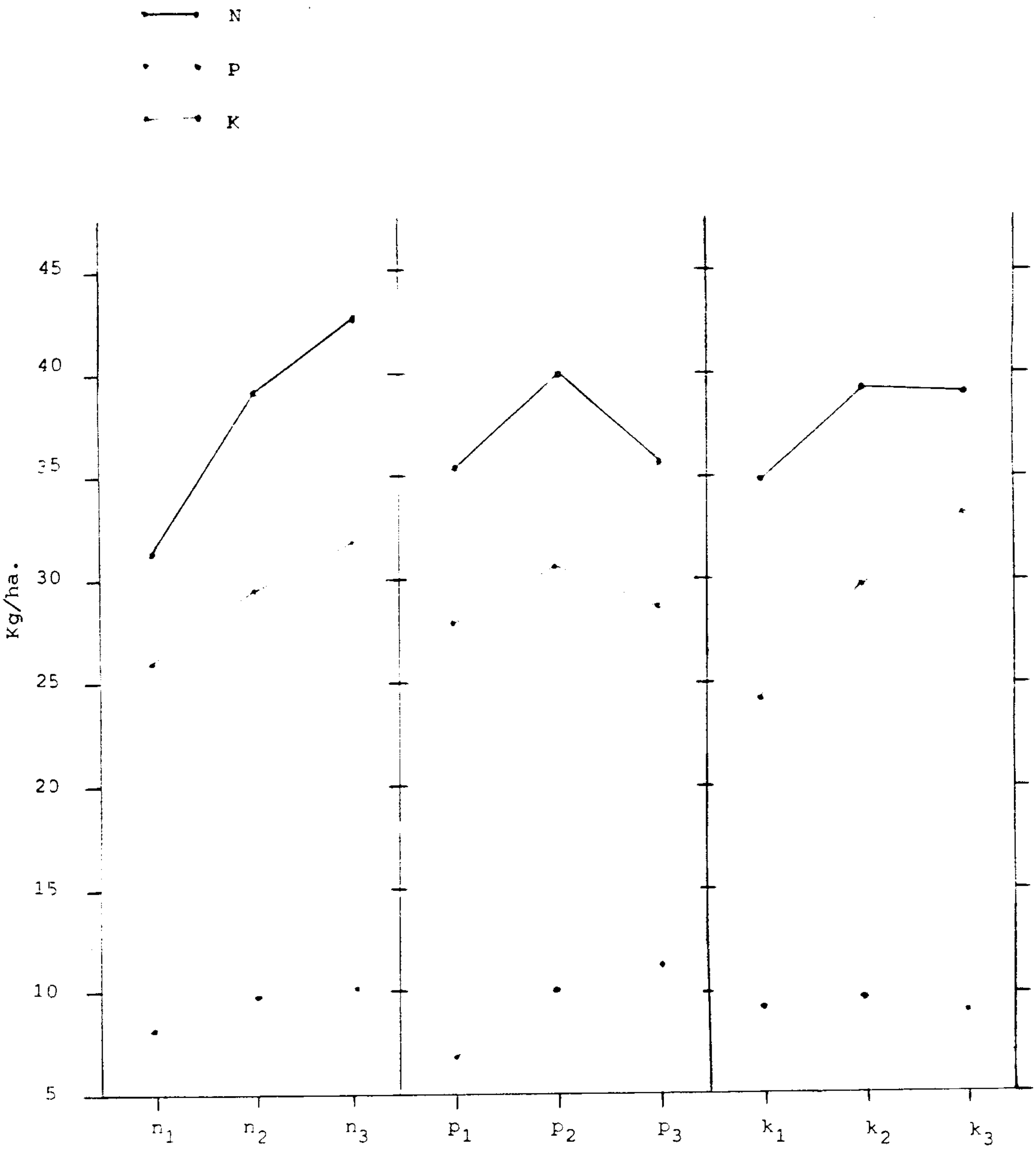


Fig.5. Effect of different levels of nitrogen, phosphorus and pottassium on the uptake of nitrogen, phosphorus and pottassium by whole plant.

a balancing effect on both nitrogen and phosphorus (Tisdale *et al*., 1985) and hence they are important in nitrogen uptake.

Phosphorus uptake by the whole plant (Table 8 and Fig.5) increased with increasing levels of nitrogen and phosphorus with the highest levels registering the maximum values of 10.34 kg/ha and 11.24 kg/ha respectively. However, the levels 70 kg N/ha and 90 kg N/ha were on par and so were 25 kg P_2O_5/ha and 35 kg P_2O_5/ha.

Potassium uptake by the whole plant increased with increasing levels of nitrogen and potassium with levels 90 kg N/ha and 75 kg K_2O/ha recording maximum uptake values of 31.83 kg/ha and 33.23 kg/ha respectively.

From the above observations (Table 7 and 8) it can be concluded that levels of fertilizer nutrients applied resulted in a marked increase in nitrogen, phosphorus and potassium uptake by both fruits and whole plants. These results are in agreement with that of Aleksandrova (1971) in cucumber, Mc Collum and Miller (1971) in pickling cucumber Jassal *et al*. (1972) in musk melon and Hegde (1987) in water melon. A stimulated growth under higher levels of major nutrients might have resulted in better proliferation of root system, higher rate of dry matter production and increased uptake of nutrients. In general, the uptake of plant nutrients at any stage is mainly related to dry matter production. In the present investigation, nitrogen had profound influence in the dry matter production. According to Tanaka et al. (1964) the nutrient availability is controlled by factors like nutrient availability in soil, nutrient absorption power of roots and rate of increase in dry matter.

The uptake values were generally lower in the present investigation. This might be due to the influence of partial shade. Similar observations were made by Krishnankutty (1983) and Rajesh Chandran (1987).

5.5. Soil analysis

The data on soil analysis after the experiment (Table 9) revealed that the available nitrogen content was significantly influenced by nitrogen and phosphorus application. Available nitrogen in the soil after the experiment increased with increasing levels of nitrogen and phosphorus from 389.82 kg N/ha to 450.80 kg N/ha and 407.25 kg N/ha to 446.44 kg N/ha respectively. The effect of levels of nitrogen 70 kg/ha and 90 kg/ha were on par and so were levels of phosphorus 15 kg P_2O_5/ha and 25 kg P_2O_5/ha and again 25 kg P_2O_5/ha and 35 kg P_2O_5/ha. Control recorded a significantly lower available nitrogen content than the treatments (346.27 kg N/ha).

The data on the available phosphorus content after the experiment (Table 9) revealed that the available phosphorus content in the soil increased with increasing level of phosphorus with the highest level recording the maximum value 57.47 kg P_2O_5/ha. Control recorded significantly lower available phosphorus content than the treatments.

The data on the available potassium content in soil after the experiment (Table 9) revealed that the levels of potassium had significant influence on the available potassium content of soil. As the level of potassium increased the available potassium content of soil increased with the highest level of application potassium recording the maximum value of 142.06 kg K_2O/ha. Control recorded a significantly lower available potassium content than the other treatments.

The increased status of available nitrogen, phosphorus and potassium in the soil at higher levels of application of fertilizer nutrients may be due to the residual effect of applied nutrients over a uniform dose of farmyard manure. Moreover, the farmyard manure had considerable positive influence on the release and availability of nitrogen, phosphorus and potassium to the plants (Venkatesa Rao, 1985 and Thangavel, 1985).

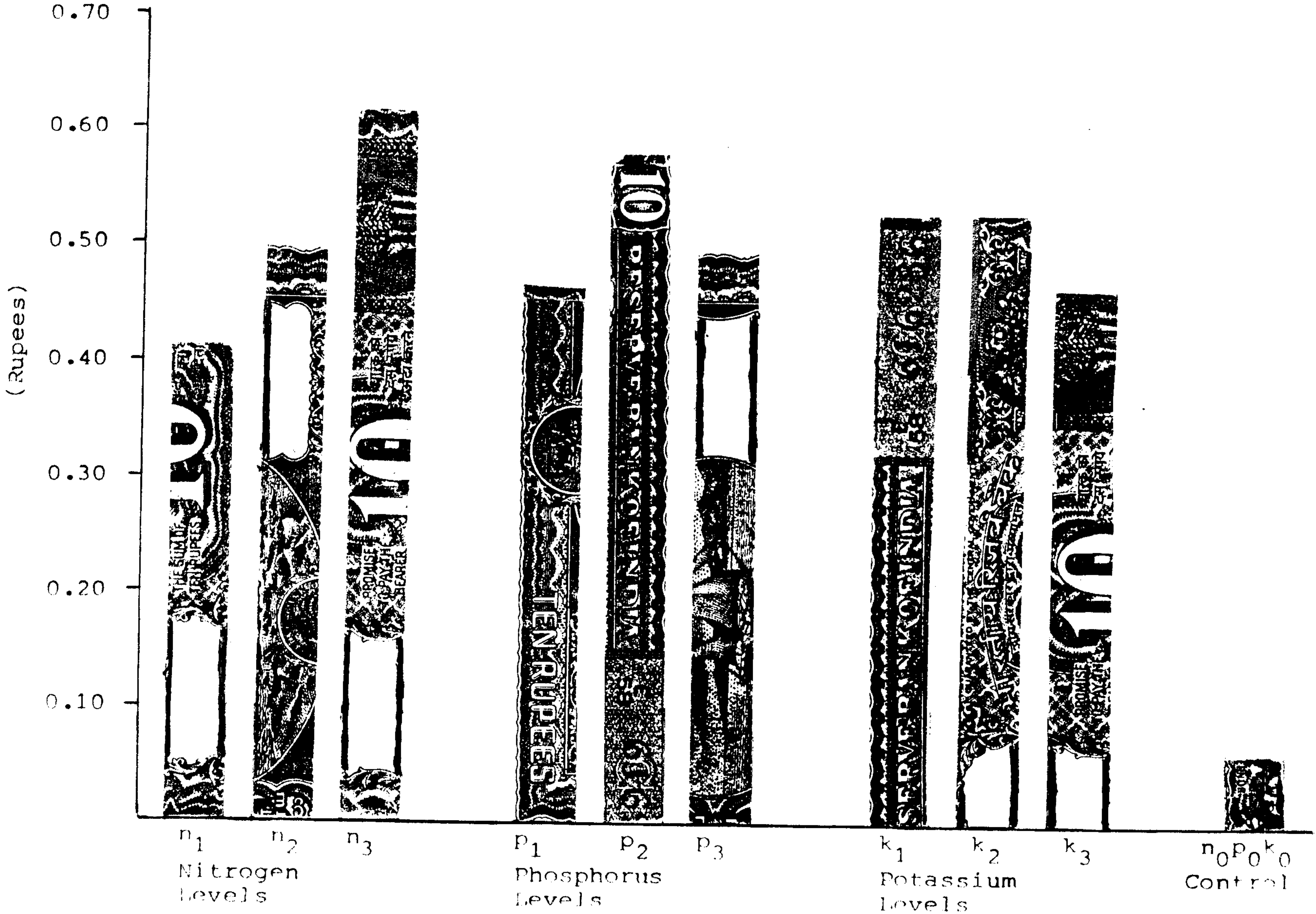


Fig.6. Effect of different levels of nitrogen, phosphorus and potassium on net return per rupee invested.

5.6. Economics of cultivation

The economic analysis of cultivation of crop is given in Table 10 and in Fig.6.

It is evident from Table 10 that all the fertilizer treatments registered significantly higher net profits than the control. Only levels of nitrogen has significant influence on the net profit. As the level of nitrogen increased from 50 kg N/ha to 90 kg/ha the net profil increased from Rs.10213.12 to Rs.15868.44. However, the effect of 50 kg N/ha and 70 kg N/ha were found to be on par and so were the effects of 70 kg N/ha and 90 kg N/ha. Though phosphorus showed an increasing trend in net profit upto the medium level 25 kg P_2O_5/ha the effect was not significant. Potassium also showed a marginal increasing trend in net profit upto medium dose (50 kg K_2O/ha).

Examining the net return per rupee invested (Fig.6, Table 10), it can be seen that nitrogen alone had significant influence. The level 50 kg N/ha recorded 41 paise per rupee invested while the level 90 kg N/ha recorded 62 paise per rupee invested. However, the levels 50 kg N/ha and 70 kg N/ha were on par and so were the levels 70 kg N/ha and 90 kg N/ha. Levels of phosphorus had a marginal increasing trend upto medium level (25 kg P_2O_5/ha) which recorded 58 paise per rupee invested but among the levels of potassium both 25 kg K_2O/ha and 50 kg K_2O/ha recorded 53 paise per rupee invested.

Thus on the basis of economic considerations the requirement of major nutrients for snake gourd under partially shaded conditions of coconut garden can be recommended as 90 kg N/ha, 25 kg P_2O_5/ha and 25 kg K_2O/ha until such time further investigations are undertaken.

SUMMARY

SUMMARY

An investigation was undertaken at the College of Agriculture, Vellayani during March-July 1988 to findout the effect of graded doses of nitrogen (50, 70 and 90 kg/ha), phosphorus (15, 25 and 35 kg/ha) and potassium (25, 50 and 75 kg/ha) on growth, yield, nutrient content and uptake of major nutrients by snake gourd cv. TA 19, under partial shaded conditions of coconut garden. The trial was conducted as a $3^3 + 1$ confounded factorial experiment in RBD with two replications. The higher order interactions NP^2K and NP^2K^2 were partially confounded in replication I and II respectively.

Biometrical observations on growth characters, yield and yield attributes were recorded. The plant content and uptake of major nutrients were also determined. The results of the study are summarised below.

1. The number of days taken for the opening of the first female flower increased with increase in levels of nitrogen and phosphorus. Potassium had no significant effect on this character.

2. Increasing levels of nitrogen significantly increased the node of appearence of first female flower. Levels of phosphorus and potassium had no significant effect on this character.

3. The levels of nitrogen had positive significant influence on the internodal length at 50% flowering. Levels of phosphorus and potassium had no significant effect on this character.

4. The different levels of nitrogen, phosphorus and potassium did not significantly influence the length of main vine at final harvest.

5. The total dry matter production markedly increased with higher levels of nitrogen application. Neither phosphorus nor potassium had any significant influence on this character.

6. The different levels of nitrogen and phosphorus significantly influenced the sex ratio at 50% flowering. The levels of potassium did not influence the character.

7. Different levels of nitrogen, phosphorus and potassium could not give enhanced fruit set.

8. The fruit yield was significantly influenced by nitrogen levels. The response to nitrogen was linear. Since the response to nitrogen was linear, an optimum level could not be arrived at. Phosphorus and potassium beyond their lowest levels did not show any significant influence on yield. The yield in control was significantly lower than the treatments.

9. The different levels of nitrogen, phosphorus and potassium did not show significant influence on harvest index.

10. Levels of nitrogen had significant positive influence on fruit weight. Different levels of phosphorus and potassium had no significant influence on this character.

11. Nitrogen, phosphorus and potassium had not significantly influenced the length and girth of fruit and number of fruits per plant. The control recorded significantly lower values for all these parameters than treatments.

12. Levels of nitrogen had significant positive influence on the protein content of fruit. Different levels of phosphorus and potassium had no significant influence on this character.

13. Plant and fruit content of nitrogen, phosphorus and potassium were significantly influenced by the respective levels of nutrients. In addition, the levels of nitrogen and potassium had significant positive influence on the potassium and nitrogen content of plants respectively.

14. Nitrogen, phosphorus and potassium uptake by fruits were significantly increased with their respective

levels. The levels of nitrogen had significant influence on phosphorus and potassium uptake by fruits.

15. Nitrogen, phosphorus and potassium levels had significant positive influence on the nitrogen uptake by whole plant. Phosphorus and potassium uptake by the whole plant were significantly influenced by the levels of nitrogen in addition to their respective levels.

16. The nitrogen and phosphorus application significantly increased the available nitrogen content in the soil after the experiment. Similarly available phosphorus and potassium status of the soil also recorded an increase by the application of the respective nutrients.

17. The different levels of nitrogen significantly increased net profit and return per rupee invested. Similar results were not obtained in the case of phosphorus and potassium.

Thus on the basis of economic considerations the requirement of major nutrients for snake gourd under partially shaded conditions of coconut garden can be recommended as 90 kg N/ha, 25 kg P_2O_5/ha and 25 kg K_2O/ha until such time further investigations are undertaken.

Future line of work

Trials may be undertaken with varying degrees of shade in comparison with open to study the effect of varying shade intensities on this crop. Since linear response was observed with regard to nitrogen levels, investigations with higher and wider levels of nitrogen is worth trying. Since the response was insignificant with present levels of phosphorus and potassium, trials may also be initiated with lower levels of the nutrients to fix optimum and economic levels.

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* Original not seen

APPENDICES

APPENDIX I

Weather condition (weekly means) during the cropping period (25th March to 14th July, 1988)

Standard week	Period From	Period To	Temperature (°C) Maximum	Temperature (°C) Minimum	Rainfall (mm)	Relative humidity (percent)
13	25-3-1988	31-3-1988	33.24	25.31	0.00	72.85
14	1-4-1988	7-4-1988	33.18	25.45	0.00	74.00
15	8-4-1988	14-4-1988	32.58	24.90	1.67	80.79
16	15-4-1988	21-4-1988	32.51	24.51	0.61	80.50
17	22-4-1988	28-4-1988	33.08	24.39	2.04	79.71
18	29-4-1988	5-5-1988	32.86	24.97	2.53	77.43
19	6-5-1988	12-5-1988	33.04	25.89	0.72	74.93
20	13-5-1988	19-5-1988	33.01	26.09	0.13	78.86
21	20-5-1988	26-5-1988	32.61	25.40	0.49	79.92
22	27-5-1988	2-6-1988	31.56	24.18	2.37	86.93
23	3-6-1988	9-6-1988	28.61	22.37	9.59	80.36
24	10-6-1988	16-6-1988	30.67	23.63	4.39	77.00
25	17-6-1988	23-6-1988	30.58	24.60	1.29	72.79
26	24-6-1988	30-6-1988	29.99	22.95	4.36	82.14
27	1-7-1988	7-7-1988	31.08	23.45	4.76	72.78
28	8-7-1988	14-7-1988	30.94	23.36	1.36	79.71

APPENDIX II

Abstract of analysis of variance table for the effect of shade on treatments

Source	df	Mean squares
Blocks	5	0.3766
N	2	0.3516
P	2	0.2969
K	2	0.2383
NxP	4	0.3789
PxK	4	1.0195
NxK	4	0.6582
NPK	2	0.1289
NP^2K F	2	1.0371
NPK^2	2	0.1289
NP^2K^2F	2	3.7050
Trtd Vs Cntrl	1	0.6719
Error	27	1.5715

* Significant at 5% level

** Significant at 1% level

F Partially confounded effects

APPENDIX III

Abstract of analysis of variance table for days taken for opening of first female flower and the node at which first female flower appeared

Source	df	Mean squares	
		Days taken for opening of first female flower	Node at which first female flower appeared
Blocks	5	3.3344	2.3297
N	2	80.1758**	25.1992**
P	2	10.7891*	4.0322
K	2	0.6914	1.0605
NxP	4	1.4727	5.3521
PxK	4	3.6777	1.6294
NxK	4	3.5020	3.1709
NPK	2	1.8281	2.5322
NP^2K F	2	2.6211	3.2314
NPK^2	2	0.9531	1.7266
NP^2K^2F	2	0.0703	0.3613
Trtd Vs Cntrl	1	67.7656**	0.0273
Error	27	2.4575	3.7899

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

F Partially confounded effects

APPENDIX IV

Abstract of analysis of variance table for internodal length, length of main vine and total dry matter production

Source	df	Mean squares		
		Internodal length (cm)	Length of main vine (m)	Total dry matter production (g/plant)
Block	5	2.5652	4.3948	3583.90
N	2	17.7549**	3.9790	12029.25**
P	2	0.5850	2.1501	3076.25
K	2	1.7998	0.0435	546.50
NxP	4	0.4570	2.1268	685.38
PxK	4	1.4883	0.6655	1378.50
NxK	4	0.8208	1.7004	4046.38
NPK	2	0.6904	5.3853	1157.50
NP^2K F	2	0.4941	2.1555	438.00
NPK^2	2	0.7090	3.1055	1936.25
NP^2K^2F	2	0.2002	2.5284	3927.25
Trtd Vs Cntrl	1	18.0019**	4.3027	81565.00**
Error	27	1.2414	1.4180	1618.20

* Significant at 5% level

** Significant at 1% level

F Partially confounded effects

APPENDIX V

Abstract of analysis of variance table for sex ratio, fruit set and harvest index

Source	df	Mean squares		
		Sex ratio (male or female)	Fruit set# (%)	Harvest index
Block	5	43.360	0.24104	0.00223
N	2	221.200**	0.18180	0.00074
P	2	79.204**	0.01525	0.00015
K	2	14.138	0.08007	0.00320
NxP	4	26.949	0.02005	0.00081
PxK	4	22.295	0.13141	0.00049
NxK	4	58.812	0.04251	0.00326
NPK	2	79.790	0.03186	0.00391
NP^2K F	2	34.279	0.06308	0.00218
NPK^2	2	6.712	0.03949	0.00861
NP^2K^2F	2	61.275	0.05084	0.00171
Trtd Vs Cntrl	1	23.561	2.18490**	0.00001
Error	27	11.098	0.09377	0.00164

* Significant at 5% level

** Significant at 1% level

F Partially confounded effects

Transformed data

APPENDIX VI

Abstract of analysis of variance table for yield

Source	df	Mean squares Yield (kg/ha)
Blocks	5	6657639
N (Linear)	1	37364490**
N (Quadratic)	1	107770
P	2	4431360
K	2	1225728
NxP	4	1284352
PxK	4	4802816
NxK	4	5304064
NPK	2	1746944
NP^2K F	2	754688
NPK^2	2	2919936
NP^2K^2F	2	6182400
Trtd Vs Cntrl	1	107094000**
Error	27	3445267

* Significant at 5% level

** Significant at 1% level

F Partially confounded effects

APPENDIX VII

Abstract of analysis of variance table for fruit weight, length of fruit, girth of fruit and number of fruits per plant

Source	df	Mean squares			
		Fruit weight (g)	Length of fruit (cm)	Girth of fruit (cm)	No. of fruits# per plant
Blocks	5	1057.20	9.9594	1.7723	0.13444
N	2	57285.50**	18.6719	2.8848	0.08807
P	2	7706.00	50.4297	3.7656	0.02391
K	2	111.00	5.1484	0.3936	0.03851
NxP	4	622.25	27.1484	1.1787	0.00982
PxK	4	2892.75	8.1172	1.7173	0.06667
NxK	4	688.75	9.8672	1.9741	0.01695
NPK	2	80.00	6.1484	2.0352	0.01721
NP^2K F	2	1486.00	8.6094	1.1660	0.03104
NPK^2	2	5462.50	32.8984	1.5195	0.02066
NP^2K^2F	2	266.50	125.2220	1.0063	0.01606
Trtd Vs Cntrl	1	49380.00**	123.5940*	15.3652*	1.04430**
Error	27	2892.148	18.4350	2.0170	0.04364

* Significant at 5% level

** Significant at 1% level

F Partially confounded effects

\# Transformed data

APPENDIX VIII

Abstract of analysis of variance table for protein content, nitrogen content, phosphorus content and potassium content of fruit

Source	df	Mean squares			
		Protein content (%)	Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)
Blocks	5	1.8539	0.0373	0.0036	0.0255
N	2	21.2554**	0.5225**	0.0055	0.0019
P	2	3.5103	0.0745	0.1423**	0.0018
K	2	0.3096	0.0033	0.0020	0.7246**
NxP	4	1.9145	0.0550	0.0032	0.0209
PxK	4	1.3086	0.0305	0.0006	0.0115
NxK	4	2.5100	0.0492	0.0056	0.0681
NPK	2	2.2393	0.0458	0.0047	0.0085
NP^2K F	2	5.8000	0.1438	0.0040	0.0402
NPK^2	2	5.5874	0.1700	0.0074	0.0186
NP^2K^2F	2	12.1750	0.3121	0.0022	0.0102
Trtd Vs Cntrl	1	24.4600**	0.6100**	0.0125	0.3986**
Error	27	2.0771	0.0532	0.0051	0.0278

* Significant at 5% level

** Significant at 1% level

F Partially confounded effects

APPENDIX IX

Abstract of analysis of variance table for nitrogen, phosphorus and potassium content of plant

Source	df	Mean squares		
		Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)
Blocks	5	0.0400	0.0575	0.0058
N	2	1.0166**	0.0781	0.3331**
P	2	0.0863	0.3859**	0.0330
K	2	0.7437**	0.0101	1.9835**
NxP	4	0.0906	0.1201	0.0379
PxK	4	0.4456	0.0489	0.0289
NxK	4	0.1004	0.0165	0.0563
NPK	2	0.3375	0.0133	0.0018
NP^2K F	2	0.1122	0.0107	0.0279
NPK^2	2	0.0353	0.0595	0.0234
NP^2K^2 F	2	0.3003	0.0195	0.0089
Trtd Vs Cntrl	1	1.2098**	0.2030**	0.8963**
Error	27	0.0726	0.0248	0.0194

* Significant at 5% level F Partially confounded effects

** Significant at 1% level

APPENDIX X

Abstract of analysis of variance table for nitrogen, phosphorus and potassium uptake by fruits

Source	df	Mean squares		
		Nitrogen uptake (kg/ha)	Phosphorus uptake (kg/ha)	Potassium uptake (kg/ha)
Blocks	5	9.159	1.140	21.318
N	2	125.118**	2.999*	33.130*
P	2	26.118	12.062**	8.123
K	2	1.608	0.666	32.576*
NxP	4	9.089	0.441	2.106
PxK	4	7.268	0.471	7.971
NxK	4	24.436	0.534	23.853
NPK	2	1.806	0.751	2.463
NP^2K F	2	10.494	0.334	0.843
NPK^2	2	29.240	0.174	1.919
NP^2K^2F	2	58.790	0.118	22.527
Trtd Vs Cntrl	1	393.334**	13.763**	333.220**
Error	27	10.250	0.572	7.922

* Significant at 5% level

** Significant at 1% level

F Partially confounded effects

APPENDIX XI

Abstract of analysis of variance table for nitrogen, phosphorus and potassium uptake by whole plants

Source	df	Mean squares		
		Nitrogen uptake (kg/ha)	Phosphorus uptake (kg/ha)	Potassium uptake (kg/ha)
Blocks	5	38.700	6.729	43.049
N	2	618.190**	24.710**	152.627**
P	2	109.300*	89.160**	35.030
K	2	113.410*	1.531	367.480**
NxP	4	20.240	7.744	2.230
PxK	4	33.220	2.010	13.230
NxK	4	50.540	2.909	58.575
NPK	2	15.590	0.149	7.639
NP^2K F	2	58.050	0.164	15.068
NPK^2	2	1.875	7.110	7.639
NP^2K^2F	2	53.460	9.390	39.583
Trtd Vs Cntrl	1	1749.270**	117.520**	1054.426**
Error	27	29.560	3.284	18.915

* Significant at 5% level

** Significant at 1% level

F Partially confounded effects

APPENDIX XII

Abstract of analysis of variance table for available nitrogen, phosphorus and potassium content of soil after the experiment

Source	df	Mean squares		
		Available nitrogen (kg N/ha)	Available phosphorus (kg P_2O_5/ha)	Available potassium (kg K_2O/ha)
Blocks	5	1029.600	2.172	363.625
N	2	18126.500**	1.531	401.688
P	2	7029.000*	1032.310**	405.656
K	2	199.500	4.344	4574.160**
NxP	4	284.500	1.309	1006.560
PxK	4	1437.000	3.020	83.170
NxK	4	882.250	2.492	47.480
NPK	2	882.000	0.227	153.375
NP^2K F	2	9618.500	0.559	83.813
NPK^2	2	541.000	9.453	30.530
NP^2K^2F	2	1593.750	2.402	84.000
Trtd Vs Cntrl	1	33810.000**	438.480**	3547.125**
Error	27	1711.500	2.968	131.300

* Significant at 5% level

** Significant at 1% level

F Partially confounded effects

APPENDIX XIII

Abstract of analysis of variance table for net profit and net return per rupee invested

Source	df	Mean squares	
		Net profit# (Rs)	Net return/rupee# invested (Rs)
Blocks	5	843.388	0.03325
N	2	2797.810*	0.10355*
P	2	780.530	0.02923
K	2	387.630	0.01544
NxP	4	141.340	0.00561
PxK	4	606.720	0.02383
NxK	4	940.200	0.03635
NPK	2	432.340	0.01591
NP^2K F	2	93.047	0.00365
NPK^2	2	603.094	0.02323
NP^2K^2F	2	797.330	0.03230
Trtd Vs Cntrl	1	30860.810**	1.20780**
Error	27	691.301	0.02712

* Significant at 5% level

** Significant at 1% level

F Partially confounded effects

Transformed data

NUTRIENT MANAGEMENT IN SNAKE GOURD
(*Trichosanthes anguina* L.)
UNDER PARTIAL SHADE

By

ABDUL HARIS A.

ABSTRACT OF A THESIS
submitted in partial fulfilment of the
requirement for the degree
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Vellayani, Trivandrum

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ABSTRACT

A field experiment was conducted at the College of Agriculture, Vellayani during March-July, 1988 to study the influence of three levels of nitrogen (50, 70 and 90 kg/ha), phosphorus (15, 25 and 35 kg/ha) and potassium (25, 50 and 75 kg/ha) on growth, yield, nutrient content and uptake of major nutrients in snake gourd cv. TA-19, under partially shaded condition of coconut garden. The experiment was laidout in a $3^3 + 1$ partially confounded factorial experiment in RBD with two replications, confounding NP^2K and NP^2K^2 in replication I and II respectively.

Higher levels of nitrogen had profound positive influence on growth characters like number of days taken for opening of the first female flower and its node of emergence, inter nodal length and total dry matter production. Higher levels of phosphorus had significant positive effect on the days taken for opening of the first female flower.

Yield attributes like fruit set and harvest index were not significantly influenced by the major nutrients. However, control recorded a significantly lower fruit set than the treatments. Nitrogen and phosphorus levels significantly increased the male to female flower ratio. The yield increased linearly with respect to nitrogen

levels. Phosphorus and potassium did not show any significant influence on yield beyond their lowest levels.

Fruit weight increased significantly with higher levels of nitrogen. Fruit length and girth and the number of fruits per plant showed an increasing trend with varying levels of nitrogen, phosphorus and potassium but were not significant. However, in all the cases, the control plots recorded significantly lower values for these parameters.

The levels of nitrogen had significant positive influence on the protein content of fruit. The nitrogen, phosphorus and potassium contents in fruits and plants were significantly and positively influenced by their respective levels. The uptake of nitrogen, phosphorus and potassium by fruits and whole plants were also significantly increased by their respective levels. In addition, nitrogen levels significantly influenced the uptake of phosphorus and potassium by whole plants and vice versa.