NUTRIENT MANAGEMENT IN BITTER GOURD
(Momordica charantia L.)
UNDER PARTIAL SHADE

BY

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THESIS

submitted in partial fulfilment of the
requirement for the Degree

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture
Kerala Agricultural University

Department of Agronomy
COLLEGE OF AGRICULTURE
Vellayani — Trivandrum

1989

Dedicated to my beloved parents

and

brother

DECLARATION

I hereby declare that this thesis entitled "Nutrient Management in bitter gourd (*Momordica charantia*. 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 bitter gourd (*Momordica charantia* L.) under partial shade" is a record of research work done independently by Shri.Ravikrishnan, M.K. 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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ACKNOWLEDGEMENT

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

Dr.V.K.Sasidhar, Professor of Agronomy, Communication Centre, Mannuthy and Chairman of Advisory Committee for his valuable guidance, inspiring encouragement and constructive criticisms which contributed the most to the completion of the study,

Dr.Mohanakumaran, Associate Director, NARP (Southern Region) for his encouragement, helpful suggestions and advice rendered during the course of the study,

Dr M.Achuthan Nair, Associate Professor of Agronomy, College of Agriculture, Vellayani for his unstinted interest at all stages of work,

Shri P.V Prabhakaran, Professor and Head of the Department of Agricultural Statistics, College of Agriculture,Vellayani for his valuable guidance in connection with the designing of the experiment and interpretation of the experimental data,

Dr(Mrs)Lekha Sreekantan, Assistant Professor of Agronomy, College of Agriculture, Vellayani for the critical scrutiny of the manuscript and for the keen interest shown throughout the study,

Sri C.E.Ajith Kumar, Junior programmer, Computer Centre, College of Agriculture, Vellayani for analysing the experimental data,

Shri Abdul Haris, Shri Murali, S., Ms. Minithomas and other Post-graduate Research Scholars in Agronomy for their friendly co-operation and assistance rendered at various stages of the work.

(contd .)

the teaching and non-teaching staff of the Department of Agronomy, College of Agriculture, Vellayani for their sincere support extended throughout the course of this investigation,

the Kerala Agricultural University for awarding a fellowship for the Post graduate programme,

and last his parents and brother who have given him constant encouragement for the successful completion of this thesis.

Vellayani
15 - 4 - 1989.

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LIST OF ABBREVIATIONS

mm	Millimetre
cm	Centimetre
m	metre
g	gram
kg	kilogram
ha	hectare
^oC	Degree celsius
cv	Cultivar
DAS	Days after sowing
DMP	dry matter production
HI	Harvest index
Fig	Figure
KAU	Kerala Agricultural University

INTRODUCTION

INTRODUCTION

Vegetables occupy an envious status in the human diet They provide proteins, carbohydrates, minerals, vitamins etc and along with cereals and other food constitute the essentials of a balanced diet. The average diet of an Indian today is ill-balanced due to scarce supply of cheap and nutritious vegetables. Vegetable crops occupy less than two percent of the total cropped area of the country, producing nearly 45 million tonnes of vegetables against a national requirement of about 98 million tonnes calculated on the basis of 280 g/day/person by the dietitians (Anon, 1988).

A planned development in the field of vegetable production will not only improve the nutritional quality of food for masses but can also meet the challenges of its adequate supply to the growing population in India. If a few selected vegetables are included in the farming systems along with cereals and pulses it will ensure higher yields per unit area in terms of bulk, calorie, proteins, vitamins and minerals, ensuring a better balanced diet to common man and higher income to small and marginal farmers and generate more farm employment.

The projected possible yield of vegetable is at least three times more than the present average yield There is thus ample scope to widen the frontiers of scientific research for increasing productivity of vegetable crops to assure the country of a better economic status and a healthier population. However the research for improvement of vegetables has received comparatively lesser attention as compared to cereals and cash crops

Momordica is one of the ninety genera of natural order cucurbitaceae. Among them, *Momordica charantia*, commonly known as bittergourd is one of the most important summer vegetables in India (Nath, 1965). This gourd is considered to be an old world species with its native home in the Tropical Africa and Asia (Hutchins and Sando, 1941, Thompson and Kelly, 1967).

The importance of this vegetable has long been accepted on account of its high nutritive value, unique medicinal properties and consumer preference. Bittergourd ranks first among the cucurbits with regards to the nutritive value of fruits and can very well be compared with any other vegetable (Gopalan *et al.*, 1982) The fruit contains two alkaloids, one of them being 'momordicine' and the bitter principles are different from ' cucurbitacines' which occur in other genera of cucurbitaceae (Anon, 1962). It is reported to possess cooling, stomachic, appetising, carminative, antipyretic, anthelmintic, aphrodisiac and vermifuge properties (Blatter *et al.*, 1935 and Nadkarni, 1954). The cultivation of this crop has been found to be highly remunerative under irrigated conditions during summer and hence is gaining popularity among the vegetable growers of the State

The land holdings in India as a rule are small With the fast rise in population and the inheritance laws the holdings in future will be even smaller. It is therefore, necessary, to adopt high intensity farming of food crops like vegetables which give higher yield in limited time. In a State like Kerala, where land resources are much limited, vegetable growing in coconut gardens has got great relevance and wide applicability Earlier studies at CPCRI, Kasargode, Kerala have indicated that the amount of light that infiltrates to the ground through a coconut canopy is as much as 50% in palms aged 40 years and increases further with increase in the age of palms. Except in gardens of eight to twenty five year old palms, the light infiltration to the ground level is enough to satisfy the requirements of intercrops (Nair, 1979).

Several programmes have been implemented by the State Government to increase the vegetable production especially in the homesteads of Kerala. The existing fertilizer recommendation for bittergourd in the State is based on trials conducted in the open situation and as such is not suitable for homesteads where vegetables when intercropped in coconut gardens invariably experience some amount of shade which may alter the nutrient requirements of the crops.

Bearing all these points discussed above in mind, the present study was undertaken with the following objectives.

1 To determine the requirements of N, P_2O_5 and K_2O for bittergourd in partial shade conditions of coconut gardens for increased yields of the crop

2 To study the economics of cultivation of the crop under different fertilizer schedules and work out the optimum fertilizer doses

3 To investigate the uptake of major nutrients by the bittergourd crop.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Work on the agronomic requirements of bittergourd in Kerala is limited, and as such, literature on this aspect is relatively less However, the available information on the effect of fertilizer nutrients and shade on the growth characters, nutrient content, uptake and yield of bittergourd and other vegetable crops are briefly reviewed and presented hereunder

2 1 Growth characters

2.1 1 Influence of major nutrients

Locascio *et al* (1972) in a field experiment to find out the influence of fertilizer placement and micronutrient rate on composition and yield of water melons noticed that the mean length of vine and fresh weight of plants were significantly improved under higher doses of nitrogen application . Katyal (1977) observed that the application of 50 tonnes per hectare farmyard manure as a basal dose and a top dressing of ammonium sulphate at the rate of 100 kg/ha soon after flowering was sufficient for a successful crop of bittergourd. Ogunremi (1978) studied the response of watermelons to nitrogen at 0 to 72 kg/ha in several trials Increased levels of nitrogen application increased the leaf number and was the highest in plots receiving 72 kg N/ha

In round melon, maximum length of vine was recorded with 75 kg N/ha (Singh *et al.*, 1983) Higher rates of nitrogen application always showed a pronounced effect in increasing vine length, number of vine per plant, number of nodes per vine and number of fruits per plant in pointed gourd Results obtained, indicated that application of nitrogen might have played an important role with regard to growth and development of pointed gourd (Das *et al.*, 1987) Mangal *et al.* (1987) had reported that the effect of nitrogen on length of muskmelon vines was on par for 60 kg and 120 kg treatments Growth of vine was significantly poor where nitrogen application was not made Mean length of vine and fresh weight of plant were significantly improved under higher doses of nitrogen application. Increasing levels of nitrogen fertilizers increased the dry matter accumulation and distribution through higher leaf area index, leaf area duration and crop growth rate and contributed larger proportion of the dry matter to fruits resulting in higher fruit yields (Hegde, 1988)

Tettiet (1971) compared the effect of factorial combination of nitrogen, phosphorus and potash on the growth and yield of pickling cucumbers grown for once over machine harvesting It was observed that phosphorus favoured early growth and hastened maturity. Piazza and Venturi (1971) in yet another experiment to study the effects of nitrogen, phosphorus and potassium fertilizing on muskmelons observed that application of phosphorus tended to increase all the characters viz vine length, number of vine per plant and number of nodes per vine over control In round melon, maximum length of vine was noticed with 30 kg P_2O_5/ha (Singh et al., 1983) Application of phosphorus was found to increase in pointed gourd the vine length, numbers of vine per plant, number of nodes per vine and number of fruits per plant over control though it did not prove much effective for any character excepting number of fruits per plant (Das et al. 1987)

Lack of potassium did not inhibit early growth, but potassium additions were found to be beneficial to growth of cucumbers (Pettiet, 1971). Penny et al (1976) observed a markedly poor growth of cucumber in potassium deficient than in full nutrient solution. This was attributed to reduced carbondioxide fixation by cotyledons which form the bulk of the photosynthetic surface at this stage of growth and to a much lower level of export of photosynthetic products from the cotyledons They further pointed out that the magnitude of these efforts increased as the seedlings got aged.

Pettiet (1971) had reported from trials on pickling cucumber that the highest yield was obtained by the annual application of 57 kg N, 91 kg P_2O_5 and 91 kg K_2O per hectare.

Application rates greater than 57 kg N/ha and 91 kg K_2O/ha delayed maturity Mc Collum and Miller (1971) observed maximum dry matter production and marketable yield at 91 kg N/ha, 98 kg P_2O_5/ha and 91 kg K_2O/ha in pickling cucumbers. In Karnataka the recommended practice for bittergourds is to apply 18 tonnes per hectare farmyard manure, 62.5 kg N/ha and 50 kg P_2O_5/ha (Anon, 1978). Randawa et al. (1981) in trials with two cultivars of musk melon reported best results with regard to plant growth from plots receiving an NPK level at 50 37.5 37.5 kg/ha Rajendran (1981) studied the effect of different doses of nitrogen, phosphorus and potash on pumpkin. He found that nitrogen, phosphorus and potash produced significant effect on the leaf area index at 30 and 60 DAS. Total dry matter content at 60 DAS and at harvest increased with increased levels of nitrogen and phosphorus. Raychaudhuri et al. (1982) studied the effect of different levels of N, P, K, Ca, Mg and Fe on growth, flowering and yield of fruits in long melon (*Cucumis melo* L var *utilissimus* Roxb) Higher doses of nutrients increased the number of branches and significantly promoted growth as evident from vine length In Kerala, an experiment to study the response of bittergourd to different water management practices and fertility levels in summer rice fallows revealed that higher levels of fertilizers increased the leaf area index and dry matter production (Georgethomas, 1984)

2.1.2. Influence of shade

In beans, photosynthesis per unit area of shaded leaf was reduced by 38 per cent according to Crookston *et al.* (1975)

Krishnankutty (1983) reported significant effect of shading on the height of vegetable cowpea at 60 DAS. He further noticed that the total dry weight of all stages of crop growth was much higher for vegetable cowpea grown without shade and there was a steady decline in the dry matter production with increase in shade intensities

Rajesh chandran (1987) in an experiment to find out the effect of graded doses of nitrogen (10, 20 and 30 kg N/ha), phosphorus (20, 40 and 60 kg P_2O_5/ha) and potassium (10,20 and 30 kg K_2O/ha) on the growth, yield and quality of vegetable cowpea var kurutholapayar grown as an intercrop in coconut garden and in the open reported that the vine length, leaf number per plant and dry matter production increased with increase in levels of nitrogen upto 30 kg/ha or phosphorus upto 60 kg P_2O_5/ha in open as well as in partially shaded conditions.

Summing up one can definitely say that all growth characters are positively affected by the major nutrients. As the level of major nutrients was increased it was noticed in most experiments, irrespective of the crop, that the growth characters like length of vine, internodal length, leaf area index and dry matter production increased. Partial shade significantly affected the growth characters too, as is evident from the review. Shade is found to exert a negative influence on the growth parameters

2.2. Yield attributes and yield

2.2.1. Influence of major nutrients

Nutrition is known to play a vital role in the physiology of plants. Tapley (1923) reported that additional supply of nitrogen to squash plants increased female flowers. A more lucid explanation is offered by Tiedjens (1928) that a correlation between flower formation and amount of available carbohydrates and nitrogen exists and that the ratio between female and male flowers is the result of this nutrient condition. Currence (1932) described nodal sequence of flower type in cucumber, the lower nodes being predominantly male and upper mostly female. In snakegourd, Singh (1950) observed that male flowers were produced earlier than female Liberal application of N was found to enhance female tendency in cucurbits (Brantley and Warren, 1958, 1960a, 1960 b, 1961, Luustgarvi, 1961). Sex regulation in cucurbitaceae according to Dhillon (1966) is considered to be a genetically controlled phenomenon although gene-environmental interaction plays a masterly role

Padda et al. (1968) in trials with musk melon obtained most profitable yield by the application of nitrogen at

56 kg/ha. The yields however were greater when double the quantity of nitrogen was used Parikh and Chandra (1969) experimented on cucumber with nitrogen levels from 0 to 120 kg/ha and found that maximum and minimum number of female and male flowers respectively were produced, when nitrogen was applied at 80 kg/ha They also observed that higher nitrogen rates delayed the appearance of first female flower. Jassal et al (1970) in a fertilizer cum irrigation trial observed significant increase in fruit weight and yield by nitrogen application in musk melon The number of flowers per plant increased with increase in the rate of nitrogen application in musk melon and the maximum number of female flowers (7.32%) was produced in response to 165 kg N/ha (Jassal et al , 1972). A significant increase in yield of pumpkin was observed in both rainy and summer season by increasing the nitrogen levels (Sharma and Shukla, 1972). Suggested rates for economic production were nitrogen at 103 kg/ha for summer crop and 96 kg/ha for rainy season crop. Pandey and Singh (1973) found that nitrogen at 50 or 100 kg/ha increased pistillate and staminate flowers, fruits as well as yield in bottlegourd But the female male flower ratio was unaffected. Wilcox (1973) observed that the optimum growth and yield of musk melon were registered when ammonium nitrate was applied preplant at the rate of 80-90 kg/ha The effect of nitrogen, phosphorus and potassium fertilization on cucumber yield was studied

by Diaz *et al* (1973) The study revealed that additional nitrogen application increased the total yield in various cucurbits

In a study on the effect of mineral fertilizers on water melon yield and quality by Knysh and Vakulenko (1976) enhancement in growth due to nitrogen application was observed. Pandey *et al.* (1974) studied the response of musk melon to foliar and soil application of nitrogen and found that foliar application of nitrogen as urea at 1.5 per cent in three applications, giving a total of 22 kg resulted in the highest number of fruits per plant and yield per hectare as compared with soil application of 50-200 kg N/ha. Soil applied nitrogen at rates above 50 kg N/ha was not beneficial to yield or fruit quality. Cantliffe (1977) observed a slight increase of pistillate flowers per plant upto a nitrogen dose of 134 kg/ha in pickling cucumbers grown for once over harvest, when applied as pre-plant.

Williams (1978) in another study on the effect of local cucumbers of supplementary mineral fertilizers over an initial field dressing of 30 t of poultry manure and 4 t of lime/ha found that significant yield increases were obtained with supplementary nitrogen upto 280 kg/ha but not with K/ Mg above the basal rates of 78/10 kg/ha. Bhosale *et al* (1978) observed that nitrogen nutrition is among the essential inputs controlling the productivity of water melon cv sugarbaby with 75 or 100 kg N/ha Ojunremi (1978) studied the response of water melon to nitrogen at 0 to 72 kg/ha in several trials. Increased levels of nitrogen application delayed flowering by a week. Fruit numbers per unit area and fruit size were highest with 48 kg N/ha Rajendran (1981) observed that the response to nitrogen was quadratic in the case of pumpkin and the economic level was worked out to be 71 kg/ha. Smittle and Threadgill (1982) subjected squash plants to factorial combinations of two irrigation levels, four nitrogen treatments and three tillage methods They observed higher marketable yield by giving 22 5 kg N/ha through irrigation water at 2,3,4,5 and 6 weeks after planting. Singh et al. (1983) reported that out of the four levels of nitrogen (0, 25, 50, 75 kg/ha) maximum number of fruits, maximum diameter of fruits, seed yield and 1000 seed weight in round melon were observed with 75 kg N/ha. Deshwal and Patil (1984) in yet another study observed that nitrogen is among the major input controlling growth and development in water melon. The maximum weight of fruits was recorded from the vines treated with 70 kg N/ha.

Srinivas and Doijode (1984) in a study on the effect of major nutrients on sex expression in musk melon observed that among the different nutrients, nitrogen alone, signi-

-ficantly increased the percentage of perfect flowers Sex ratio was maximum at 50 kg N/ha and minimum in control. With increase in the nitrogen levels there was significant increase in perfect flowers at same level of P (control). There was progressive increase in fruit weight with increase in nitrogen levels and was highest with highest level of nitrogen, an increase of 121 per cent and 1.9 per cent over control and 50 kg N respectively. Prabhakar (1985) in yet another field experiment for five years in musk melon observed that there was a significant increase in fruit yield due to nitrogen fertilizer upto 50 kg N/ha. The increase in fruit yield was associated with number of fruits, weight per fruit and total soluble solids. Increasing levels of nitrogen application significantly increased dry matter production upto 180 kg/ha in water melon although the magnitude of increase from 60-120 kg N/ha was considerably higher than that observed from 120-180 kg N/ha. Increasing levels of nitrogen fertilization upto 180 kg/ha increased the fruit yield of water melon although the difference between application rates of 120 and 180 kg N/ha was not significant. The increase in yield was attributed to significant increase in fruit size and harvest index (Hegde, 1987). John <u>et al</u> (1988) observed that in the irrigated sand, yields of marketable pumpkin fruits increased with nitrogen rate upto 202 kg N/ha and then levelled off, in the dryland loam, marketable fruit weight increased for the initial nitrogen movement of 67 kg/ha and appeared to decrease slightly at 269 kg N/ha. High nitrogen rates stimulated excess vine growth in both soils

Bishop et al (1969) showed that in cucumber, phosphorus wasof greater importance in yield response than nitrogen or potash. They indicated that nitrogen and phosphorus at approximately 50 and 100 kg/ha respectively were adequate Piazza and Venturi (1971) reported that application of phosphorus did not prove much effective for any characters excepting the fruit number per plant in musk melon. The highest yield of melons observed with phosphorus application was mainly due to increase in fruit number Much beneficial effects of phosphorus were observed in increasing the weight of Honey dew melon by Karchi et al.(1977). Rajendran (1981) observed that the response to applied phosphorus was linear in the case of pumpkin. He recommended a fertilizer schedule consisting of 50 kg P_2O_5/ha as optimum dose along with nitrogen. Singh et al. (1983) reported that out of two levels of phosphorus, the maximum number of fruits, maximum diameter of fruits, seed yield and 1000 seed weight in round melon were observed with 30 kg P_2O_5/ha. Srinivas and Doijode (1984) reported from studies on the effect of major nutrients in musk melon that phosphorus application increased the percentage of perfect flowers. Phosphorus application resulted in signi-

-ficant increase in yield over no P application. Deshwal and Patil (1984) observed in water melons that a dosage of 30 kg P_2O_5/ha gave significantly more weight of fruit. Application of phosphorus at the rate of 60 kg P_2O_5/ha increased fruit yield by 75 per cent in musk melon (Prabhakar, 1985). Buwalda and Freeman (1988) in a study on the effect of phosphorus fertilizers levels on phosphorus accumulation, growth and yield of hybrid squash in field found that fruit yield increased 109 and 67 per cent by phosphorus application in the early and late sown crops respectively. These increases resulted from significant effects on fruit number per plant and average fruit weight.

Deshwal and Patil (1984) reported from trials in water melon that application of 50 kg K_2O/ha significantly increased the weight of fruits over control. Application of potassium fertilizers increased percentage of perfect flowers in musk melon (Srinivas and Doijode, 1984). Prabhakar (1985) in yet another field experiment with musk melon observed that application of potassium at the rate of 60 kg K_2O/ha increased fruit yield by 16%.

Mahakal et al. (1977) reported an optimum dose of N, P and K at 75:50:100 kg/ha for tinda (Citrullus vulgaris var: fistulosus) from trials conducted on a medium heavy soil. Highest fertilizer dose tried (75:100:150 kg/ha of N, P_2O_5 and K_2O) gave only a slight increase in yield. Highest yields were reported in water melon cv. sugarbaby with

75 or 100 kg N/ha, 30 kg P_2O_5/ha and 75 or 100 kg K_2O/ha. In an experiment at KAU, the highest fruit yield in bittergourd was recorded with a fertilizer combination of N-50, P_2O_5-0 and K_2O - 50 kg/ha (Anon, 1980). A similar study on the effect of graded doses of N, P_2O_5 and K_2O on the growth and yield of bittergourd in open has revealed that maximum yield was recorded when the nutrients were given at the rate of 50:25:50 kg /ha (Anon, 1981). Randawa <u>et al</u>. (1981) in trials with two cultivars of muskmelon reported best results with regard to plant growth, number of fruits per vine, fruit weight per vine and fruit quality from plots receiving an NPK level at 50: 37.5 : 37.5 kg/ha. Rajendran (1981) studied the effect of different dose of NPK on pumpkin. He found that nitrogen, phosphorus and potash alone produced significant difference in the number of days required for the female flower production, percentage fruit set and equitorial parameters of fruit and fruit weight. The effect of different levels of nitrogen, phosphorus, potassium, calcium, magnesium and iron on growth, flowering and yield of fruits in long melon was studied in sand culture by Raychaudhuri <u>et al</u>. (1982). Nitrogen deficiency delayed the appearance of fruit flower bud by six days as compared to the control plants. The deficiency treatment, in general, caused reduction of both male and female flower compared to the respective high dose; the percentage of reduction in female flowers was more conspicuous than the male flowers.

The ratio of female to male flower was highest under low P (1:12) and lowest under high K, Ca, Mg (1:6). The plants grown under low dose of N and P (1/10 N; 1/10 P) failed to set fruits and all the female flowers dropped off within 3-7 days after their appearance. It is reported based on studies conducted at the College of Horticulture, Kerala, that the effects of nitrogen and potash on the yield of bittergourd were found to be significant (Anon, 1983). Another trial at KAU revealed that application of nitrogen at the rate of 50 kg/ha and P_2O_5 and K_2O at the rates of 25 kg/ha produced the highest yield in bittergourd (Anon, 1984). George Thomas (1984) reported that the bittergourd crop responded well to fertilizers and the highest level tried viz. Farmyard manure 18 tonnes + NPK 60:30:60 kg/ha produced maximum yield and net returns. Higher levels of fertilizers increased the mean number of fruits produced per plant, mean length and weight of fruits and yield of fruits. In a two year trial with musk melon that received nitrogen at 80-200 kg/ha and 40-80 kg P_2O_5/ha in different combinations, the average yield ranged from 15 t/ha at N -80, P_2O_5 - 40 kg/ha to 11.1 t/ha at N-200 and P_2O_5 - 40 kg/ha (Meisheri et al., 1984). In a trial to study the influence of nitrogen and phosphorus on the yield of bittergourd in the coastal region of Karnataka, Lingaiah et al. (1988) reported that treatment which received 80:30:0 kg N, P_2O_5, K_2O/ha recorded the highest yield of 17.12 t/ha followed by 80:30:15 kg N, P_2O_5, K_2O/ha with an yield of 15.58 t/ha.

The increase in yield was due to enhanced number and length of fruits. In general the data revealed better response of crop to higher levels of nitrogen and phosphorus than potassium.

2.2.2. <u>Influence of shade</u>

Considerable reduction in the yield of vegetable cowpea due to shading was observed by Krishnankutty (1983). On per cent basis, the yields under 25, 50 and 75% shade levels were 39.9, 19.45 and 13.48 respectively compared to these grown in the open. He also observed a delay in flowering in vegetable cowpea with increased shade intensities. The yield components viz., number of pods per plant and weight of pods per plant decreased with increasing shade levels.

Rajesh chandran (1987) has reported that the highest yields and net return were obtained from the vegetable cowpea raised in the open than those under partial shade. Plants raised in the open showed an increased pod number per plant, seed number per pod, yield of fresh pods and yield of fresh bhusa. He further reported that the days to first flowering, flowering period and the days to first picking remained unaffected due to the application of N, P or K, However, the plants raised under the partial shade took more days for flowering and picking. The total flowering period was more in the case of plants grown in the open.

In general vegetable cowpea performed much better in open when compared to partial shade.

2.3. Nutrient contents and uptake

2.3.1. Influence of major nutrients

Bishop et al. (1969) in a trial with cucumbers observed that the effect of fertilizers on the nutrient percentages in lamina and petioles were generally similar and the ratio of the percentage of a given nutrient in the lamina to that in the petioles was relatively constant.

Tayel et al. (1965) found that application of nitrogen fertilizers increased both nitrogen percentage and the total nitrogen content in different plant parts of cucumber. It was also observed that the total nitrogen absorbed by the plants per unit area increased with nitrogen fertilization. From a study on the nitrogen, phosphorus and potassium contents of cucumber leaves during different phases of growth it was found that cucumbers required higher nitrogen dose from the time of flower bud formation until the end of growth (Grozdova, 1970). Aleksandrova (1971) observed a significant increase in leaf nitrogen content by increasing nitrogen rates in cucumber. Top dressing with nitrogen fertilizers increased productivity only in a soil with low nitrate availability (less than 12 mg/100g). In muskmelons, Jassal et al. (1972) observed that the percentages of nitrogen and phosphorus in the plant tissues were highest after maximum application of the respective nutrients.

Wilcox (1973) in another trial determined leaf nitrogen content and related it to yield. Optimum leaf nitrogen composition in relation to yield was over 4.5% and the optimum petiole nitrate nitrogen composition was over 15000 ppm during plant growth and fruit formation respectively. Kagohashi et al. (1978) reported the characterization of nutrient uptake by muskmelon. They observed that the rates of nitrogen uptake by melon plants grown in hydroponic culture rose gradually before pollination, increased rapidly after pollination remained high for about 15 days and then suddenly fell to pre-pollination levels. Laske (1979) showed from another trial with domestic cucumbers planted at the rate of 1.2 plants/m^2 that it removed the equivalent of 500 kg N/ha during the growing season. He noted that when N = 1, the removal of N: P_2O_5: K_2O: CaO : MgO was 1.0: 0.4: 2.0: 1.6: 0.24. Fertility levels significantly increased the percentages of nitrogen in plant parts of bittergourd at all stages of growth except in vines at final harvest stage wherein the trend was almost similar (George Thomas, 1984). Nitrogen fertilizers increased leaf nitrogen content and fruit accumulation of nitrates in cucumber (Novotorova and Pavlova, 1986). Hegde (1987) in another experiment to study the effect of irrigation and fertilizers on dry matter production, fruit yield, mineral uptake and field water use efficiency in water melons reported that increasing nitrogen application significantly increased the mineral uptake although the difference between

120 and 180 kg N/ha was not significant. Difference in mineral uptake among nitrogen levels followed the difference in dry matter production.

Locascio (1967) while experimenting with water melon observed an increase in tissue phosphorus content due to applied phosphorus. The need for phosphorus by cucumber increased during flower bud formation, decreased slightly during flowering and rose again during cropping (Grozdova, 1970). George Thomas (1984) reported that the different levels of fertilizers did not produce any significant effect on the phosphorus content of leaves, vines and fruits.

Fiskell and Breland (1967) observed that the leaf potassium content decreased sharply with increasing yield in water melon. Potassium was readily absorbed during the early growth of cucumber declined during flower bud formation and then rose again (Grozdova, 1970).

Mc Collum and Miller (1971) reported that the total uptake of nitrogen, phosphorus and potassium by pickling cucumbers was 485, 65 and 782 kg/ha respectively. They estimated the nutrients removed by the harvested fruits as 216, 329 and 296 kg/ha respectively. Tesi et al. (1981) reported that when adequate fertilizers were applied, the uptake of nitrogen, phosphorus and potassium in Cucurbita pepo amounted to 170.5, 71.2 and 394.4 kg/ha respectively. He also observed that nutrient requirements were greatest during the 15 days preceding the first harvest and during the subsequent 15 days.

2.3.2. <u>Influence of shade</u>

The N and P contents in vegetable cowpea grown in the open or under partial shade did not differ significantly (Krishnankutty, 1983). The uptake of nitrogen and phosphorus were more with the plants grown under full light and less with those grown under high shade. K content of plant increased with increase in shade intensity.

Rajesh chandran (1987) reported that the uptake of N, P and K was much higher in the vegetable cowpea crop raised in the open when compared to that raised under partial shade. He also found that the total N and the available P_2O_5 contents of the soil after the experiment was higher in the open fields compared to the partially shaded fields.

The uptake and utilization of major nutrients is definitely influenced by the addition of increasing levels of nutrients as fertilizers, as is evident from the review presented above. In shaded condition it is generally observed that the uptake of major nutrients is adversely affected and the contents of these in the plant tissue is found to be relatively low.

The review presented in the foregoing section clearly indicate that the major nutrients definitely play a dominant role in the various physiological activities of the vegetable crops, thereby influencing the various growth characters like length of vine, internodal length, leaf area index, total dry matter production and yield attributes like fruit set, sex ratio, fruit length, girth and weight and total fruit yields. Moreover, the application of fertilizers have a positive influence on the uptake, translocation and utilization of the major nutrients by the crop. The influence of shade is also pronounced in the case of vegetable crops which are generally adapted to the open situations. Shaded conditions influence the crops in such a way that most of the growth characters are affected due to a general reduction in uptake, translocation and utilization of nutrients.

In general it is observed that plants grown in the open conditions performed better than those under partial shade.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation was undertaken with the objective of determining the nitrogen, phosphorus and potash requirements for bittergourd under partially shaded conditions. The field experiment was conducted during the summer season of 1988 The materials used and the methods adopted for the study are briefly described below.

3 1 MATERIALS

3 1 1. Experimental site

The experiment was conducted at the Instructional farm attached to the College of Agriculture, Vellayani. The farm is located at 8.5°N latitude and 76.9°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 of the experimental site are given overleaf

A. Mechanical composition

Constituent	Content in soil (%)	Method used
Coarse sand	13 80	Bouyoucos
Fine sand	33.50	Hydrometer method
Silt	28 00	
Clay	24.70	(Bouyoucos, 1962)
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 permagnate method (Subbaiah and Asija,1956)
Available P_2O_5	38.49 kg/ha	Medium	Bray colorimetric method(Jackson,1973)
Available K_2O	138 kg/ha	Medium	Ammonium acetate method(Jackson,1973)
Organic carbon	0 729%	High	Walkely and Black rapid titration method(Jackson, 1973)
pH	5 2	Acidic	1 2 soil solution ratio using pH meter

3.1.3 Cropping history of the field

The experimental site selected was a coconut plantation with palms of 50 years age having an average light infiltration of about 60 per cent to the ground No crops had been grown in the interspaces of the palms for ten months prior to the present investigation before which it had been intercropped with guinea grass

3.1.4 Season

The experiment was conducted during the summer season of 1988 (27th March to 12th July)

3.1.5 Weather conditions

The experimental site enjoys a humid tropical climate Data on maximum temperature, minimum temperature, rainfall and relative humidity during the entire crop season were collected from the meteorological observatory at the College of Agriculture and are presented as weekly averages in Appendix I and in Fig 1

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

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- 210SB photometric sensor.

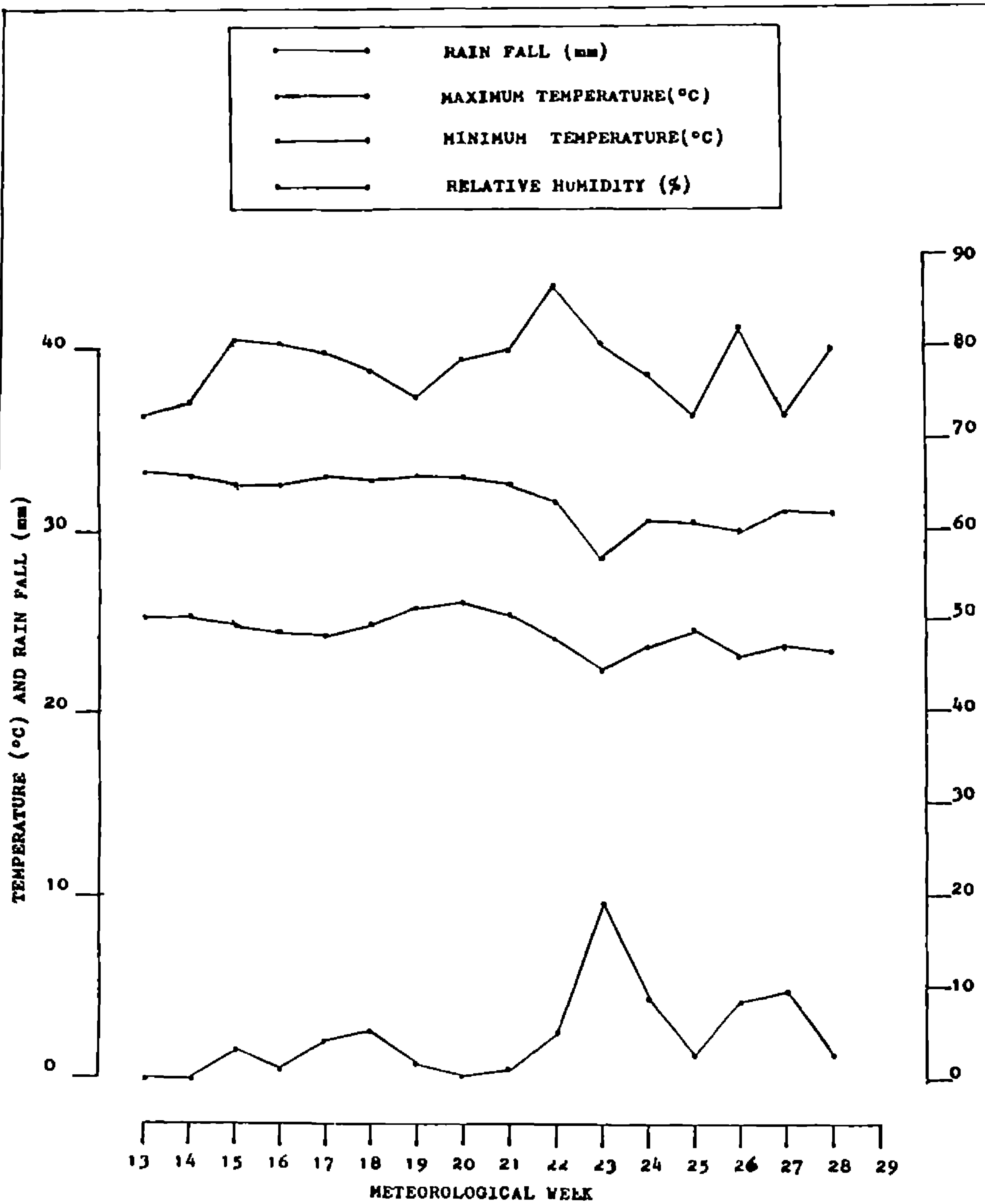


Fig 1 Weather data during cropping period (25 3 1988 to 14 7-1988)

3 1 7 Cultivar used

The cultivar used for the study was VK-1 (Priya) This cultivar was developed through single plant selection method at the Department of Olericulture, College of Horticulture, Kerala Agricultural University It is a high yielding variety of about 110 days duration and is grown on a commercial scale in Kerala. It produces long broad fruits with prominent spines and is devoid of smooth ridges.

3 1 8. Source of seed material

The seeds were obtained from the Department of Olericulture, College of Horticulture, Trichur, Kerala.

3 1.9 Fertilizers

Fertilizers with the following analysis were used for the study.

Urea	46 per cent N
Super phosphate	16 per cent P_2O_5
Muriate of potash	60 per cent K_2O

3 2 METHODS

3 2 1. Design and Layout

The experiment was laid out in a $3^3 + 1$ factorial experiment in randomised block design with partial confounding Factorial combinations of the three levels each of the three factors were allocated to the different plots using

PLATE-I The fruit of cultivar VK-1 (Priya)

PLATE I

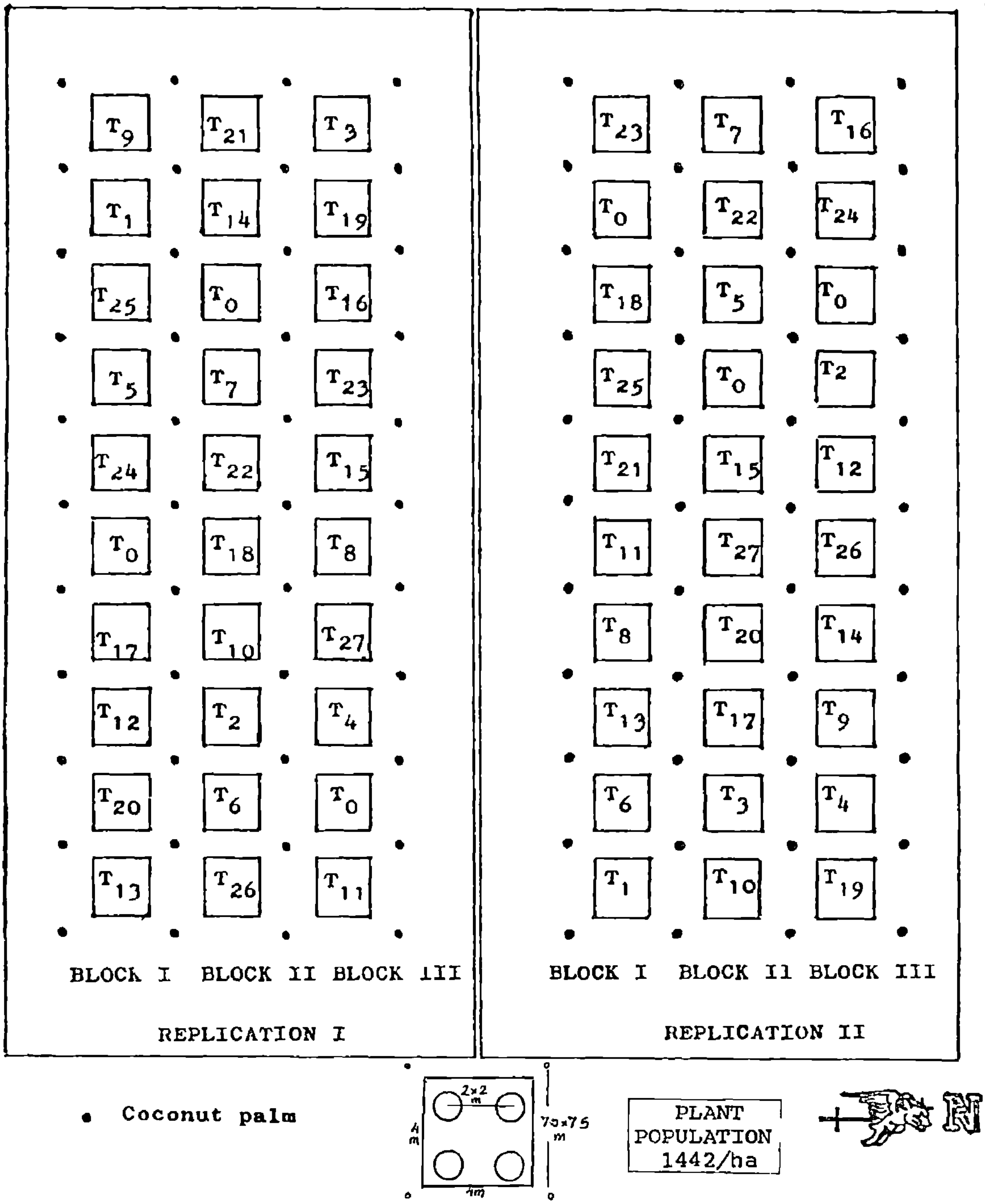


Fig . 2 Lay out plan - 3^3+1 Factorial experiment in R B D .

random numbers The layout plan is shown in Figure 2

Plot size	- 16 m^2
Spacing	- 2 x 2 m
Treatment combinations	- 27
Blocks	- 3
Replications	- 2
Total number of plots	- 60
Nature of confounding	- NP^2K was confounded in replication I and NP^2K^2 in replication II

3.2 2 Treatments

Three levels each of N, P_2O_5 and K_2O were fixed as the treatments The Package of practices recommendation of KAU was taken as basis for fixing the treatments.

Nitrogen

n_1	50 kg/ha
n_2	70 kg/ha
n_3	90 kg/ha

Phosphorus

p_1	15 kg/ha
p_2	25 kg/ha
p_3	35 kg/ha

Potash

k_1	25 kg/ha
k_2	50 kg/ha
k_3	75 kg/ha

Control — No application of N, P and K fertilizers

3.2.3. Treatment combinations

Treatment combinations are as follows

T_0	$n_o p_o k_o$	(control)
T_1	$n_1 p_1 k_1$	
T_2	$n_1 p_1 k_2$	
T_3	$n_1 p_1 k_3$	
T_4	$n_1 p_2 k_1$	
T_5	$n_1 p_2 k_2$	
T_6	$n_1 p_2 k_3$	
T_7	$n_1 p_3 k_1$	
T_8	$n_1 p_3 k_2$	
T_9	$n_1 p_3 k_3$	
T_{10}	$n_2 p_1 k_1$	
T_{11}	$n_2 p_1 k_2$	
T_{12}	$n_2 p_1 k_3$	
T_{13}	$n_2 p_2 k_1$	
T_{14}	$n_2 p_2 k_2$	
T_{15}	$n_2 p_2 k_3$	
T_{16}	$n_2 p_3 k_1$	
T_{17}	$n_2 p_3 k_2$	
T_{18}	$n_2 p_3 k_3$	
T_{19}	$n_3 p_1 k_1$	
T_{20}	$n_3 p_1 k_2$	
T_{21}	$n_3 p_1 k_3$	
T_{22}	$n_3 p_2 k_1$	
T_{23}	$n_3 p_2 k_2$	
T_{24}	$n_3 p_2 k_3$	
T_{25}	$n_3 p_3 k_1$	
T_{26}	$n_3 p_3 k_2$	
T_{27}	$n_3 p_3 k_3$	

3 2.4 Field Culture

3.2.4.1. Land preparation

The experimental plot was dug twice, stubbles removed, clods broken and the field was laid out into blocks and plots

Four pits of diameter 60 cm and 30-45 cm depth were taken in each plot at a spacing of 2 x 2 m. Each pit was half filled with a mixture of top soil and dried and powdered cowdung before planting.

3 2.4.2. Fertilizer application

Fertilizers were applied to all the plots other than the six control plots as per the treatments. Nitrogen, phosphorus and potash were applied to the plots in the form of urea, superphosphate and muriate of potash respectively in the stipulated doses as per the treatment combinations The entire quantity of phosphorus and potash and 50 per cent nitrogen were applied as basal dose one day prior to sowing. The remaining quantity of nitrogen were applied in two equal splits at 30 and 60 DAS. Organic matter as dried and powdered cowdung was applied at the rate of 25 t/ha to all plots including the six control plots.

3.2.4.3. Seeds and sowing

Bold seeds selected for planting were soaked in water overnight before sowing. Four seeds were planted in each pit at a spacing of 30 cm.

3.2.4.4. After cultivation

At ten days after sowing the plant population in each pit was limited to two by thinning. Regular weeding operations were carried out to keep the plots weed free for the entire cropping period. Twenty days after sowing a standard of one metre length was fixed in each pit and the plants were twined around it. At 30 DAS pandals of height 1.85 m were errected around each plot separately to prevent the vines of one plot from spreading on to the adjacent one. Care was taken to trail the vines on the pandal regularly. Pot irrigation was done on every alternate day for the entire cropping period

3.2.4 5. Plant protection

After fruit set, the fruits were covered with paper bags to ensure meachnical protection against fruit flies. Malathion 0.2 per cent suspension containing jaggery at 10 g per litre was sprayed at fortnightly intervals after fruit set initiation against attack by fruit flies. Quinalphos at 0.05 per cent concentration was sprayed on the foliage when attack by epilachna beetle was noticed. Adults, grubs and eggmasses occurring on leaves were removed and destroyed.

3 2.4.6 Harvesting

The crop was harvested at regular intervals from 45 DAS. In total four harvests were done over the entire cropping period. Fruits were harvested when they matured, the maturity for vegetable purpose being judged by visual observation.

3 2 5. Measurement of shade intensity

Light intensity in each plot and in the open was measured in Kilo lux during the 50 per cent flowering (63 DAS) stage at 11 A.M , 1 30 P.M and 4 P.M Average of these three readings were recorded and 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 the shaded condition

3 2.6. Biometrical observations

The following observations were recorded.

3.2.6.1. Days for opening of first male flower

The mean value of the days for opening of first male flower in two sample plants, counted from the date of sowing of the crop was recorded.

3.2 6 2 Days for opening of first female flower

The mean value of the days for opening of first female flower in two sample plants, counted from the date of sowing of the crop was recorded.

3.2.6.3. Node at which the first male flower appeared

Node at which the first male flower appeared in the two sample plants was counted from the cotyledon node and the mean value was worked out.

3.2.6.4 Node at which the first female flower appeared

Node at which the first female flower appeared in the two sample plants was counted from the cotyledon node and the mean value was worked out.

3.2.6.5 Internodal length

Internodal length was measured at 50 per cent flowering stage. Two plants from opposite pits were selected and length of ten consecutive internodes were measured at a height of about 30 cm from the ground level. From the data obtained, the mean internodal length was calculated and expressed in cm.

3.2.6.6 Sex ratio

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

3.2.6.7. Yield per plot

Fruits were harvested as and when they matured, the maturity for vegetable purpose being judged by visual observations. The entire yield was totalled and expressed in kg/ha.

3.2.6.8. Number of fruits per plant

The total number of fruits obtained from a plot was divided by eight to get the number of fruits per plant.

3.2.6.9. Per fruit weight

The weight of the fruits from a single plot was divided by the total number of fruits from that plot to get the per fruit weight which was expressed in grams

3.2.6.10. Length of fruit

During harvests ten fruits were randomly selected from each plot and the length of the fruit from the stalk end to the tip was measured in cm and averaged.

3.2.6.11. Girth of fruits

During harvest ten fruits were selected randomly from each plot and the girth was recorded in cm at top 1/4th bottom 1/4th and the middle of the fruit and then averaged.

3 2.6.12. 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 6.13. Length of main vine

Total length of main vine was measured in cm when cropping was completed. Length of two sample plants were measured and then averaged.

3.2.6.14. Total dry matter production (DMP)

The fruits and vines of the sample plants at harvest were separately chopped and oven dried to constant weight at 80 ± 5°C The total dry weight of plants was recorded and expressed in grams per plant.

3 2.6.15 Harvest Index (HI)

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

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}}$$

3.2 7. Chemical analysis

3 2.7.1 Plant analysis

The whole plant was analysed for nitrogen, phosphorus and potassium at the final harvest. Two fruits from each harvest were selected at random from each plot These were bulked with samples from the same plot at the other harvests The plants and fruit samples were chopped and dried in an air oven at 80^{o}C separately till constant weights were achieved 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 analyses were carried out.

3 2 7.1 1. Total nitrogen content

Total nitrogen content was estimated by modified microkjeldahl method as given by Jackson (1973) and the values were expressed as percentages

3.2.7.1.2. 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.

3.2.7.1 3. Total phosphorus content

Phosphorus content was estimated colorimetrically (Jackson, 1973) after wet digestion of the sample using 2 1 mixture of nitric acid and perchloric acid and developing colour by vanadomolybdo phosphoric yellow colour method and read in a Bausch and Lomb spectronic 2000 spectrophotometer

3.2.7.1.4. Uptake of phosphorus

This was calculated by multiplying the phosphorus content and dry weights of the plants or fruits as the case may be. The values were expressed in kg/ha.

3.2.7.1.5. Total potash content

Total potash content in plants was estimated by the flame photometric method in a Perkin-Elmer 3030 Atomic Absorption Spectrophotometer after wet digestion of the sample using diacid mixture.

3.2.7.1.6. Uptake of potash

This was calculated by multiplying the dry weights and potash content of the plants or fruits as the case may be. The uptake values were expressed in kg/ha.

3.2.7.1 7. Protein content of the fruits

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

3 2.7.2. 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 permagnate method (Subbiah and Asija, 1956). Available phosphorus content was estimated by Bray's colorimetric method (Jackson, 1973) and available potash by ammonium acetate method (Jackson, 1973).

3.2.8. Economics of cultivation

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

1. Cost of 1 kg N	- Rs.5.33
2. Cost of 1 kg P_2O_5	- Rs.6.25
3. Cost of 1 kg K_2O	- Rs.2.91
4. Cost of 1 ton FYM	- Rs.230.00
5. Cost of cultivation of bittergourd per ha excluding cost of treatments, in a coconut garden assuming the area available for intercropping is 70%	- Rs.23,794.00
6. Price of 1 kg bittergourd	- Rs 6.00

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

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

$$\text{Return per rupee invested (Rs.)} = \frac{\text{Gross income}}{\text{Cost of cultivation}}$$

3.2.9. Statistical analysis

The data on shade intensity was first analysed by employing the technique of analysis of variance. The effect of shade was found to be insignificant (See Appendix II) and it is assumed that all plots recorded almost uniform intensity of sunlight. Hence, analysis of covariance was not resorted to and the entire data were analysed by the technique of analysis of variance and their 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 different plant nutrients on the per plot yield of bittergourd the relevant sum of squares of N, P & K were partitioned into linear and quadratic orthogonal components and significance of each component tested as described by Snedecor and Cochran (1967) Appropriate response curve models were fitted for estimating optimum and economic doses.

The data were analysed using a Keltron Versa IWS computer system.

RESULTS

RESULTS

The experimental data collected were statistically analysed to bring out the effect of different levels of nitrogen, phosphorus and potassium and their interactions. The results obtained in the study are presented under the following sections.

4.1 Growth characters

4.2 Yield attributes and yield

4.3 Quality characters

4.4 Chemical analyis of plant samples

4.5 Soil analysis

4.6 Economic of cultivation.

4.1 Growth characters

4.1.1 Days for opening of first male flower

The transformed data on the mean number of days taken for the opening of the first male flower are presented in Table 1 and the analysis of variance in Appendix III.

There was significant difference in the days taken for opening of the first male flower in the control and treatments.

Nitrogen levels had significant influence on this character. The days taken for the opening of the first male flower increased with levels of nitrogen. The effects of phosphorus, potassium and the interactions of N, P and K were not significant.

4 1.2 Days for the opening of first female flower

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

Significant differences in the number of days taken for the opening of the first female flower was observed in the control and the treatments.

The levels of nitrogen had a significant influence on this parameter and the number of days taken increased with increasing levels of nitrogen. However the main effects of phosphorus and potassium and the different interactions of N, P and K were not significant, in this respect.

4.1.3 Node at which the first male flower appeared

The transformed data on the mean node at which the first male flower appeared are presented in Table 1 and the analysis of variance in Appendix III.

Nitrogen significantly influenced this character. As the levels increased, the node number at which the first male flower appeared also increased. All the three levels of phosphorus and potash and the different NPK interactions failed to register any influence on this character. The

Table 1 Effect of nitrogen phosphorus, potash and their interactions on the days for opening of first male flower, first female flower and node at which the first male and female flower appeared *

Treatments	Days for opening of first		Node of first ppe rance of	
	Male flower	Female flower	Male flower	Fem le flower
n_1	5 53	5 87	2 97	4 56
n_2	5 68	6 08	3 25	5 11
n_3	5 96	6 45	3 55	5 31
SEm±	0 04	0 04	0 05	0 04
CD (0 05)	0 12	0 12	0 13	0 12
p_1	5 67	6 09	3 23	4 89
p_2	5 71	6 11	3 23	4 99
p_3	5 78	6 19	3 31	5 10
SEm	0 04	0 04	0 05	0 04
CD (0 05)	NS	NS	NS	0 12
k_1	5 72	6 14	3 19	4 98
k_2	5 71	6 14	3 29	4 95
k_3	5 73	6 12	3 28	5 01
SEm	0 04	0 04	0 05	0 04
CD (0 05)	NS	NS	NS	NS
n_1p_1	5 49	5 83	2 90	4 37
n_1p_2	5 53	5 89	3 01	4 58
n_1p_3	5 56	5 90	3 00	4 73
n_2p_1	5 64	6 07	3 22	4 99
n_2p_2	5 69	6 04	3 21	5 09
n_2p_3	5 70	6 11	3 30	5 24
n_3p_1	5 88	6 37	3 55	5 30
n_3p_2	5 92	6 41	3 47	5 30
n_3p_3	6 08	6 56	3 63	5 33
SEm±	0 07	0 07	0 08	0 07
CD (0 05)	NS	NS	NS	NS
n_1k_1	5 52	5 87	2 91	4.49
n_1k_2	5.50	5 85	2 98	4.56
n_1k_3	5 55	5 90	3 01	4 63
n_2k_1	5 66	6.09	3 21	5 10
n_2k_2	5 69	6 12	3 26	5 11
n_2k_3	5 67	6 02	3 28	5 12
n_3k_1	5 98	6 46	3 46	5 34
n_3k_2	5 93	6 45	3 64	5 30
n_3k_3	5 97	6 43	3 55	5 29
SEm	0 07	0 07	0 08	0 07
CD (0 05)	NS	NS	NS	NS
k_1p_1	5 68	6 12	3 20	4 91
k_1p_2	5 73	6 14	3 5	4 95
k_1p_3	5 76	6 16	3 23	5 07

Contd

Table 1 (Contd)

Treatments	Days for opening of first		Node of first appearance of	
	Male flower	Female flower	Male flower	Female flower
k_2p_1	5 66	6 09	3 28	4 87
k_2p_2	5 70	6 12	3 32	5 01
k_2p_3	5 76	6 21	3 28	5 09
k_3p_1	5 66	6 06	3 20	4 89
k_3p_2	5 71	6 08	3 23	5 01
k_3p_3	5 83	6 21	3 41	5 13
SEm+	0 07	0 07	0 08	0 07
CD (0 05)	NS	NS	NS	NS
$n_op_ok_o$	5 34	5 70	2 70	4 12
$n_1p_1k_1$	5 47	5 82	2 85	4 32
$n_1p_1k_2$	5 48	5 81	2 90	4 3[illegible]
$n_1p_1k_3$	5 51	5 85	2 95	4 46
$n_1p_2k_1$	5 55	5 90	2 96	4 49
$n_1p_2k_2$	5 49	5 85	3 10	4 64
$n_1p_2k_3$	5 54	5 92	3 00	4 61
$n_1p_3k_1$	5 55	5 86	2 94	4 67
$n_1p_3k_2$	5 53	5 90	2 95	4 68
$n_1p_3k_3$	5 60	5 94	3 10	4 82
$n_2p_1k_1$	5 59	6 05	3 25	5 07
$n_2p_1k_2$	5 65	6 08	3 24	4 98
$n_2p_1k_3$	5.67	6.09	3.19	4.92
$n_2p_2k_1$	5 72	6.10	3.18	5 02
$n_2p_2k_2$	5 72	6 11	3 28	5 10
$n_2p_2k_3$	5 63	5 92	3 19	5 17
$n_2p_3k_1$	5 67	6 11	3 21	5 21
$n_2p_3k_2$	5 71	6 18	3.25	5 26
$n_2p_3k_3$	5 72	6 05	3 45	5 26
$n_3p_1k_1$	5 98	6 47	3 50	5 33
$n_3p_1k_2$	5 85	6 38	3 69	5 27
$n_3p_1k_3$	5 80	6 26	3.47	5 30
$n_3p_2k_1$	5 92	6 42	3 31	5 34
$n_3p_2k_2$	5 89	6 41	3 59	5 28
$n_3p_2k_3$	5 94	6 39	3 50	5 27
$n_3p_3k_1$	6 05	6 50	3 55	5 34
$n_3p_3k_2$	6 03	6 56	3 64	5 34
$n_3p_3k_3$	6 16	6 13	3 69	5 30
SEm_	-	-	-	-
CD (0 05)	NS	NS	NS	NS

NS Not significant

* ransformed dat (Squ re root transformation)

control registered significantly lower values of node number in comparison with the treated.

4.1 4. Node at which first female flower appeared

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

It is seen that nitrogen and phosphorus significantly influenced this character The mean node number at which the first female flower appeared increased with increasing levels of nitrogen and phosphorus, but p_1 and p_2 were found to be on par The main effects of potash and NPK interaction of first and second order did not influence this character.

Significant difference was observed between the control and the plots where treatments of different levels of major nutrients were applied.

4.1.5. Internodal length

The data on the influence of N P and K and their interactions on the internodal length are presented in Table 2 and the analysis of variance in Appendix IV.

There was significant difference in internodal length between the control and different fertilizer treatments. The internodal length increased with increase in levels of nitrogen

However, none of the interactions of N P and K nor the main effects of P and K had any effect on this parameter.

4.1.6. Length of main vine

The data on the length of main vine are presented in Table 2 and the analysis of variance in Appendix IV

The main effect of nitrogen was found to influence the length of the vine However, n_1 was on par with n_2 which was in turn on par with n_3. The main effects of P and K and the various NPK interactions were not found to be significant.

4.1.7. Total dry matter production (DMP)

The data on the total DMP are presented in Table 2 and analysis of variance in Appendix IV.

As the level of nitrogen was increased the total DMP also registered an increase and the effect of nitrogen was found to be significant on this character. The levels of phosphorus were also found to significantly influence this character. p_3 recorded the maximum DMP among the three levels of phosphorus followed by p_2 and p_1 Phosphorus levels, p_2 and p_3 were, however found to be on par

The control recorded significantly lower DMP than the treatments. Neither the main effect of K nor the interaction effects of NPK significantly influenced this character

Table 2 Effect of nitrogen, phosphorus, potash and their interactions on the internodal length, length of main vine and total dry matter production

Treatments	Internodal length (50% Flowering) (cm)	Length of main vine (cm)	Total dry matter production (g/plant)
n_1	7 99	694 67	324 58
n_2	9 14	713 69	398 59
n_3	10 58	760 31	452 29
SEm±	0 14	17 75	6 53
CD(0 05)	0 39	51 50	18 96
P_1	9 17	731 06	373 91
P_2	9 07	697 06	395 93
P_3	9 48	740 56	405 63
SEm±	0 14	17 75	6 53
CD(0 05)	NS	NS	18 96
K_1	9 09	740 44	378 65
K_2	9 23	715 31	397 28
K_3	9 39	712 92	399 54
SEm±	0 14	17 75	6 53
CD(0 05)	NS	NS	NS
n_1P_1	7 74	711 58	292 33
n_1P_2	8 09	692 42	339 48
n_1P_3	8 15	680 00	341 93
n_2P_1	9 05	701 92	385 51
n_2P_2	8 93	687 33	397 06
n_2P_3	9 45	751 83	413 19
n_3P_1	10 71	779 67	443 90
n_3P_2	10 19	711 42	451 24
n_3P_3	10 85	789 83	461 75
SEm±	0 23	30 74	11 32
CD (0 05)	NS	NS	NS
n_1k_1	7 89	735 00	302 86
n_1k_2	7 91	669 50	324 49
n_1k_3	8 17	679 50	346 39
n_2k_1	8 99	713 25	383 77
n_2k_2	9 03	715 75	405 91
n_2k_3	9 42	712 08	406 09
n_3k_1	10 42	773 08	449 3[illegible]
n_3k_2	10 74	760 67	461 43
n_3k_3	10 59	747 17	446 13
SE	0 23	30 74	11 32
CD (0 05)	NS	NS	NS

Contd

Table 2 (Contd)

Treatments	Int rnodal length (50% flowering)	Length of m in vine	Total dry matter production
k_1p_1	8 92	743 33	363 90
k_1p_2	8 90	734 00	390 80
k_1p_3	9 47	744 00	381 26
k_2p_1	9 27	731 92	377 01
k_2p_2	8 98	675 58	402 79
k_2p_3	9 43	738 42	412 02
k_3p_1	9 30	717.92	380.83
k_3p_2	9.33	681 58	394.18
k_3p_3	9 55	739 25	423 60
SEm±	0 23	30 74	11 32
CD (0 05)	NS	NS	NS
$n_0p_0k_0$	6 96	679 50	230 12
$n_1p_1k_1$	7.43	736 50	255 47
$n_1p_1k_2$	7 88	654 50	299 49
$n_1p_1k_3$	7 90	743 75	322 03
$n_1p_2k_1$	7 92	735 75	325 84
$n_1p_2k_2$	7 87	691 00	337 57
$n_1p_2k_3$	8 48	650 50	352 04
$n_1p_3k_1$	8.33	732 75	324 27
$n_1p_3k_2$	7 99	663 00	336 41
$n_1p_3k_3$	8 14	644 25	365 12
$n_2p_1k_1$	8 58	738 25	375 46
$n_2p_1k_2$	8 98	739 25	397 01
$n_2p_1k_3$	9 60	628 25	384 06
$n_2p_2k_1$	8 89	694 5	385 78
$n_2p_2k_2$	8 67	662 00	400 54
$n_2p_2k_3$	9 21	705 50	404 87
$n_2p_3k_1$	9 48	707 00	390 07
$n_2p_3k_2$	9 44	746 00	420 19
$n_2p_3k_3$	9 43	802 50	429 34
$n_3p_1k_1$	10 76	755 25	460 78
$n_3p_1k_2$	10 95	802 00	434 52
$n_3p_1k_3$	10 41	781 75	436 42
$n_3p_2k_1$	9 88	771 75	457 80
$n_3p_2k_2$	10 42	673 75	470 29
$n_3p_2k_3$	10 29	698 75	425 63
$n_3p_3k_1$	10 61	792 25	429 43
$n_3p_3k_2$	10 86	806 25	479 48
$n_3p_3k_3$	11 08	771 00	476 35
SEm ±		-	
CD (0 05)	NS	NS	NS

NS - Not significant

4 2. Yield attributes and yield

4.2.1. Sex ratio

The data on the influence of N, P and K and their interactions on the sex ratio are presented in Table 3a and the analysis of variance in Appendix V.

The main effects of nitrogen, phosphorus and potash had no significant influence on this character The second order interactions viz NxPxK had pronounced influence on this character, with $n_3p_3k_3$ recording the maximum value No other interaction was found to have any significant influence on this parameter.

4.2 2. Fruit set

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

The main effect of N, P and K had significant influence on this parameter The fruit set improved with increasing levels of nitrogen but levels n_1 and n_2 were on par. The level p_2 was found to record the highest fruit set followed by p_3 and p_1 among the levels of phosphorus and level k_1 recorded the maximum effect followed by k_2 and k_3 among the different levels of potash. However, levels k_1 and k_2 were found to be on par and so were the levels k_2 and k_3. None of the interactions except N x P proved to be significant. Among the N x P interactions n_3p_2 recorded the maximum fruit set.

4 2.3 Yield per plot

The data on the yield of fruits are given in Table3a and the analysis of variance in Appendix V

There was significant difference between the control and fertilizer treatments on the yield of fruits

The main effect of nitrogen and phosphorus had profound influence on yield of fruits with increase in nitrogen levels, the yield also registered an increase, although the levels n_1 and n_2 were found to be on par Among the levels of phosphorus, p_2 recorded maximum yield followed by p_3 and p_1 However p_1 was found to be on par with p_3 and p_3 with p_2

Of the various interactions only NxPxK had significant influence on this character with $n_3p_2k_2$ recording the maximum yield of 12340.63 kg/ha.

4 2 4. No. of fruits per plant

The transformed data on the number of fruits per plant are given in Table3a and the analysis of variance in Appendix V.

Even though there was significant difference for this character between the control plots and the fertilizer treatments, none of the main effects or the interactions revealed any significant influence on this parameter

Table 3a Effect of nitrogen, phosphorus, potash and their interactions on the sex ratio, fruit set, yield and number of fruits per plant

Treatments	Sex ratio (50% flowering)	Fruit set* (%)	Yield (kg/ha)	Fruits/plant*
n_1	6.43	1.96	6821.95	3.07
n_2	6.38	2.50	7247.85	3.23
n_3	6.75	3.46	8461.04	3.58
SEm±	0.22	0.31	277.53	0.15
CD (0.05)	NS	0.90	805.37	NS
p_1	6.52	2.16	6969.38	3.14
p_2	6.46	3.40	8108.16	3.47
p_3	6.59	2.35	7453.30	3.27
SEm±	0.22	0.31	277.53	0.15
CD (0.05)	NS	0.90	805.37	NS
k_1	6.08	3.34	7626.53	3.44
k_2	6.85	2.64	7806.01	3.33
k_3	6.63	1.94	701 30	3.10
SEm±	0.22	0.31	277.53	0.15
CD(0.05)	NS	0.90	NS	NS
n_1p_1	6.34	1.99	6440.04	3.01
n_1p_2	6.53	1.98	7309.38	3.17
n_1p_3	6.44	1.89	6710.42	3.03
n_2p_1	6.28	1.79	6290.11	3.96
n_2p_2	6.15	2.58	7446.88	3.26
n_2p_3	6.71	3.14	8006.56	3.48
n_3p_1	6.94	2.68	8171.98	3.45
n_3p_2	6.70	5.65	9568.23	3.99
n_3p_3	6.62	2.03	7642.92	3.29
SEm±	0.38	0.54	480.69	0.27
CD (0.05)	NS	1.56	NS	NS
n_1k_1	5.91	1.99	7078.13	3.16
n_1k_2	6.88	2.04	7113.02	3.16
n_1k_3	6.51	1.83	6274.69	2.89
n_2k_1	6.39	3.44	7349.27	3.44
n_2k_2	6.77	2.15	7022.92	3.05
n_2k_3	5.98	1.92	7371.36	3.20
n_3k_1	5.95	4.58	8452.19	3.73
n_3k_2	6.91	3.72	9522.03	3.78
n_3k_3	7.39	2.06	7408.86	3.23
SEm±	0.38	0.54	480.69	0.27
CD (0.05)	NS	NS	NS	NS
k_1p_1	6.16	2.66	7153.02	3.33
k_1p_2	5.87	4.48	8320.31	3.59
k_1p_3	6.23	2.87	7406.25	3.41

Contd

Table 3a (Contd)

Treatments	Sex ratio (50% flowering)	Fruit set* (%)	Yield (kg/ha)	Fruit /plant*
k_2p_1	6 91	2 07	6750 21	3 10
k_2p_2	6 66	3 48	8646 35	3 53
k_2p_3	6 99	2 37	8261 46	3 36
k_3p_1	6 49	1 75	7004 89	2 97
k_3p_2	6 86	2 25	7357 81	3 30
k_3p_3	6 55	1 82	6692 19	3 04
SEm±	0 38	0 54	480 69	0 27
CD (0 05)	NS	NS	NS	NS
$n_0p_0k_0$	6 72	1 56	5328 34	2 58
$n_1p_1k_1$	6 32	1 73	6029 69	2 85
$n_1p_1k_2$	6 43	2 39	7240 63	3 40
$n_1p_1k_3$	6 28	1 86	6067 82	2 77
$n_1p_2k_1$	5 40	1 95	7176 57	3 18
$n_1p_2k_2$	6 57	2 07	7898 44	3 29
$n_1p_2k_3$	7 605	1 91	6853 13	3 04
$n_1p_3k_1$	6 01	2 30	8028 13	3 45
$n_1p_3k_2$	7 64	1 66	6200 00	2 80
$n_1p_3k_3$	5 66	1 71	5903 13	2 85
$n_2p_1k_1$	6 48	2 12	6435 94	3 18
$n_2p_1k_2$	6 205	1 66	6515 63	2 85
$n_2p_1k_3$	6 14	1 59	5918 75	2 84
$n_2p_2k_1$	6 26	3 86	9337 5	3 58
$n_2p_2k_2$	6 02	1 58	5700 00	2 69
$n_2p_2k_3$	6 19	2 30	8303 13	3.49
$n_2p_3k_1$	6 43	4 33	7274 38	3 57
$n_2p_3k_2$	8 09	3 20	8853 13	3 61
$n_2p_3k_3$	5 62	1 88	7892 19	3 27
$n_3p_1k_1$	5 68	4 13	8993 44	3 96
$n_3p_1k_2$	8,11	2 14	6494 38	3 07
$n_3p_1k_3$	7 04	1 80	9028 13	3 31
$n_3p_2k_1$	5 94	7 62	9446 88	4 01
$n_3p_2k_2$	7 38	6 79	12340 63	4 61
$n_3p_2k_3$	6 78	2 54	6917 19	3 37
$n_3p_3k_1$	6 24	1 99	6916 25	3 21
$n_3p_3k_2$	5 25	2 24	9731 25	2 66
$n_3p_3k_3$	8 39	1 87	6281 25	2 99
SEm±	0 65		1 03	
CD (0 05)	1 89	NS	2416 11	NS

NS - Not significant

* - Transformed data (S u re root transform tion)

*(Logit transformatio)

Table 3b. Trend analysis of the nitrogen and phosphorus nutrients in the yield of bittergourd fruits (Analysis of variance)

Source	df	SS	MSS	F
N	2	26038790	13019390	9.391039**
N_L	1	24179544	24179544	17.44**
N_Q	1	18592458	1859246	1.34
P	2	11759360	5879680	4.241032*
P_L	1	3587425	3587425	2.587652
P_Q	1	8171934	8171935	5.8945132*
Error	27	37431810	1386363	

* Significant at 5% level

** Significant at 1% level

4 2.5. Per fruit weight

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

Only the main effect of potassium was found to influence this character. As the levels of K increased the weight per fruit also increased. However k_2 and k_3 were found to be on par.

4.2.6. Length of fruits

The data on the length of fruits are given in Table 4 and analysis of variance in Appendix VI

Pronounced difference in the length of fruits was observed between the control and fertilizer treatments

The main effect of nitrogen recorded significant influence on this character. As the levels were increased from 50 kg/ha to 90 kg/ha the mean value of length of fruits also increased.

All the interactions were observed to be not significant.

4.2.7. Girth of fruits

The data on the girth of fruits are presented in Table 4 and the analysis of variance in Appendix VI.

There was significant difference between the control plots and fertilizer treatments in this character. Nitrogen and potassium were found to have pronounced effects

Table 4 Effect of nitrogen phosphorus, potash and their interactions on the per fruit weight, length of fruit, girth of fruit and harvest index

Treatments	Weight/fruit (g)	Length of fruit (cm)	Girth of fruit (cm)	Harvest index*
n_1	144 89	22 77	13 94	0 58
n_2	140 49	24 69	16 20	1 04
n_3	132 60	27 13	18 22	1 32
SEm+	3 76	0 55	0 24	0 32
CD (0 05)	NS	1.59	0.70	NS
p_1	143 09	24 14	16 25	0 88
p_2	135 37	25 53	16 16	0 95
p_3	139 53	24 92	15 95	1.11
SEm+	3 76	0 55	0 24	0 32
CD (0 05)	NS	NS	NS	NS
k_1	129 82	25 64	16 06	0 95
k_2	142 48	24 31	15 65	0 97
k_3	145 68	24 64	16 64	1 02
SEm+	3 76	0 55	0 24	0 32
CD (0 05)	10 92	NS	0 70	NS
n_1p_1	144 28	23 15	14 46	0 42
n_1p_2	146 11	23 03	13 96	0 55
n_1p_3	144 29	22 12	13 41	0 78
n_2p_1	145 54	23 56	16 30	0 91
n_2p_2	141 20	25 40	16 58	1 03
n_2p_3	134 74	25 09	15 71	1 18
n_3p_1	139 44	25 71	17 99	1 31
n_3p_2	118 79	28 14	17 93	1 28
n_3p_3	139 58	27 54	18 73	1 38
SEm±	6 52	0 95	0 42	0 55
CD (0 05)	NS	NS	NS	NS
n_1k_1	140 87	23 93	14 25	0 54
n_1k_2	143 14	22 33	13 35	0 56
n_1k_3	150 67	22 04	14 23	0 64
n_2k_1	126 26	25 19	16 04	0 99
n_2k_2	151 82	24 81	14 83	1 04
n_2k_3	143 39	24 06	17 73	1 09
n_3k_1	123 33	27 80	17 91	1 32
n_3k_2	132 49	25 78	18 78	1 32
n_3k_3	142 9	27 82	17 96	1 33
SEm+	6 52	0 95	0 42	0 55
CD (0 05)	NS	NS	1 21	NS
k_1p_1	130 92	24 54	14 94	0 83
k_1p_2	130 16	25 85	17 03	0 90
k_1p_3	128 39	26 [illegible]3	16 22	1 12

Contd

Table 4 (contd)

Treatments	Weight/fruit (g)	Length of fruit (cm)	Girth of fruit (cm)	Harvest index*
k_2p_1	141 53	23 09	16 27	0 89
k_2p_2	140 00	25 43	15.09	0 91
k_2p_3	145 92	24 41	15 60	1 09
k_3p_1	156 81	24 79	17 55	0 91
k_3p_2	135 94	25 30	16 35	0 04
k_3p_3	144 30	23 82	16 02	1 12
SEm+	6 52	0 95	0 42	0 55
CD (0 05)	NS	NS	1 21	NS
$n_0p_0k_0$	164 84	23 08	12 45	0 30
$n_1p_1k_1$	150 06	23 69	12 99	0.34
$n_1p_1k_2$	125 19	24 19	14 33	0 45
$n_1p_1k_3$	1[illegible]7 61	21 59	16 07	0 47
$n_1p_2k_1$	142 98	22 67	16 07	0 49
$n_1p_2k_2$	146 29	24 73	12 30	0 47
$n_1p_2k_3$	149 05	21 71	13 52	0 69
$n_1p_3k_1$	129 58	25 45	1[illegible] 69	0 80
$n_1p_3k_2$	157 94	18 09	13 43	0 75
$n_1p_3k_3$	145 35	22 83	13 11	0 78
$n_2p_1k_1$	129 19	24 61	15 40	0 85
$n_2p_1k_2$	160 68	21.85	15 16	0 95
$n_2p_1k_3$	146 75	24 22	18 35	0.95
$n_2p_2k_1$	130 16	25.39	16 95	0 94
$n_2p_2k_2$	157.19	25 40	14 34	0 99
$n_2p_2k_3$	136 24	25 41	18 47	1.15
$n_2p_3k_1$	119 44	25 56	15 77	1 18
$n_2p_3k_2$	137 59	27 19	14 98	1 18
$n_2p_3k_3$	147.19	22 54	16 37	1.18
$n_3p_1k_1$	113 53	25 32	16 43	1 29
$n_3p_1k_2$	138 73	23 24	19 33	1 29
$n_3p_1k_3$	166 06	2[illegible] 59	18 22	1 32
$n_3p_2k_1$	117 34	29 48	18 09	1 27
$n_3p_2k_2$	116 52	26 17	18 64	1 30
$n_3p_2k_3$	122 52	28 78	17 06	1 27
$n_3p_3k_1$	136 14	28 59	19 22	1 39
$n_3p_3k_2$	142 23	27 95	1[illegible] 38	1 36
$n_3p_3k_3$	140 37	26 09	18 59	1 39
SEm±	-		-	-
CD (0 05)	NS	NS	NS	NS

NS - Not significant

* - Transformed c *(Logit transformation)

on this parameter. As the levels of nitrogen were increased, the girth of fruits also increased significantly. Similar effect was observed in the case of K also. Maximum girth was recorded for k_3, followed by k_1 and k_2. However, k_2 and k_1 and k_1 and k_3 were found to be on par. All the nk and kp interactions were found to be significant.

4.2.8. Harvest Index

The transformed data on HI are given in Table 4 and the analysis of variance in Appendix VI.

HI of plots where the fertilizer treatments were applied registered significantly higher values when compared to the control. The main effects of nitrogen phosphorus and potash and the various interaction effects failed to show any profound influence on this parameter.

4.3. Quality characters

4.3.1. Protein content of fruits

The data on the protein content of fruits are presented in Table 5 and the analysis of variance in Appendix VII.

The control recorded a significant reduction in protein content as compared with the fertilizer treatments Neither the main effects N, P and K nor their interactions were found to be significant in this respect.

Table 5 Effect of nitrogen, phosphoius potash and their in eractions on the protein content of the fruits

Tre tments	Protein content of fruits (%)
n_1	17 82
n_2	18 59
n_3	17 67
SEm±	0 55
CD (0 05)	NS
p_1	17 75
p_2	17 93
p_3	18 39
SEm±	0 55
CD (0 05)	NS
k_1	18 49
k_2	17 39
k_3	18 20
SEm+	0 55
CD (0.05)	NS
n_1p_1	18 16
n_1p_2	17 21
n_1p_3	18 08
n_2p_1	18 94
n_2p_2	19 04
n_2p_3	17 79
n_3p_1	16 16
n_3p_2	17.54
n_3p_3	19 31
SEm±	0 95
CD (0.05)	NS
n_1k_1	18 67
n_1k_2	17 87
n_1k_3	16.92
n_2k_1	19.29
n_2k_2	17.25
n_2k_3	19 23
n_3k_1	17 50
n_3k_2	17 05
n_3k_3	18 46
SEm+	0 95
CD (0 05)	NS
k_1p_1	1[illegible] 38
k_1p_2	18 13
k_1p_3	18 96

Contd

Table 5 (Contd)

Treatments	Protein content of fruit (%)
k_2p_1	16 81
k_2p_2	18 37
k_2p_3	1C 98
k_3p_1	16 06
k_3p_2	17 29
k_3p_3	19 25
SEm+	0 95
CD (0 05)	NS
$n_op_ok_o$	14 71
$n_1p_1k_1$	18 38
$n_1p_1k_2$	18 60
$n_1p_1k_3$	17 50
$n_1p_2k_1$	18 38
$n_1p_2k_2$	17 5
$n_1p_2k_3$	15 75
$n_1p_3k_1$	19 2?
$n_1p_3k_2$	1 50
$n_1p_3k_3$	17 50
$n_2p_1k_1$	20 13
$n_2p_1k_2$	17 63
$n_2p_1k_3$	19 07
$n_2p_2k_1$	19 38
$n_2p_2k_2$	19 25
$n_2p_2k_3$	18 50
$n_2p_3k_1$	18 38
$n_2p_3k_2$	14 86
$n_2p_3k_3$	20 13
$n_3p_1k_1$	16 63
$n_3p_1k_2$	14 22
$n_3p_1k_3$	17 63
$n_3p_2k_1$	16 63
$n_3p_2k_2$	18 36
$n_3p_2k_3$	17 63
$n_3p_3k_1$	19 25
$n_3p_3k_2$	18 57
$n_3p_3k_3$	20.13
SEm^{+}	-
CD (0 05)	NS

NS - Not significant

4.4 Chemical analysis of plant samples

4.4.1 Nitrogen content of fruits

The data on the nitrogen content of fruits are presented in Table 6 and the analysis of variance in Appendix VIII

The control recorded significantly lower nitrogen content than the treatments All the treatments failed to record any significant variation in the nitrogen content of fruits. The effect of all the levels of N, P and K and their various interactions were found to be not significant.

4.4.2 Phosphorus content of fruits

The data on this parameter are presented in Table 6 and the analysis of variance in Appendix VIII

It is seen that none of the treatments could exert any significant influence on this character The effect of all the levels of N, P and K and the various interactions were found to be not significant

4.4 3. Potash content of fruits

The data on the potash content of fruits are presented in Table 6 and the analysis of variance in Appendix VIII.

The main effect of potassium was found to exert significant effect on the potash content of fruits. As the level of potassium was increased from 25 kg K_2O /ha to

Table 6 Effect of nitrogen phosphorus, pot sl and their interactions on the nitrogen phosp orus and potassium conten of fruits

Treatments	Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)
n_1	2 85	1 06	6.46
n_2	2 97	1 09	6 23
n_3	2 83	1 10	6 11
SEm±	0 09	0 03	0 13
CD (0 05)	NS	NS	NS
p_1	2 84	1 08	6 33
p_2	2 87	1 07	6 26
p_3	2 94	1 10	6 22
SEm±	0 09	0 03	0 13
CD (0 05)	NS	NS	NS
k_1	2 96	1 06	5 94
k_2	2 78	1 10	6 21
k_3	2 91	1 09	6 65
SEm±	0 09	0 03	0 13
CD (0 05)	NS	NS	0 38
n_1p_1	2 91	0 98	6 85
n_1p_2	2 75	1.11	5 98
n_1p_3	2 83	1 11	6 54
n_2p_1	3 03	1 09	5 93
n_2p_2	3 05	1 07	6 55
n_2p_3	3 85	1 11	6 23
n_3p_1	2 59	1 17	6 21
n_3p_2	2 81	1 04	6 23
n_3p_3	3 09	1 10	5 88
SEm±	0 15	0 06	0 02
CD (0 05)	NS	NS	0 66
n_1k_1	2 99	1 03	6 13
n_1k_2	2 86	1 03	6 25
n_1k_3	2 71	1 14	7 01
n_2k_1	3 09	1 11	5 89
n_2k_2	2 76	1 11	5 89
n_2k_3	3 08	1 05	6 72
n_3k_1	2 80	1 04	5 80
n_3k_2	2 73	1 18	6 28
n_3k_3	2 95	1 09	6 23
SEm±	0 15	0 06	0 22
CD (0 05)	NS	NS	NS
k_1p_1	2 94	1 02	6 03
k_1p_2	2 90	1 06	5 93
k_1p_3	3 03	1 10	5 85

(Co td)

Table 6 (Contd)

Treatments	Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)
k_2p_1	2 6[illegible]	13	6 2
k_2p_2	2 94	1 08	6 08
k_2p_3	2 72	1 10	6 27
k_3p_1	2 89	1 09	6 68
k_3p_2	2 77	1 08	6 75
k_3p_3	3 08	1 11	6 28
SEm	0 15	0 06	0 22
CD (0 05	NS	NS	NS
$n_op_ok_o$	2 36	0 96	5 47
$n_1p_1k_1$	2 94	0 89	6 94
$n_1p_1k_2$	2 98	0 96	6 44
$n_1p_1k_3$	2 80	1 07	7 19
$n_1p_2k_1$	2 94	1 08	5 40
$n_1p_2k_2$	2 80	1 08	5 87
$n_1p_2k_3$	2 52	1 17	6 71
$n_1p_3k_1$	3 08	1 10	6 05
$n_1p_3k_2$	2 80	1 04	6 46
$n_1p_3k_3$	2 80	1 17	7 11
$n_2p_1k_1$	3 22	1 06	5 09
$n_2p_1k_2$	2 82	1 12	5 87
$n_2p_1k_3$	3 05	1 08	6 83
$n_2p_2k_1$	3 1	1 12	6 24
$n_2p_2k_2$	3 08	1 10	6 43
$n_2p_2k_3$	2 96	1 00	6 96
$n_2p_3k_1$	2 94	1 15	6 34
$n_2p_3k_2$	2 38	1 11	5 95
$n_2p_3k_3$	3 22	1 07	6 38
$n_3p_1k_1$	2 66	1 11	6 08
$n_3p_1k_2$	2 28	1 31	6 52
$n_3p_1k_3$	2 82	1 11	6 03
$n_3p_2k_1$	2 66	0 97	6 17
$n_3p_2k_2$	2 94	1 08	5 96
$n_3p_2k_3$	2 82	1 07	6 58
$n_3p_3k_1$	3 08	1 03	5 16
$n_3p_3k_2$	2 97	1 15	6 39
$n_3p_3k_3$	3 22	1 11	6 08
SEm $\pm$	-		
CD (0 05)	NS	NS	NS

NS - Not significant

75 kg K_2O/ha, the potash content of fruits also increased However, the effect of k_1 and k_2 were found to be on par

Among the various interactions, only N x P had significant influence on this parameter and the maximum influence was observed with n_1p_1 combination

4.4 4. Nitrogen content of plants

The data on this parameter are presented in Table 7 and the analysis of variance in Appendix IX

None of the main effects nor their interactions had any marked influence on this character Plants from control plots also registered no significant difference in the total nitrogen content as compared with plants in the various fertilizer treatments.

4 4 5 Phosphorus content of plants

The data on the phosphorus content of plants are presented in Table 7 and the analysis of variance in Appendix IX

None of the main effects nor interactions of nitrogen, phosphorus and potash had any significant influence on this character. The control registered a significantly lower value with regard to this parameter as compared to fertilizer treatments.

4.4.6. Potash content of plants

The data on this parameter are presented in Table 7

Table 7 Effect of nitrogen, phosphorus, potash and their interactions on the nitrogen, phosphorus and potassium content of plants

Treatments	Nitrogen content (%)	Phosphorus content (%)	Potassium content (%)
n_1	1.79	0 67	3 00
n_2	1 86	0 63	2 81
n_3	1 86	0 71	3 02
SEm±	0 09	0 03	0 09
CD (0 05)	NS	NS	NS
p_1	1 74	0.66	2 86
p_2	1 87	0 66	3.05
p_3	1.89	0 65	2 91
SEm±	0 09	0 03	0 09
CD (0 05)	NS	NS	NS
k_1	1 88	0 70	2 43
k_2	1 80	0 65	2 88
k_3	1 83	0 66	3.52
SEm±	0 09	0 03	0.09
CD (0 05)	NS	NS	0 28
n_1p_1	1 78	0 64	2 74
n_1p_2	1 67	0 70	3 34
n_1p_3	1 92	0 65	2 91
n_2p_1	1 67	0 62	2 75
n_2p_2	2 02	0 63	2 75
n_2p_3	1 90	0 65	2 96
n_3p_1	1 78	0 73	2 96
n_3p_2	1 91	0 66	3 07
n_3p_3	1 88	0 74	2 86
SEm±	0 16	0 04	0 10
CD (0 05)	NS	NS	NS
n_1k_1	1 78	0 67	2 26
n_1k_2	1 84	0 64	2 81
n_1k_3	1 75	0 68	3 93
n_2k_1	1 87	0 69	2 75
n_2k_2	1 83	0 61	3 12
n_2k_3	1 90	0 60	2 81
n_3k_1	2 00	0 73	3 09
n_3k_2	1 72	0 70	3 51
n_3k_3	1 84	0 69	3 51
SEm+	0 16	0 04	0 10
CD (0 05)	NS	NS	0 49
k_1p_1	1 64	0 68	1 91
k_1p_2	2 06	0 69	2 95
k_1p_3	1 94	0 72	2 34
k_2p_1	1 66	0 65	2 87
k_2p_2	1 77	0 61	2 61
k_2p_3	1 96	0 69	3 17

(Contd)

Table 7 (Contd)

reatments	Nitrogen content (%)	Pl sphorus content (%)	Potassium content (%)
k_3p_1	1 93	0 65	3 72
k_3p_2	1 77	0 70	3 62
k_3p_3	1 80	0 62	2 81
SEm+	0 16	0 04	0 10
CD (0 05)	NS	NS	NS
$n_0p_0k_0$	1.52	0.55	2 58
$n_1p_1k_1$	1 83	0 70	2 05
$n_1p_1k_2$	1 60	0.57	2.32
$n_1p_1k_3$	1.93	0.66	3 86
$n_1p_2k_1$	1 74	0 73	3 03
$n_1p_2k_2$	1 83	0 67	2 76
$n_1p_2k_3$	1 44	0 71	4 25
$n_1p_3k_1$	1 76	0 59	1 70
$n_1p_3k_2$	2 11	0 69	3 35
$n_1p_3k_3$	1 83	0 68	3 69
$n_2p_1k_1$	1 36	0 66	2 12
$n_2p_1k_2$	1 76	0 61	2 51
$n_2p_1k_3$	1 88	0 58	3 60
$n_2p_2k_1$	2 20	0 64	2 78
$n_2p_2k_2$	1 82	0 54	2 31
$n_2p_2k_3$	2 06	0 72	3 16
$n_2p_3k_1$	2 04	0 77	2 85
$n_2p_3k_2$	1 91	0 68	3 42
$n_2p_3k_3$	1 75	0 50	2 61
$n_3p_1k_1$	1 73	0 69	1 88
$n_3p_1k_2$	1 62	0 77	3 79
$n_3p_1k_3$	1 99	0 72	3 69
$n_3p_2k_1$	2 24	0 69	3 05
$n_3p_2k_2$	1 67	0 61	2 75
$n_3p_2k_3$	1 82	0 67	3 46
$n_3p_3k_1$	2 02	0 81	2 48
$n_3p_3k_2$	1 88	0 71	2 73
$n_3p_3k_3$	1 74	0 68	3 39
SEm		-	0 29
CD (05)	NS	NS	0 84

NS - Not significant

and the analysis of variance in Appendix IX

The main effect of potassium had significant influence on the potash content of plants. As the levels of K were increased from k_1 to k_3, the content of potash also increased. Among the interactions P x K, N x K and N x P x K registered pronounced influence on this character with p_1k_3, n_1k_3 and $n_1p_2k_3$ recording the maximum values respectively The control registered significantly lower value than the treatments

4 4 7. Nitrogen uptake by fruits

The data on nitrogen uptake by fruits are presented in Table 8 and the analysis of variance in Appendix X

As the levels of nitrogen were increased, the nitrogen uptake was found to increase significantly. None of the main effects of potassium and phosphorus had any significant influence on this parameter. Among the various interactions, N x P, P x K and N x P x K recorded significant influence with n_3p_1, p_1k_3 and $n_3p_1k_3$ recording the maximum values respectively.

The control plots gave significantly lower N uptake as compared to the fertilizer treatments

4 4.8. Phosphorus uptake by fruits

The data on the phosphorus uptake by fruits are presented in Table 8 and the analysis of variance in Appendix X

Table 8 Effect of nitrogen, phosphorus, potash and their interactions on the N, P & K uptake by fruits

Treatments	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)
n_1	2 30	1 29	6 75
n_2	3 13	1 20	8 53
n_3	4 15	0 98	5 41
SEm±	0 30	0 18	0 96
CD (0 05)	0 88	NS	NS
p_1	3 43	1 20	5 84
p_2	2 74	1 00	4 96
p_3	3 39	1 28	9 87
SEm±	0 30	0 18	0 96
CD (0 05)	NS	NS	2 80
k_1	2 80	0 81	4 03
k_2	3 03	1 25	7 35
k_3	3 69	1 41	9 31
SEm±	0 30	0 18	0 96
CD (0 05)	NS	NS	2 80
n_1p_1	1 82	1 52	6 66
n_1p_2	2 04	0 87	4 19
n_1p_3	3 02	1 46	9 36
n_2p_1	2 65	4 75	5 02
n_2p_2	3 77	1 33	6 06
n_2p_3	2 97	1 34	14 52
n_3p_1	5 83	1 12	5 85
n_3p_2	2 44	0 80	4 66
n_3p_3	4 19	1 03	5 74
SEm±	0 52	0 31	1 67
CD (0 05)	1 52	NS	NS
n_1k_1	2 02	0 69	3 25
n_1k_2	2 87	1 27	8 51
n_1k_3	2 00	1 89	8 46
n_2k_1	2 72	0 89	4 26
n_2k_2	2 83	1 02	5 61
n_2k_3	3 83	1 70	15 75
n_3k_1	3 66	0 86	4 19
n_3k_2	3 55	1 44	7 93
n_3k_3	5 25	0 64	3 74
SEm±	0 52	0 31	1 67
CD (0 05)	1.52	NS	4 84
k_1p_1	3 29	0 85	4 59
k_1p_2	2 82	0 96	4 10
k_1p_3	2 29	0 64	3 38
k_2p_1	2 41	1 11	6 42
k_2p_2	2 65	0 93	5 30
k_2p_3	4 20	1 68	10 34

(Contd)

Table 8 (Contd)

Treatments	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)
k_3p_1	4 60	1 63	6 52
k_3p_2	2 78	1 11	5 52
k_3p_3	3 70	1 51	15 90
SEm+	0 52	0 31	1 67
CD (0 05)	NS	NS	4 84
$n_0p_0k_0$	1 48	2 17	3 61
$n_1p_1k_1$	1 32	0 31	2 17
$n_1p_1k_2$	2 47	1 29	8 98
$n_1p_1k_3$	1 69	2 96	8 85
$n_1p_2k_1$	2 78	1 14	4 20
$n_1p_2k_2$	2 00	0 81	4 46
$n_1p_2k_3$	1 34	0 68	3 93
$n_1p_3k_1$	1 97	0 61	3 39
$n_1p_3k_2$	4 13	1 72	12.11
$n_1p_3k_3$	2 97	2 08	4 31
$n_2p_1k_1$	1 94	0 68	3 27
$n_2p_1k_2$	2.81	0 80	4.20
$n_2p_1k_3$	3.19	1 34	7 61
$n_2p_2k_1$	3 85	1 24	5 42
$n_2p_2k_2$	2 91	0 98	5 70
$n_2p_2k_3$	4 56	1 77	7 06
$n_2p_3k_1$	2.38	0 74	4 07
$n_2p_3k_2$	2 78	1 29	6 94
$n_2p_3k_3$	3 75	2 00	32 55
$n_3p_1k_1$	6 63	1 55	8 35
$n_3p_1k_2$	1 94	1 23	6 10
$n_3p_1k_3$	8 93	0 57	3 09
$n_3p_2k_1$	1 84	0 50	2 67
$n_3p_2k_2$	3 03	1 02	5 73
$n_3p_2k_3$	2 44	0 89	5 56
$n_3p_3k_1$	2 51	0 56	2 68
$n_3p_3k_2$	5 69	2 07	11 97
$n_3p_3k_3$	4 38	0 46	2 55
SEm±	0 91	-	2 89
CD (0 05)	2 64	NS	8 38

NS Not significant

The control plots registered significantly lower uptake of phosphorus compared with fertilizer treatments.

None of the main effects nor their interactions recorded any pronounced influence on this parameter.

4.4.9. Potash uptake by fruits

The data on the uptake of potassium by the fruits are presented in Table 8 and the analysis of variance in Appendix X.

The main effects of phosphorus and potassium and the interaction effects of N x K, P x K and N x P x K recorded significant influence on potassium uptake. Among the interactions n_1k_3, p_3k_2 and $n_1p_1k_3$ registered maximum uptake and among the levels of phosphorus, p_3 recorded the maximum uptake followed by p_1 and p_2. However p_2 and p_1 were on par. There was an increase in K uptake with increase in K levels also. The levels k_1 and k_2 were however on par.

4 4.10. Nitrogen uptake by plants

The data on the nitrogen uptake are given in Table 9 and the analysis of variance in Appendix XI.

Significant difference in the uptake of nitrogen was observed between the control and fertilizer treatments.

While the main effect of nitrogen significantly influenced the uptake of N by plants, none of the interactions of N, P and K nor the main effects of P and K influenced this parameter. As the levels of nitrogen were increased, the uptake of nitrogen also registered a significant increase.

4.4.11. Phosphorus uptake by plants

The data on the phosphorus uptake by plants are given in Table 9 and the analysis of variance in Appendix XI.

The control plots recorded significantly lower uptake values for phosphorus than the fertilizer treatments. The main effect of nitrogen had a significant influence on the phosphorus uptake. As the level of nitrogen was increased from n_1 to n_3, the uptake of P also increased.

None of the interactions nor the main effects of P x K were found to be significant with regard to this parameter.

4.4.12. Potash uptake by plants

The data on the potash uptake by plants are given in Table 9 and the analysis of variance in Appendix XI.

The control plants registered significant difference in the uptake of potash when compared to fertilizer treatments. The main effects of nitrogen, phosphorus and potash recorded marked influence on this parameter. As the levels of nitrogen were increased from n_1 to n_3, the uptake of potash also increased. Although phosphorus levels could increase the uptake of potassium, p_1 and p_2 were on par while p_2 in turn was on par with p_3. The level k_3 recorded maximum uptake followed by k_2 and k_1

Of the interactions, only the first order interactions viz N x P, P x K and N x K had any pronounced influence with n_2p_3, p_3k_3 and n_3k_3 recording the maximum values respectively

Table 9 Effect of nitrogen, phosplorus, potash and t eir interactions on the uptake of N P & K by plants.

Treatments	N uptake (kg/ha)	P uptake (kg/ha)	up ake (kg/ha)
n_1	31 24	12 10	56 10
n_2	40 40	13 88	6 82
n_3	45 91	1C 82	73 68
SEm±	1 61	0 42	1 93
CD (0 05)	4 67	1 22	5 61
p_1	36 07	13 65	60 12
p_2	39 91	14 07	65 21
p_3	41 57	15 09	69 27
SEm±	1 61	0 42	1 93
CD (0 05)	NS	NS	5 61
k_1	38 74	14 11	5ᴗ 52
k_2	3 62	13 76	64 91
k_3	40 19	14 51	79 17
SEm±	1 61	0 42	1 93
CD (0 05)	NS	NS	5 61
n_1p_1	27 83	10 87	47 ɔ2
n_1p_2	30 19	12 78	61 02
n_1p_3	35 69	12 68	59 75
n_2p_1	35 12	12 93	58 21
n_2p_2	43 81	13 86	60 64
n_2p_3	42 28	14 86	75 63
n_3p_1	45 27	17 16	74 63
n_3p_2	45 73	15 57	73 97
n_3p_3	46 74	17 77	72 44
SEm±	2 79	0 73	3 35
CD (0 05)	NS	NS	9 72
n_1k_1	23 83	10 86	37 71
n_1k_2	32 92	11 74	54 36
n_1k_3	31 96	13 73	76 24
n_2k_1	38 84	14 33	53 93
n_2k_2	40 00	13 44	61 64
n_2k_3	42 37	13 87	78 89
n_3k_1	4 5	17 14	59 93
n_3k_2	42 96	17 39	78 73
n_3k_3	4C 25	1 92	82 39
SEm	2 79	0 73	3 3ɔ
CD (0 05)	I S	I S	9 72
k_1p_1	32 86	1ɔ 23	41 17
k_1p_2	43 71	14 29	61 60
k_1p_3	39 65	14 82	48 80

(Contd)

Table 9 (Contd)

Treatments	N uptake (kg/ha)	P uptake (kg/ha)	K uptake (kg/ha)
k_2p_1	33 77	13 58	62 06
k_2p_2	38 16	13 05	57 86
k_2p_3	43 94	15 96	74 81
k_3p_1	41 59	14 14	77 12
k_3p_2	37 87	14 88	76 17
k_3p_3	41 12	14 50	84 22
SEm	2 79	0 73	3 35
CD (0 05)	NS	NS	9 72
$n_0p_0k_0$	18 91	8 56	33 27
$n_1p_1k_1$	24 59	9 30	28 33
$n_1p_1k_2$	26 41	9 76	43 60
$n_1p_1k_3$	32 48	13 56	70 62
$n_1p_2k_1$	31 47	13 08	53 83
$n_1p_2k_2$	32 73	12 16	50 95
$n_1p_2k_3$	26 38	13 10	78 29
$n_1p_3k_1$	30 44	10.21	30 97
$n_1p_3k_2$	39 61	13 32	68 51
$n_1p_3k_3$	37 02	14 51	79 79
$n_2p_1k_1$	27 81	13 25	43.39
$n_2p_1k_2$	37 77	13 01	54 11
$n_2p_1k_3$	39 77	12 52	77 09
$n_2p_2k_1$	45 99	13 51	58 96
$n_2p_2k_2$	39.43	11 69	51.97
$n_2p_2k_3$	46 03	14 24	70 98
$n_2p_3k_1$	42 73	16 23	59 45
$n_2p_3k_2$	42 81	15 63	78 84
$n_2p_3k_3$	41 3	12 71	88.60
$n_3p_1k_1$	46 16	17 15	51 78
$n_3p_1k_2$	37 14	17 97	88 46
$n_3p_1k_3$	52.51	16 36	83 64
$n_3p_2k_1$	53 66	16 28	72 01
$n_3p_2k_2$	42 32	15 30	70 65
$n_3p_2k_3$	41 20	15 15	79 2[illegible]
$n_3p_3k_1$	45 78	18 01	55 98
$n_3p_3k_2$	49 41	18 93	77 07
$n_3p_3k_3$	45 04	16 27	84 29
SEm			-
CD (0 05)	NS	NS	NS

4.5. Soil analysis

4.5.1. Available nitrogen content of the soil after the experiment

The data on this parameter are presented in Table 10 and the analysis of variance in Appendix XII.

The available nitrogen status of the soil after the experiment was significantly different in the control and fertilizer treatments with the control giving lower values.

The main effects of nitrogen and phosphorus influenced the available nitrogen status of the soil after the experiment, markedly. As the levels of N and P were increased, the available nitrogen status of the soil increased significantly Among the interactions only N x P interaction showed significant influence with n_3p_3 recording the maximum. The main effect of potassium showed no significant influence.

4.5.2. Available phosphorus content of the soil after the experiment

The data on the available phosphorus content of the soil after the harvest are given in Table 10 and the analysis of variance in Appendix XII.

It is seen that the main effects of nitrogen and phosphorus had pronounced effects on the available phosphorus content of soil.

As the levels of nitrogen and phosphorus were increased, the content of available phosphorus also increased, significantly. However n_2 and n_3 were found to be on par. The main effect of potassium was not significant. All the interaction effects except N x K were found to be not significant Among the N x K interaction n_3k_2 recorded maximum values for available phosphorus content of soil.

The control plots registered significantly lower values of available phosphorus as compared with fertilizer treatments.

4.5.3 Available potassium content of soil after the experiment

The data on the available potassium content of the soil after the experiment are presented in Table 10 and the analysis of variance in Appendix XII.

The main effect of nitrogen, phosphorus and potassium significantly influenced this parameter. Of the three levels of nitrogen, n_1 showed the maximum value of available potash followed by n_3 and n_2. However n_3 and n_1 were found to be on par. In the case of phosphorus, p_1 recorded the maximum value of available potassium followed by p_2 and p_3 However, p_3 and p_2 were found to be on par. As the levels of potassium were increased the potash content of soil also increased

Of the various interactions, only N x P and N x K had pronounced influence on this parameter with n_1p_1 and n_3k_3 recording the maximum available soil potassium after the experiment.

Table 10. Effect of nitrogen, phosphorus, potash and their interactions on the available nitrogen, phosphorus and potassium in the soil after the experiment

Treatments.	Available nitrogen (kg/ha N)	Available phosphorus (Kg/ha P_2O_5)	Available potassium (Kg/ha K_2O)
n_1	361 44	31 21	144 00
n_2	424 61	39 22	137 11
n_3	532 22	39 51	142 72
SEm±	0.79	0.46	0.95
CD (0 05)	2 29	1 35	2 76
p_1	434 39	29 45	146 78
p_2	440.28	37 07	139.50
p_3	443 61	43 42	137 56
SEm±	0 79	0.46	0 95
CD (0 05)	2 29	1 35	2 76
k_1	438 39	36 12	130 94
k_2	439 83	36.76	142 83
k_3	440 06	37 05	150 06
SEm+	0 79	0 80	0 95
CD (0 05)	NS	I S	2 76
n_1p_1	352 00	23 49	149 17
n_1p_2	363 83	31 47	143 83
n_1p_3	368 50	30 67	139 00
n_2p_1	420 67	31 48	145 50
n_2p_2	425 67	40 59	128 67
n_2p_3	427 50	45 57	137 17
n_3p_1	530 50	33 38	145 67
n_3p_2	531 33	39 14	146 00
n_3p_3	534 83	46 01	136 50
SEm±	1 37	0 80	1 65
CD (0 05)	3 97	NS	4.78
n_1k_1	359 00	29 48	135 17
n_1k_2	363 33	31 45	147 67
n_1k_3	362 00	32 70	149 17
n_2k_1	424 30	39 45	128 00
n_2k_2	424 67	33 30	136 67
n_2k_3	424 83	39 90	146 67
n_3k_1	531 83	39 43	129 67
n_3k_2	531 50	40 54	144 17
n_3k_3	533 33	3 56	154 33
SEm±	1 37	0 80	1 65
CD (0 05)	NS	2 34	4 78
k_1p_1	4 3 17	28 91	139 17
k_1p_2	439 17	30 63	129 17
k_1p_3	442 83	42 62	124 50

Contd

Table 10 (contd)

Treatments	Available nitrogen (kg/ha N)	Available phosphorus(kg/ha P_2O_5)	Available potassium (kg/ha k_2O
k_2p_1	435 50	29 82	147 50
k_2p_2	440 83	37 38	140 83
k_2p_3	443.17	43 09	140 17
k_3p_1	434 50	29 63	153 67
k_3p_2	440 83	37 19	148 50
k_3p_3	444 83	44 34	148 00
SEm±	1 37	0 80	1 65
CD (0 05)	NS	NS	NS
$n_op_ok_o$	343 50	24 55	142 00
$n_1p_1k_1$	350 50	22 90	149 00
$n_1p_1k_2$	352 00	23 78	148.50
$n_1p_1k_3$	353 50	23 80	150 00
$n_1p_2k_1$	359 50	30 11	128 00
$n_1p_2k_2$	369 00	31 70	151 50
$n_1p_2k_3$	363 00	32 61	152 00
$n_1p_3k_1$	367 00	35 44	128 50
$n_1p_3k_2$	369 00	38 87	143 00
$n_1p_3k_3$	369 50	41 70	145 50
$n_2p_1k_1$	418 50	31 85	136 50
$n_2p_1k_2$	422 00	31 28	145 50
$n_2p_1k_3$	421 50	31 33	154 50
$n_2p_2k_1$	426 00	39 44	123 00
$n_2p_2k_2$	425 00	40 53	125 50
$n_2p_2k_3$	426 00	41 82	137 50
$n_2p_3k_1$	428 50	47 07	124 50
$n_2p_3k_2$	427 00	43 09	139 00
$n_2p_3k_3$	427 00	46 56	148 00
$n_3p_1{}^{l}{}_1$	530 50	31 98	132 00
$n_3p_1k_2$	532 50	34 4	148 50
$n_3p_1k_3$	528 50	33 77	156 50
$n_3p_2k_1$	532 00	40 36	136 50
$n_3p_2k_2$	528 50	39 91	145 50
$n_3p_2k_3$	535 50	37 15	156 00
$n_3p_3k_1$	533 00	45 96	120 50
$n_3p_3k_2$	533 50	47 30	138 50
$n_3p_3k_3$	538 00	44 77	150 50
SEm+	-	-	-
CD (0 05)	NS	NS	NS

NS - Not significant

4.6 Economics of cultivation

4.6.1 Net profit

The data on net profit are presented in Table 11 and the analysis of variance in Appendix XIII

All fertilizer treatments registered significantly higher net profits than the control.

Only the main effects of nitrogen, phosphorus and potassium exerted significant influence on this parameter. As the level of nitrogen was increased, the net profit also increased, with the maximum net profit being obtained at n_3. Treatments n_1 and n_2 were found to be on par Of the levels of phosphorus, p_2 recorded the highest net profit followed by p_3 and p_1 In the case of potassium, k_2 recorded the maximum net profit, but was on par with k_1 while k_3 came last.

None of the interactions registered any significant influence on the net profit

4.6.2. Net returns per rupee invested

The data on the net returns per rupee invested are presented in Table 11 and the analysis of variance in Appendix XIII.

All fertilizer treatments registered significantly higher net profits than the control.

The main effects of nitrogen, phosphorus and potassium markedly influenced this parameter. As the levels of nitrogen were increased from n_1 to n_3 the net returns per rupee invested

Table 11 Effect of nitrogen, phosphorus, potash and their inter ctions on the net profit and net return per rupee invested

Treatments	Net profit ( )	Net return per rupee invested (Rs)
n_1	16569 72	0 68
n_2	19018 24	0 78
n_3	24494 97	1 00
SEm+	1369 88	0 16
CD (0 05)	3975 33	0 06
p_1	15714 23	0 64
p_2	24180 18	0 99
p_3	20188 52	0 82
SEm+	1369 88	0 16
CD (0 05)	3975 33	0 06
k_1	21363 23	0 88
k_2	22847 26	0 93
k_3	15872 43	0 65
SEm-	1369 88	0 16
CD (0 05)	3975 33	0 06
n_1p_1	14376 9	0 59
n_1p_2	19494 21	0 80
n_1p_3	15837 97	0 65
n_2p_1	13334 29	0 55
n_2p_2	20212 40	0 83
n_2p_3	23508 03	0 96
n_3p_1	19431 43	0 80
n_3p_2	32833 93	1 34
n_3p_3	21219 55	0 86
SEm$\pm$	23 2 69	0 10
CD (0 05)	NS	0 28
n_1k_1	18179 73	0 75
n_1k_2	18316 09	0 75
n_1k_3	13213 34	0 54
n_2k_1	19699 53	0 81
n_2k_2	17668 66	0 72
n_2k_3	19686 53	0.80
n_3k_1	26210 43	1 07
n_3k_2	32557 05	1 32
n_3k_3	14717 43	0 60
SEm$\pm$	2372 69	0 10
CD (0 05)	NS	0 28

(Contd)

Table 11 (Contd)

Treatments	Net profit (Rs)	Net return per rupee invested (Rs)
k_1p_1	18584 87	0 76
k_1p_2	25525 85	1 05
k_1p_3	19978 97	0 82
k_2p_1	16094 98	0 66
k_2p_2	27409 35	1 12
k_2p_3	25037 48	1 02
k_3p_1	12462 85	0 51
k_3p_2	19605 35	0 80
k_3p_3	15549 11	0 63
SEm±	2372 69	0 10
CD (0 05)	NS	NS
$n_0p_0k_0$	8176 02	0 34
$n_1p_1k_1$	11952 14	0 50
$n_1p_1k_2$	19144 20	0 79
$n_1p_1k_3$	12034 59	0 49
$n_1p_2k_1$	18770 09	0 78
$n_1p_2k_2$	23028 59	0 95
$n_1p_2k_3$	16683 95	0 68
$n_1p_3k_1$	23816 95	0 97
$n_1p_3k_2$	12775 48	0 54
$n_1p_3k_3$	10921 48	0 45
$n_2p_1k_1$	14282 04	0 59
$n_2p_1k_2$	14687 43	0 60
$n_2p_1k_3$	11033 40	0 45
$n_2p_2k_1$	25628 90	1 06
$n_2p_2k_2$	9731 15	0 40
$n_2p_2k_3$	25 77 15	1 03
$n_2p_3k_1$	19187 65	0 79
$n_2p_3k_2$	28587.40	1 17
$n_2p_3k_3$	22749 04	0 92
$n_3p_1k_1$	29520 44	1 21
$n_3p_1k_2$	14453 30	0 59
$n_3p_1k_3$	14320 55	0 59
$n_3p_2k_1$	32178 55	1 31
$n_3p_2k_2$	49468 30	2 01
$n_3p_2k_3$	16854 94	0 69
$n_3p_3k_1$	16932 30	0 69
$n_3p_3k_2$	33749 55	1 37
$n_3p_3k_3$	12976 80	0 53
SEm±		0 17
CD (0 05)	NS	0 49

NS - Not significant

Table 12 Economics of Cultivation

Treatments	Cost of production excluding the treatments (Rs)	Additional cost of the treatment (Rs)	Total cost of production Y (Rs)	Fruit yield (kg)	Value X(Rs)	Net profit Rs (X - Y)	Net return per rupee invested (X-Y / Y)
$n_0p_0k_0$ (Control)	23794 00	Nil	23794 00	5328 34	31970 02	8176 02	0 344
$n_1p_1k_1$	2 794 00	432 80	24226 80	6029 69	36178 14	11951 34	0 493
$n_1p_1k_2$	23794 00	[illegible]05 55	24[illegible]9[illegible] 55	7240 63	43443 75	19144 20	0 788
$n_1p_1k_3$	23794 00	578 30	24372 [illegible]0	6067 82	36406 89	12034 59	0 494
$n_1p_2k_1$	23794 00	495 30	24289 [illegible]0	7176 57	43059 39	18770 09	0 773
$n_1p_2k_2$	23794 00	568 05	24362 05	7898 44	47390 64	23028 59	0 945
$n_1p_2k_3$	23794 00	640 80	24434 80	6853 13	41118 75	16683 95	0 683
$n_1p_3k_1$	23794 00	557 80	24351 80	8028 13	48168 75	23816 95	0 978
$n_1p_3k_2$	23 94 00	6 0 [illegible]	24424 5[illegible]	6200 00	37200 03	127 5 48	0 523
$n_1p_3k_3$	23 94 00	7 3	24[illegible]7 [illegible]0	[illegible]00[illegible] 22	3[illegible]419 2[illegible]	10921 99	0 446
$n_2p_1k_1$	23794 00	[illegible]39 60	243[illegible] 60	[illegible]43[illegible] 94	38615 64	14 8 04	0 587
$n_2p_1k_2$	23794 00	61 [illegible]5	440[illegible]	6515 6[illegible]	3909[illegible] 78	14687 4	0 602
$n_2p_1k_3$	2 794 00	[illegible]65 10	1 9 0	[illegible]91[illegible] 75	35512 50	1103[illegible] 4[illegible]	0 451
$n_2p_2k_1$	23794 00	60 1	24 96 1[illegible]	8[illegible]37 [illegible]0	[illegible]007[illegible] 00	2 [illegible]28 90	1 050
$n_2p\ k_2$	23794 00	67 85	244[illegible] 8	5700 00	34[illegible]0 00	9731 15	0 397
$n\ p_2k_3$	23794 00	74 60	24 4 6	8 0[illegible] 13	49[illegible]18 75	2527 15	0 9
$n_2p_3k_1$	23794 [illegible]0	[illegible]4 6[illegible]	24 8 [illegible]	7274 [illegible]8	4[illegible]646 25	1[illegible]187 65	0 [illegible]84
$n\ p$	23794 00	[illegible]	4531 3[illegible]	88[illegible]3 13	5[illegible]118 7[illegible]	28[illegible]7 40	1 1[illegible]5
n_2p_3k	237[illegible]4 00	81[illegible] 1[illegible]	2460 1	7892 1[illegible]	4 3 3 14	22749 04	0 925
$n_3p_1\ 1$	23794 [illegible]0	64[illegible] 0	244 0 2[illegible]	8[illegible]93 44	589[illegible]0 64	29[illegible]20 44	1 2[illegible]8
$n\ p_1$	3 04 0[illegible]	18 0[illegible]	24 12 [illegible]	64[illegible]4 [illegible]8	38[illegible] 5	144 0	0 8[illegible]
$n\ p_1k$	[illegible]3794 [illegible]	[illegible]1 70	24[illegible]	90 8 1 [illegible]	541[illegible] 7	[illegible] 8[illegible] 05	[illegible]03
$n_3p_2k_1$	2 794 00	[illegible]8 70	24 02 0	9446 68	56[illegible]8 2[illegible]	[illegible]21 [illegible] 55	
n_3p_2k	[illegible] 94 00	7[illegible] 4[illegible]	2 5	[illegible]40 63	7404 5	49468 [illegible]0	1[illegible]
$n\ o\ k_3$	2 94 00	[illegible]4 20	[illegible]464[illegible]	6917 1[illegible]	41 0[illegible] 14	168[illegible]4 4	[illegible]84
$n_3p\ 1$	[illegible] 94 00	1 [illegible]	4 [illegible] [illegible]0	[illegible]91[illegible] [illegible]5	41 [illegible]7 [illegible]0	6[illegible]2 0	0 68[illegible]
$n\ p\ 2$	794 00	[illegible] 9[illegible]	246 7 [illegible]	948 2	[illegible]887 [illegible]	[illegible] 9 [illegible]	1 3 9
$n\ p_3k_3$	23794 00	916 70	4710 0	6 81 25	37687 5[illegible]	12976 8[illegible]	0 525

r s)
or ? - 2 0 00   1 kg N - 5   1 c P O 5   1 kg K_2O 2 91   c Pittercourd 6 0

also increased, but n_1 and n_2 were found to be on par Among the levels of phosphorus p_2 recorded the maximum net profit followed by p_3. Considering the different levels of potassium the level k_2 recorded the highest net profit which was on par with k_1.

Among the various interactions, N x P, N x K and N x P x K was found to have pronounced effects on this parameter with n_3p_2, n_3k_2 and $n_3p_2k_2$ recording the highest values of net return per rupee invested respectively

DISCUSSION

DISCUSSION

An experiment was conducted at the College of Agriculture, Vellayani to determine the nitrogen, phosphorus and potash requirements for bittergourd under partial shade situation (home stead condition), to investigate the uptake of major nutrients by the crop and to study the economics of cultivation under different fertilizer schedules

Data on biometric characters like days for opening of first male and female flowers, nodes at which the first male and female flower appeared, inter nodal length at fifty per cent flowering, length of main vine at final harvest and total dry matter production were recorded. Data on yield attributes and quality characters like sex ratio, fruit set, yield per plot, number of fruits per plant, per fruit weight, length of fruits, girth of fruits harvest index and protein content of fruits were recorded Chemical analysis of plant and soil samples were also done and economics of cultivation were worked out under different fertilizer schedules

The results obtained on the above mentioned parameters are briefly discussed in this chapter

5.1 Growth characters

It is seen that there was significant difference in the days taken for opening of first male and female flowers in the control plots and in the different fertilizer treatments.

As seen from the data, in the control plots, the plants came to flowering much earlier than other plots The first male flower was found to open by about 29 DAS and the first female flower by about 32 DAS in the control plots.

Nitrogen levels also had significant influence on these characters As the level of nitrogen was increased from 50 kg/ha to 90 kg/ha, the days taken for the first male flower opening increased from 31 to 36 and that for the female flower from 34 to 42. As the levels of phosphorus and potassium were increased, a similar trend was observed, but no significant difference could be detected in these cases. None of the interactions were found to be significant on these parameters.

One of the main functions of nitrogen is to promote vegetative growth (Tisdale et al , 1985). As the nitrogen levels were increased, the vegetative growth was promoted which naturally delayed the production of flowers. The same trend was observed in cucumber by Parikh and Chandra (1969), in water melon by Ogunremi (1978) and in pumpkin by Rajendran (1981) It was also observed that male flowers

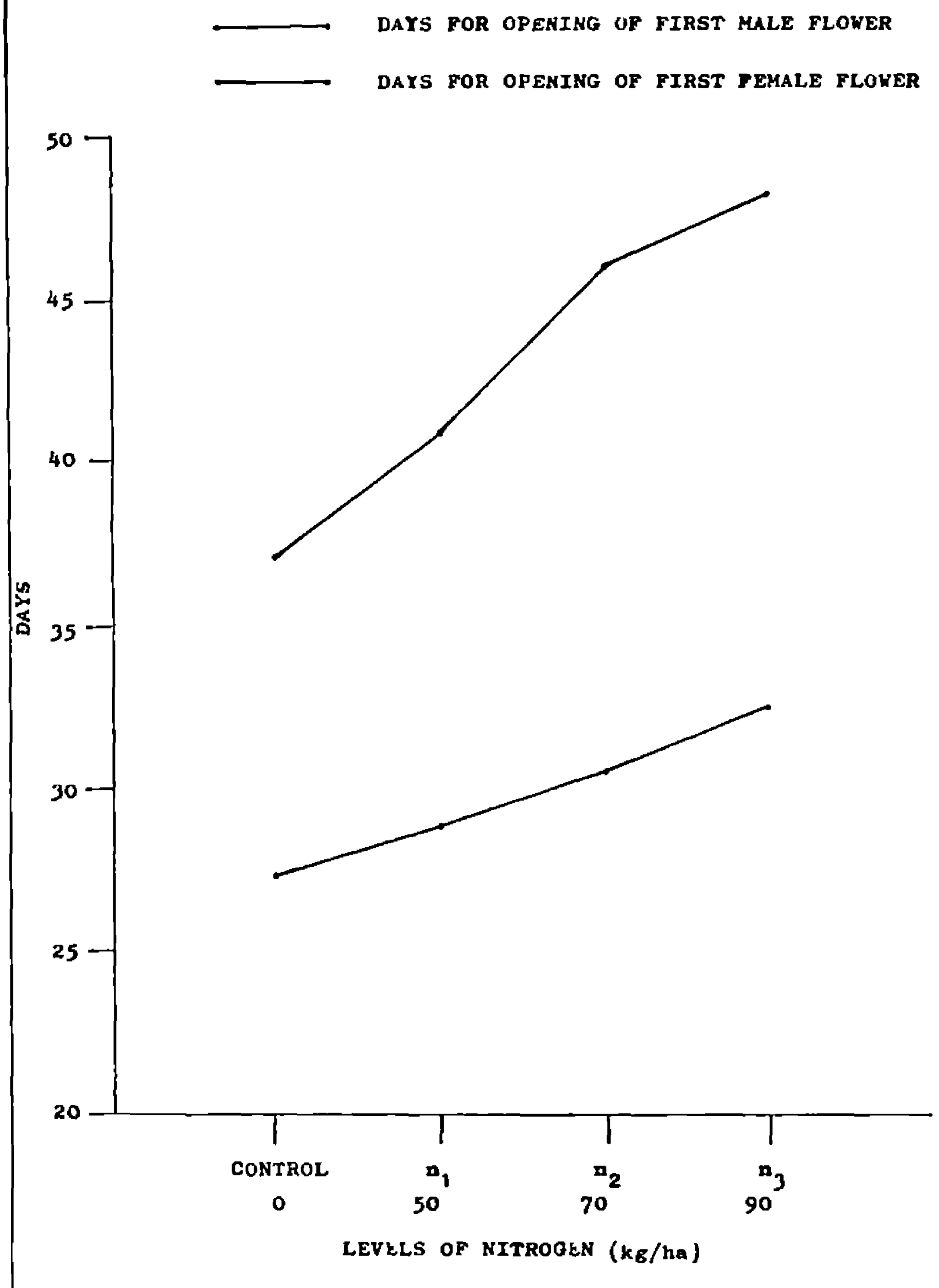


Fig 3 Effect of nitrogen on the days for opening of first male and female flowers

were produced earlier than female in bittergourd. Similar observation was recorded in snakegourd also (Singh, 1950)

The delay in flowering may also be due to the effect of shade, but it is uniform for all the treatments Shading has been reported to delay flowering in many vegetables, especially those adapted to open conditions Considerable delay in flowering has been observed in vegetable cowpea with increased shade intensities (Krishnan kutty, 1983, Rajesh Chandran, 1987)

There was significant difference between the control plots and the fertilizer treatments with regard to the node at which the first female flower appeared. Nitrogen and phosphorus significantly influenced this character As the nitrogen level was increased, the node number at which the first female flower appeared also increased from 21 to 28. With regard to phosphorus the node number increased from 23 to 26. However the treatments 15 kg P_2O_5/ha and 25 kg P_2O_5/ha were found to produce the same effect Although potash tended to increase the node number, the effect was not significant. The fact that the female flower first appeared at the seventeenth node in the control clearly illustrates the point that increased fertilizer application delays the shift to reproductive cycle in bittergourd

With regard to the node where the first male flower appeared, only nitrogen could exert any pronounced effect. As the level of nitrogen was increased from 50 kg/ha to 90 kg/ha, the node number also increased from 9 to 13.

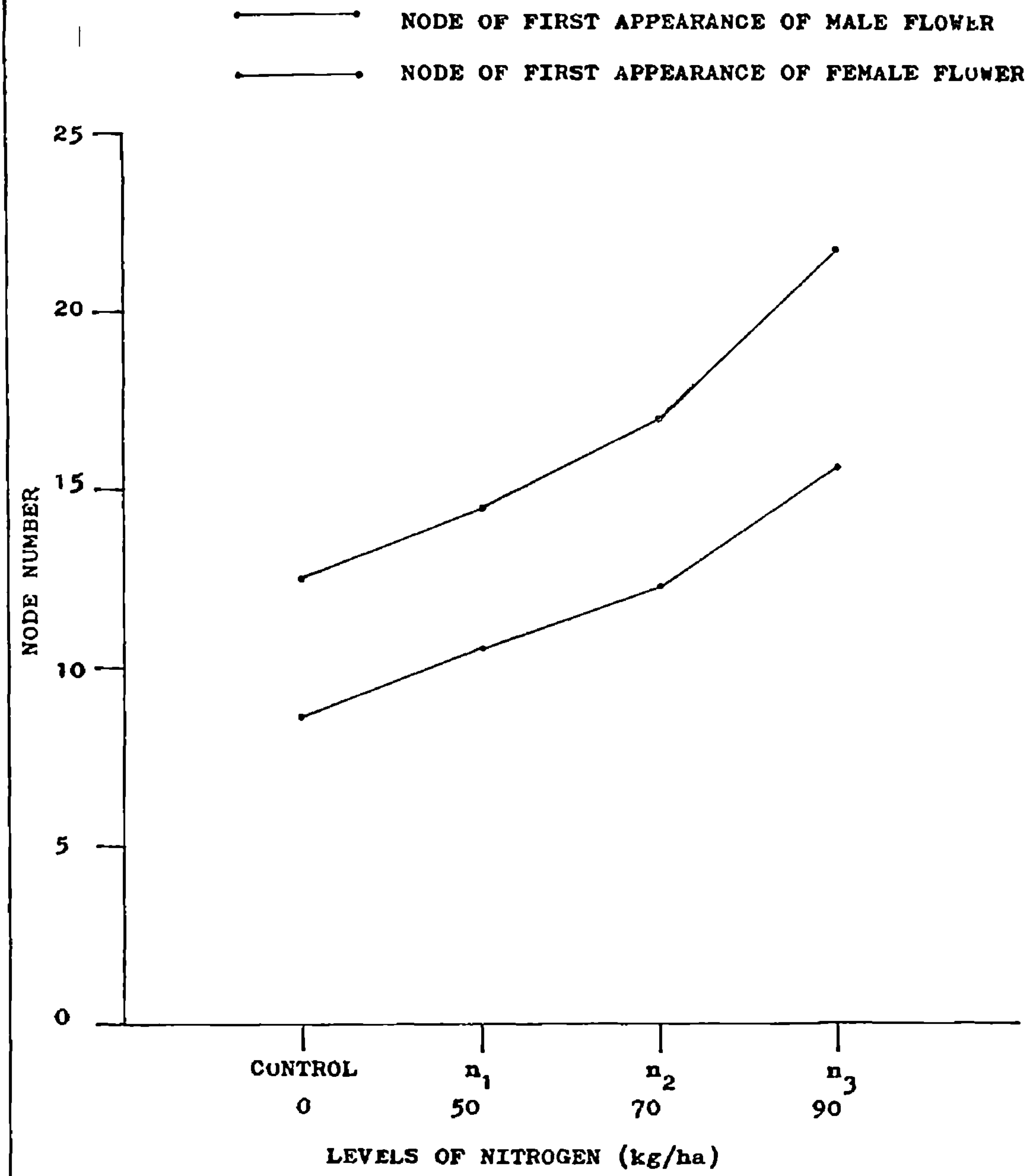


Fig.4 Effect of nitrogen on the node at which the first male and female flowers appeared.

Although similar increases were observed for phosphorus and potash the effect was not significant None of the interactions were found to be significant in this aspect

The internodal length measured at 50 per cent flowering (45 DAS) stage of the crop revealed significant difference between control and fertilizer treatments While the control plots registered an average internodal length of 6.96 cm, the fertilizer treatments recorded an internodal length more than the control (Table 2). Among the major nutrients tried, only nitrogen had significant effect on this character. The mean internodal length increased from 7.99 to 10.58 cm when the nitrogen level was increased from 50 kg/ha to 90 kg/ha.

The influence of nitrogen in promoting vegetative attributes of plants is a well established phenomenon which needs no further explanation and as such it is quite natural that increasing levels of nitrogen increased the internodal length. Similar findings have been reported by Piazza and Venturi (1971) and Das *et al*. (1987).

An appraisal of Table 2 revealed that the control plots recorded a main vine length of about 679 5 cm which was significantly lower than that of the fertilizer treatments. The main effect of nitrogen was found to influence this parameter. As nitrogen levels were increased, an increase in the length of main vine from 694 67 cms to 760.13 cms was observed. However 50 kg N/ha was found to be on par with 70 kg N/ha which in turn was on par with 90 kg N/ha The main effects of phosphorus and potash and their various interactions were not significant

The reason for the significant increase in the length of main vine is due to the characteristic effect of nitrogen in promoting vegetative growth. Similar increases in vine length have been reported in musk melons by Randawa et al. (1981), Locascio et al (1972) in water melon, Raychaudhuri et al (1982) in long melons and Das et al (1987) in pointed gourd

Nitrogen and phosphorus levels were found to have significant influence on dry matter production of bitter gourd. As the levels of nitrogen were increased, the dry matter production increased from 324 58 g/plant to 452.29g/plant and when levels of phosphorus were increased, the dry matter production rose from 373.91g/plant to 405 63g/plant However 25 kg P_2O_5/ha and 15 kg P_2O_5/ha were found to be on par. Although graded levels of potash increased the dry matter production, the increase was not significant.

The control plots recorded a significantly lower dry matter production of 230 12g/plant in comparison with the plots receiving the fertilizer treatments indicating that higher levels of fertilizers increased the dry matter production in bittergourd, although it did not reach the level of significance in certain cases.

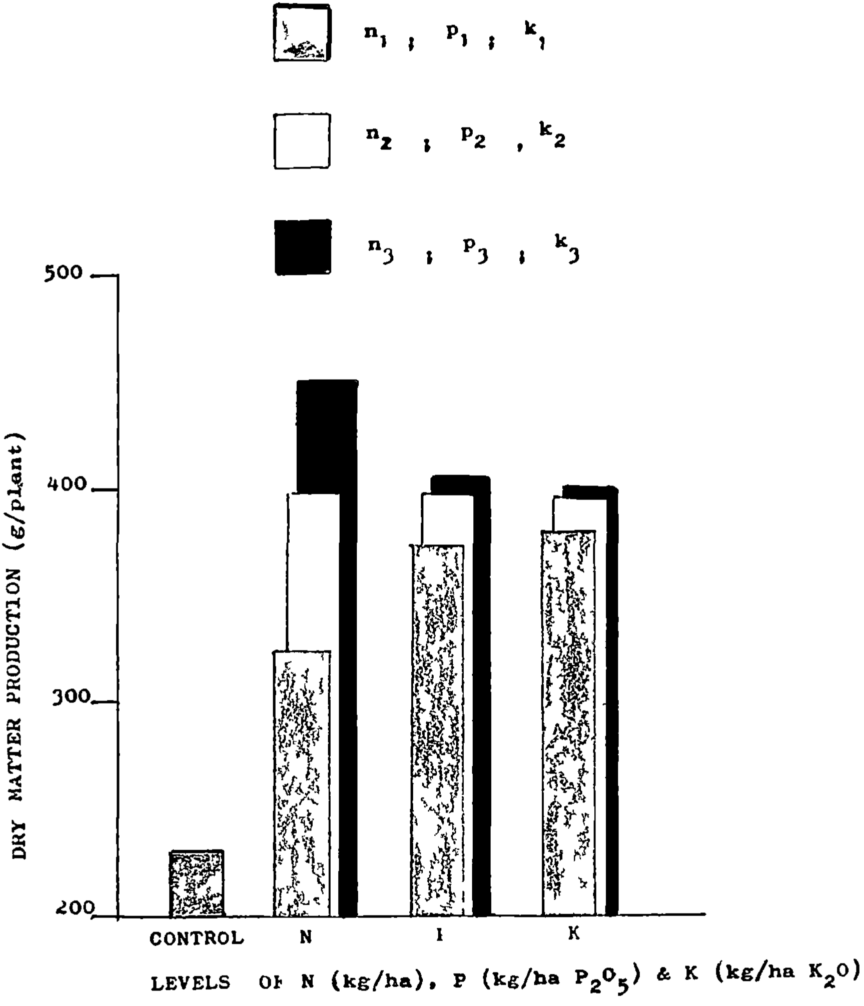


Fig. 5 Effect of levels of N, P & K on the dry matter production of bitter gourd.

The role of nitrogen in plant growth has been discussed earlier. Nitrogen being an important constituent of chlorophyll has a pivotal role in the production of more leaves in plants. 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 in turn increases the dry matter production.

5.2 Yield attributes and yield

As seen from Table 3, the main effects of nitrogen, phosphorus and potash on the sex ratio of bittergourd were not significant. However, the additive effects of the individual nutrients had resulted in the NPK interaction being significant with $n_3p_3k_3$ recording the maximum mean number of male flowers per female flower (8.39).

The increased fertilizer treatments increased the productionof male and female flowers even though it delayed the folower initiation considerably. Although there was an increase in the pistillate and staminate flowers, the female male flower ratio remained unaffected. Similar results have been reported by Parikh and Chandra (1969) in cucumber, Reki et al. (1968) and Jassal et al. (1972) in musk melon, Pandey and Singh (1973) in bottle gourd and Raychaudhuri et al (1982) in long melon.

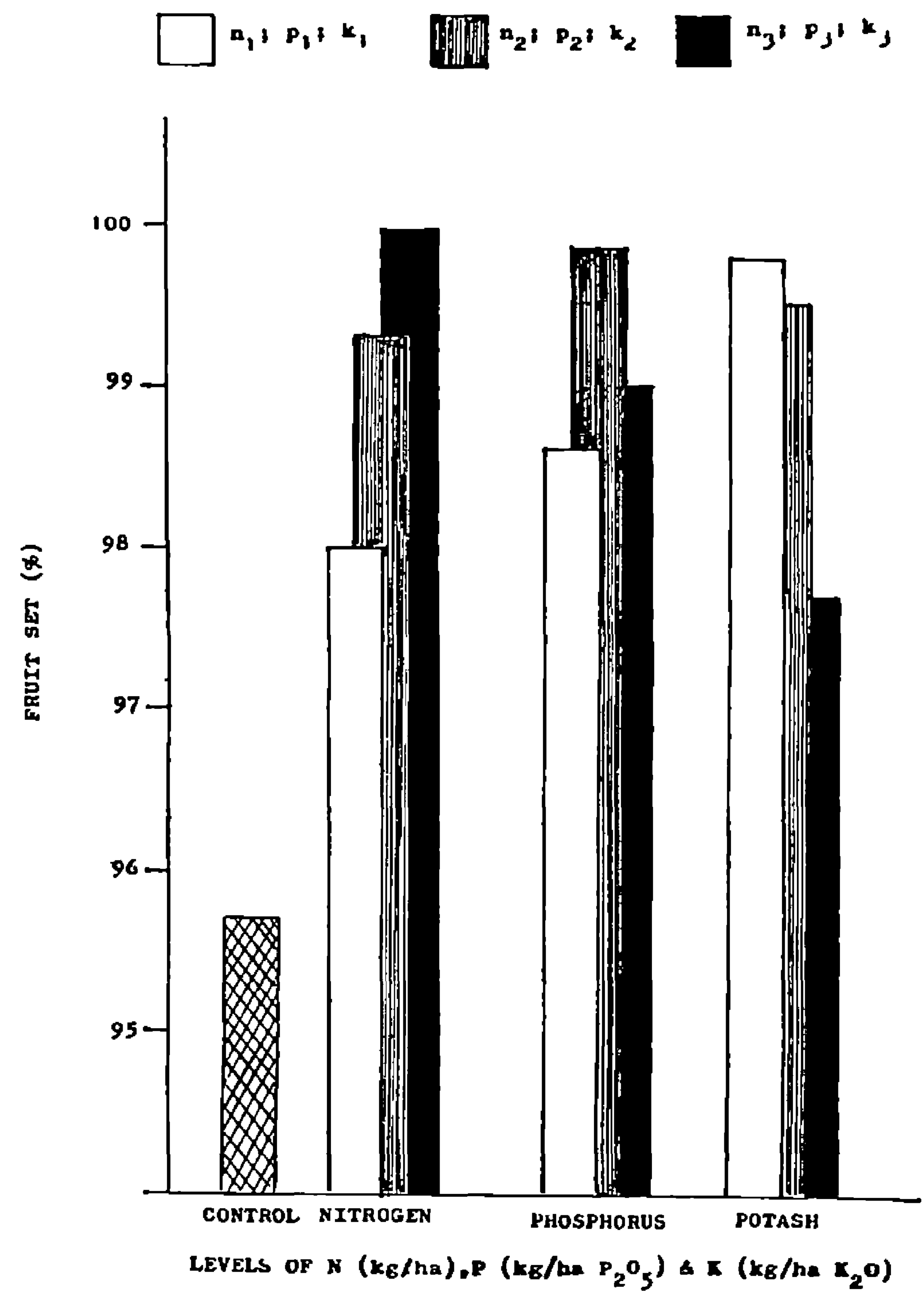


Fig 6 Effect of nitrogen phosphorus and potassium on fruit set

An appraisal of Table 3arevealed that nitrogen, phosphorus and potash had significant influence on the fruit set in bittergourd. As the nitrogen levels were increased, the fruit set increased considerably, although 50 kg N/ha and 70 kg N/ha were found to be on par The response of phosphorus has been found to be quadratic in nature with the level 25 kg P_2O_5/ha recording the maximum fruit set followed by 35 kg P_2O_5/ha and 15 kg P_2O_5/ha In the case of potassium, the response was found to be inversely proportional to the increasing levels of potash The interaction N x P was found to be significant with n_3p_2 recording maximum fruit set (99%)

Higher levels of nutrients would have created an optimum balance of nutrients resulting in higher photosynthetic activity This higher photosynthetic activity would have resulted in the production of greater amount of photosynthates which were translocated to the fertilised flower, thus influencing its development into healthy fruits. Similar trends were reported by Rajendran (1981) in pumpkin and Raychaudhuri <u>et al</u> (1982) in water melon

It is seen from Table 3a that there was significant difference in the yield of fruits between the control and fertilizer treatments The control plots recorded the lowest yield of 5328.34 kg/ha

The main effects of nitrogen and phosphorus alone had profoundinfluence on the yield per plot. With increase in nitrogen level, there was a linear increase in yield from

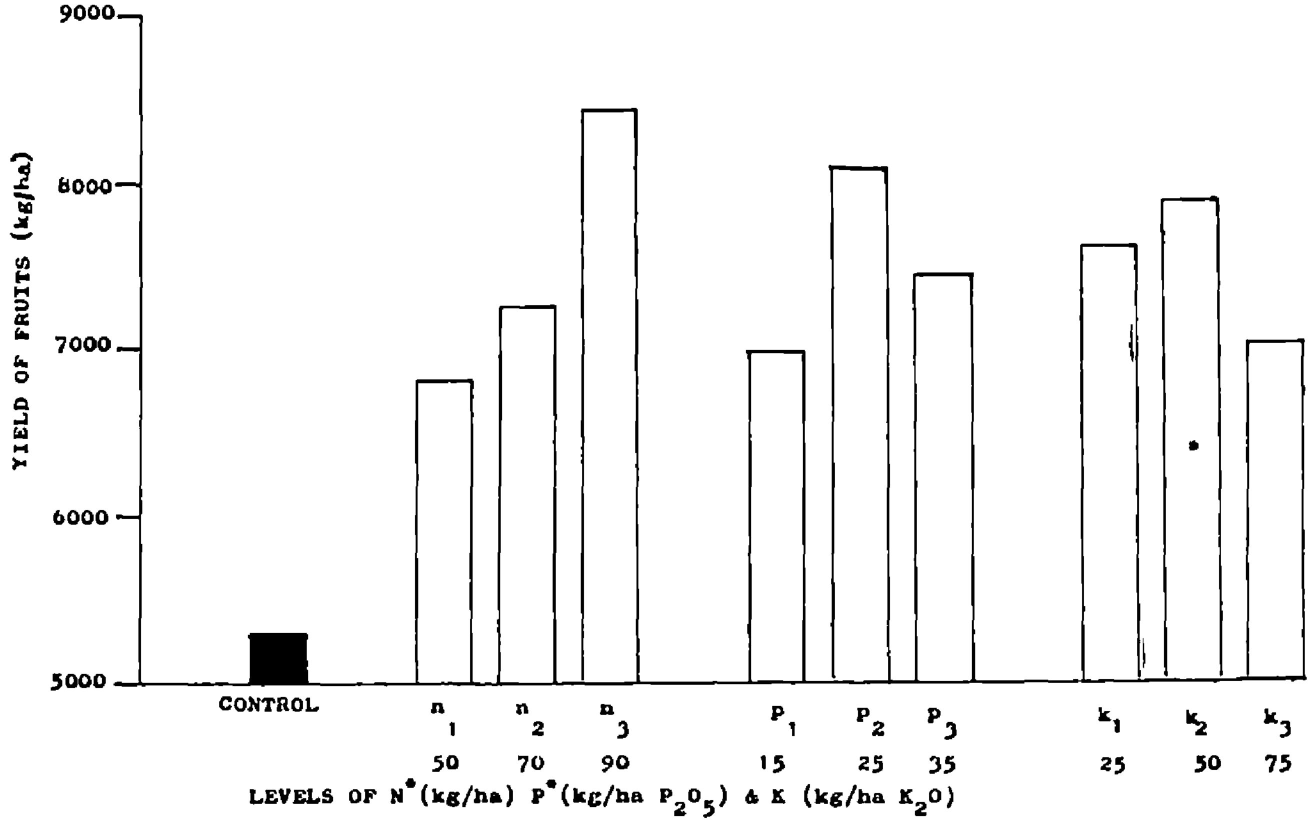


Fig 7 Effect of nitrogen phosphorus and potassium on the yield of fruits

*– SIGNIFICANT EFFECTS

6821 95 kg/ha to 8461.04 kg/ha However 50 kg N/ha and 70 kg N/ha were found to be on par The linear response of nitrogen was proved by the trend analysis studies of nitrogen nutrient by partitioning the relevant sum of squares into linear and quadratic orthogonal components (Table 3b) and significance of each component tested as described by Snedecor and Cochran (1967) A linear regression equation was fitted for the response of nitrogen which is as follows

$$Y = 5236\ 298 + 32\ 9237\ N \quad (R^2 = 97\%)$$

From this equation the response line for nitrogen was traced (Fig.8) As nitrogen shows a linear response, an optimum dose could not be fixed. The highest dose may be taken as the optimum dose until further studies are carried out in this aspect.

In the case of phosphorus, the trend analysis studies showed a quadratic response (Table 3b) As phosphorus levels were increased from 15 kg P_2O_5/ha to 25 kg P_2O_5/ha, the fruit yield increased from 6969 38 to 8108 16 kg/ha When the level of phosphorus was further increased to 35 kg P_2O_5/ha, the yield declined to 7453.30 kg/ha. The levels of 15 kg P_2O_5/ha and 30 kg P_2O_5/ha were found to be on par and so were the levels of 35 kg P_2O_5 and 25 kg P_2O_5/ha A quadratic regression equation was fitted for phosphorus which is as follows

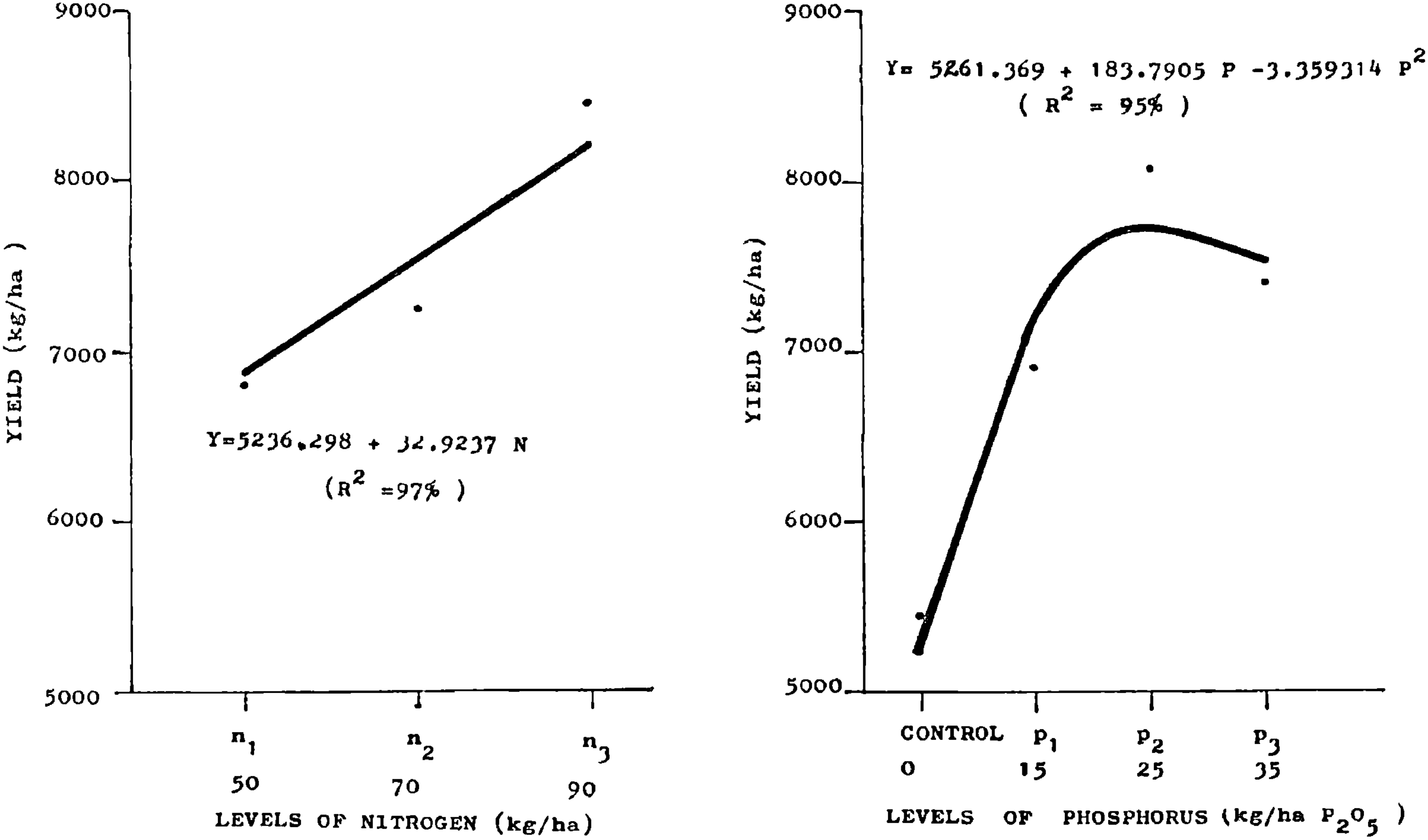


Fig.8 Response of bitter gourd to nitrogen and phosphorus.

$$Y = 5261\ 369 + 183\ 7905P - 3\ 359314\ P^2\ (R^2 = 95\%)$$

From the equation, a response curve was traced (Fig 8) and the optimum was worked out to be 27.36 kg/ha P_2O_5

The effect of potassium was found to be not significant Among the various interactions, NxPxK interaction was found to be significant with $n_3p_2k_2$ recording the maximum yield of 12340.63 kg/ha As the effect of potash was found to be not significant, the lowest dose of 25 kg K_2O/ha can be taken as the optimum level

The yield or any crop is a very complex competitive character resulting from different factors the more important being the yield per plant and number of plants/unit area (Tanaka et al., 1964). The yield per plant is controlled by many factors such as the nutrients taken up by the plants, the genetic potential and the environmental conditions to which it is subjected during its life cycle Yield is the fixed expression of all the yield attributing characters like number of fruits per plant, per fruit weight, length and girth of fruits etc. An increase in the application of major nutrients have definitely increased those attributes, though it did not reach the level of significance in some cases The favourable influence of fertilizer nutrient application on 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. Such a phenomenon has resulted in better growth and yield of the crop showing inter-relation between yield and nutrient uptake The importance of major nutrients on the synthesis of aminoacids, proteins and other metabolic products needs little explanation (Agarwala and Sharma 1976, Tisdale et al , 1985). Similar trends of increased yields under increasing levels of nutrients have been reported by Dhesi et al , (1966) and from Kerala Agricultural University (Anon, 1980, Anon, 1981, Anon, 1983)

An appraisal of Table3a revealed that even though the control plots recorded a significantly lower mean number of fruits per plant (6.6) than the fertilizer treatments none of the main effects nor their interactions were found to be significant. Fertilizer nutrient application, especially nitrogen increased the number of fruits/plot from 9.42 to 12.82 but it was not found to be statistically significant The favourable influence of fertilizer application on this character can be ascribed to the increased availability and uptake of plant nutrients required for production of flowers and growth and development of fruits Higher fruit number per plant with increased application of nitrogen was reported by Jassal et al. (1972) and Piazza and Venturi (1971) in musk melon, Pandey and Singh (1973) in bottle gourd Agarwala and Sharma (1976) stated that the size and quality of fruits was poorer and it matured early when nitrogen supply was a limiting factor. George Thomas (1984) also reported similar findings in bitter gourd.

The main effect of potassium alone was found to influence the per fruit weight significantly as is seen from the data (Table 4). There was a linear increase in per fruit weight as the levels of potassium were increased from 25 kg K_2O/ha to 75 kg K_2O/ha. The potassium level of 75 kg K_2O/ha recorded the maximum per fruit weight of 145.68 g followed by 50 kg K_2O/ha with 142.48 g and then 25 kg K_2O/ha with 129.82 g. However effects of 50 kg K_2O/ha and 75 kg K_2O/ha were found to be on par

It is a well known fact that the nutrient potassium promotes the growth of meristematic tissue (Tisdale et al 1985). But in the earlier stages of growth a low level of potassium proved sufficient for optimum growth. In the later stages, potassium might have been utilised to a larger extent for fruit development. Besides an increased level of potassium might have created an optimum balance of nutrients and contributed to the production of a greater quantity of photosynthates which were translocated to the developing fruits and thus influencing the size and weight of fruits. Similar trend has been reported by George Thomas (1984) in bitter gourd.

Nitrogen was found to influence the length and girth of fruits significantly. It has been seen from Table 4 that the control plots registered significantly lower values for length (23.08 cm) and girth (12.45 cm). As nitrogen

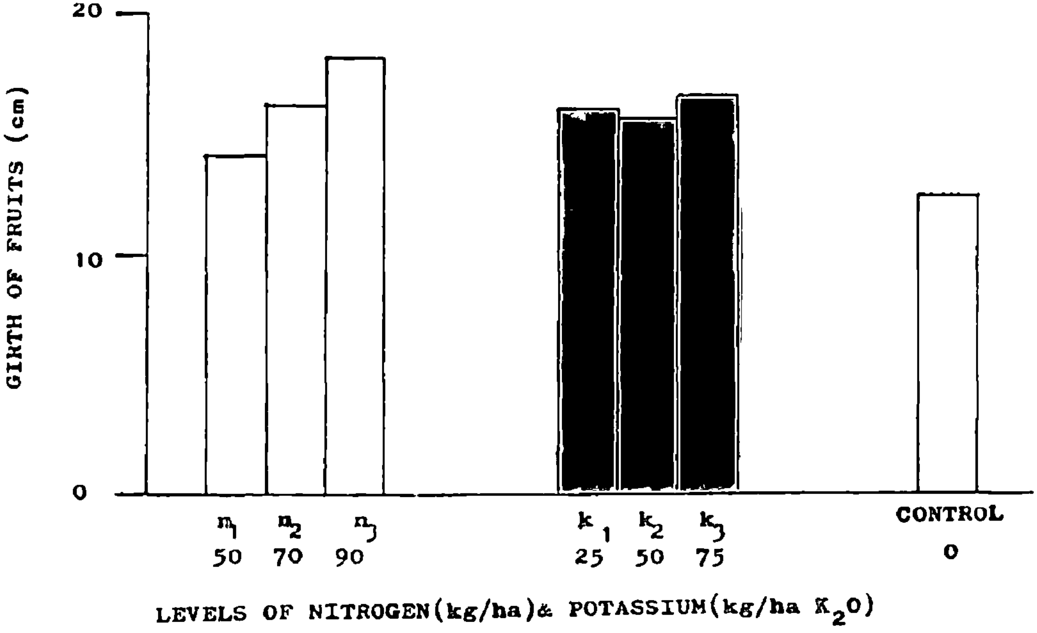


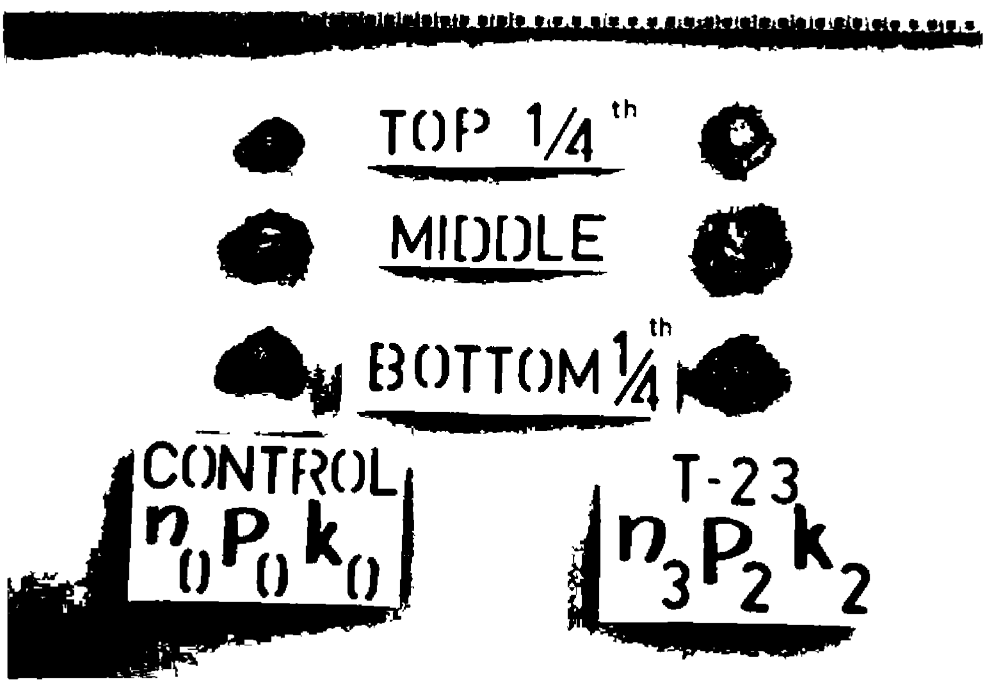
Fig. 9 Effect of nitrogen and potassium on the girth of bitter gourd fruits.

PLATE-II Effect on length of fruits

PLATE-III Effect on girth of fruits

PLATE II

PLATE III



levels were increased from 50 kg N/ha to 90 kg N/ha, the mean length of fruits increased from 22.77 to 27.13 cm and the mean girth from 13.94 to 18.22 cm.

The girth of the fruits was also influenced profoundly by potassium. The mean girth of the fruits decreased from 16.06 cm to 15.65 cm and then rose to 16.64 cm with increase in levels of potassium. However levels 50 kg K_2O/ha and 25 kg K_2O/ha were found to be on par and so were 25 kg K_2O and 75 kg K_2O/ha.

The length and girth of fruits are mostly varietal traits. However the result of the present study points out the necessity for the application of fertilizer nitrogen and potassium for further expression of genetic potential. Similar results were reported by George Thomas (1984) and Lingaiah et al. (1988) in bittergourd

With regard to Harvest Index, none of the main effects nor their interactions were found to be significant, although the control plots registered significantly lower values of 0.53.

Harvest index is defined as the ratio of economic yield to biological yield In the present study it is seen that higher levels of nitrogen, phosphorus and potash could increase the harvest index values, though not significantly. The data on yield attributes (Table 3a) clearly indicate that the application of nitrogen, phosphorus and potassium significantly increased most of the yield attributes. Along with this the vegetative characters were also increased with increasing levels of nitrogen, phosphorus and potash (Table 2). However, the role of nitrogen may be selective in the sense that the vegetative characters were improved only to the extent to contribute substantially to the productive attributes so as to get relatively higher harvest index values. This is in agreement with the findings of Hegde (1987) in water melons.

5.3. Quality characters

It can be seen from Table 5 that the control plots recorded a significant reduction in protein content of fruits (14.71%) as compared to fertilizer treatments. None of the main effects nor their interactions were significant on this character. Significant treatment variation in protein content was not observed because none of these effects exerted any profound influence on the nitrogen content of fruits.

5.4. Analysis of plant samples and uptake of nutrients

It is evident from the tables 6 and 7 that none of the main effects nor their interactions had any marked influence on the nitrogen and phosphorus contents of fruits and plants. The lack of significant variation due to nitrogen and phosphorus may be because of the fact that the availability of these nutrients due to fertilizer application was only just enough to maintain its contents more or less at the same level in plant parts at various stages of growth.

The main effect of potassium had significant influence on the potassium uptake by fruits and plants. As the level of potassium was increased from 25 kg K_2O/ha to 75 kg K_2O/ha, the content of fruits increased from 5.94% to 6.65% and that of plants from 2.43% to3.52%.

The additive effects of the individual nutrients would have resulted in the significant effect of the interactions K x P, N x K and Nx P x K on the potassium content of plants and N x P on the potassium content of fruits

An increased percentage of K in plants and fruits denote an increased availability due to its application. Potassium is a nutrient which is governed by luxury consumption and as such will be absorbed by plants in excess of their requirements on increased availability in soil (Tisdale et al., 1985). Tesi et al.(1981) reported similar results in Cucurbita pepo and George Thomas (1984) in bittergourd.

It may be noted that nitrogen, phosphorus and potassium contents in plants and fruits were influenced by the various major nutrients though it did not reach the level of significance in certain cases. Better absorption of these nutrients might also have been caused by better growth and activity of the roots (Tisdale et al., 1985). Similar trends were reported by Locascio (1967) in water melon and George Thomas (1984) in bittergourd.

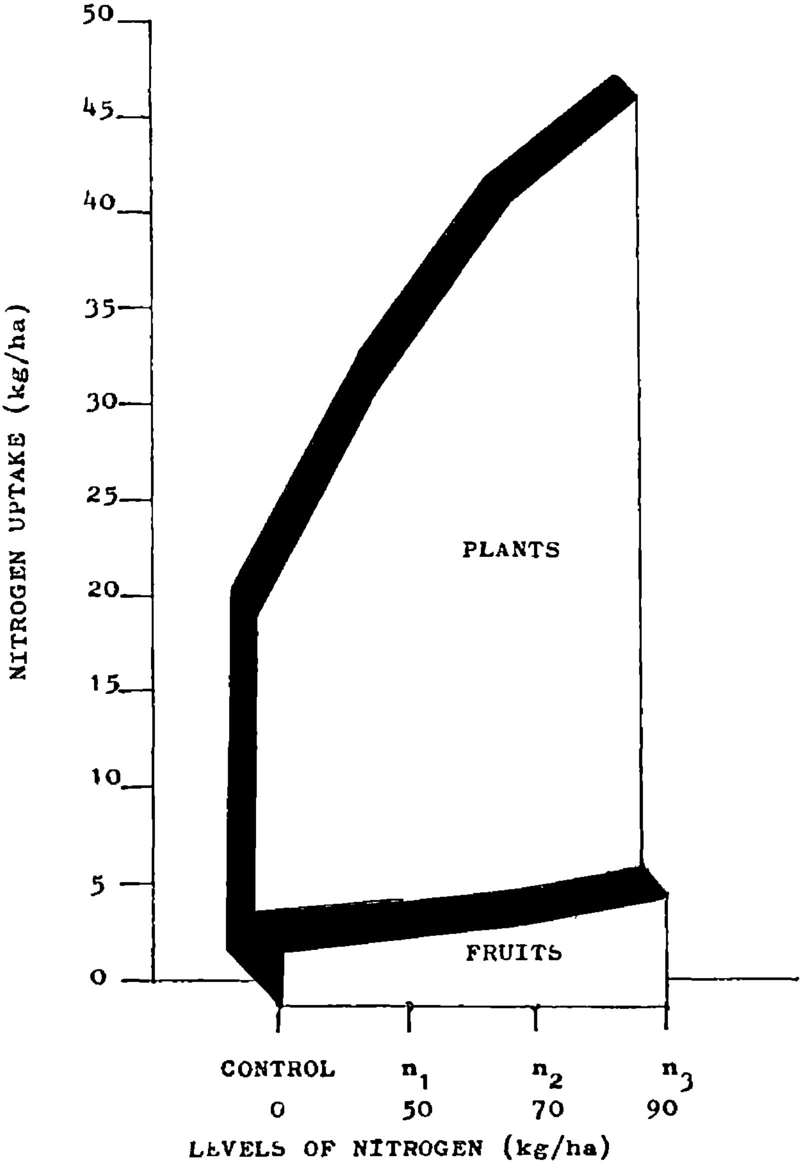


Fig.10 Effect of nitrogen on the nitrogen uptake by the fruits and plants.

An appraisal of the Tables 8 and 9 revealed that nitrogen played a significant role in the uptake of nitrogen by fruits and plants. As the level of nitrogen was increased from 50 kg/ha to 90 kg/ha, the nitrogen uptake by fruits increased from 2.30 to 4.15 kg/ha and that of plants from 31.24 to 45.91 kg/ha. The control plots recorded significantly lower uptake of nitrogen by fruits (1.48 kg/ha) and by plants (18.91 kg/ha). Among the different interactions n_3p_1, p_1k_3 and $n_3p_1k_3$ recorded the maximum nitrogen uptake by fruits of 5.83, 4.60 and 8.93 kg/ha respectively.

With regard to the phosphorus uptake by fruits and plants, a considerably reduced uptake was observed in the control plots. While none of the main effects had any significant influence on the phosphorus uptake by fruits, nitrogen significantly influenced the phosphorus uptake by plants, and the uptake values increased from 12 11 to 16.82 kg/ha.

It is evident from Table 8 that the potassium uptake by fruits was significantly influenced by the main effects of phosphorus and potassium. Among the three levels of phosphorus, 35 kg P_2O_5/ha recorded the maximum uptake (9.87 kg/ha) followed by 15 kg P_2O_5/ha (5.84 kg/ha) and 25 kg P_2O_5/ha (4.96 kg/ha). A linear increase in uptake of potassium was observed with increase in potassium levels The uptake of potassium increased from 4 03 to 9.31 kg/ha with increase

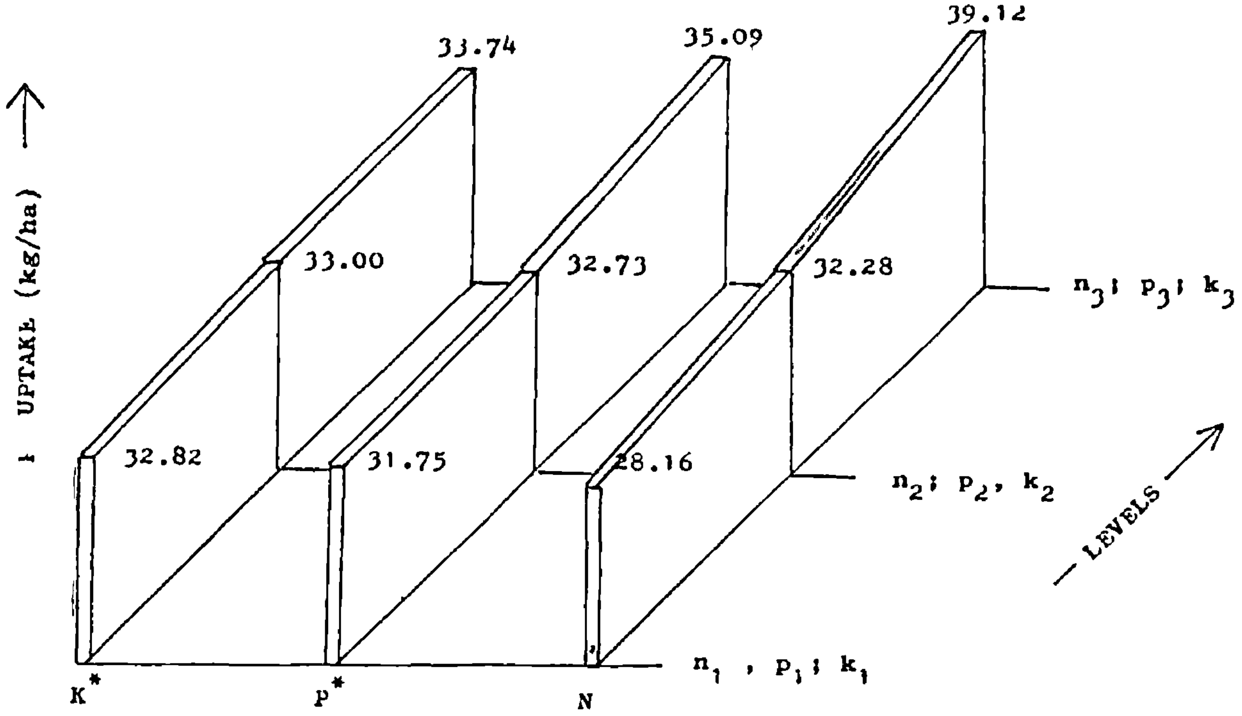


Fig. 11 Effect of nitrogen , phosphorus and potash on the uptake of phosphorus by plants.

* effect not significant

in levels of potassium. Among the different interaction n_2k_3, p_3k_3 and $n_3p_3k_3$ recorded the maximum uptake of 15.75, 15.90 and 32 55 kg/ha of potassium respectively.

With regard to the potassium uptake by plants, the main effect of nitrogen, phosphorus and potassium were found to be significant. The control plots recorded significantly lower uptake of 33.27 kg/ha when compared to the fertilizer treatments. As levels of nitrogen, phosphorus and potassium increased, the uptake of potassium by plants increased linearly. With increase in levels of nitrogen phosphorus and potash, the increase in potassium uptake was from 56.10 to 73.68, 60.12 to 69.27 and 50.52 to 79.17 kg potassium per hectare. The additive effects of the various main effects had resulted in the significant effect of interaction N x P, N x K and P x K with n_2p_3, n_3k_3 and p_3k_3 recording the maximum uptake of 75.63, 82.39 and 84.22 kg/ha of potassium

It is seen that levels of fertilizer nutrients resulted in a marked increase in nitrogen, phosphorus and potassium uptake by both fruits and plants. Those results are in agreement with that of Brown et al. (1960), Mc Collum and Miller (1971), Kagohashi et al (1978), Tesi et al , (1981), Pankov and Aleksandrova (1982), George Thomas (1984) and Hegde (1987) A stimulated growth under higher level of fertilizer application might have resulted in better proliferation of root system and increased intake efficiency of plants

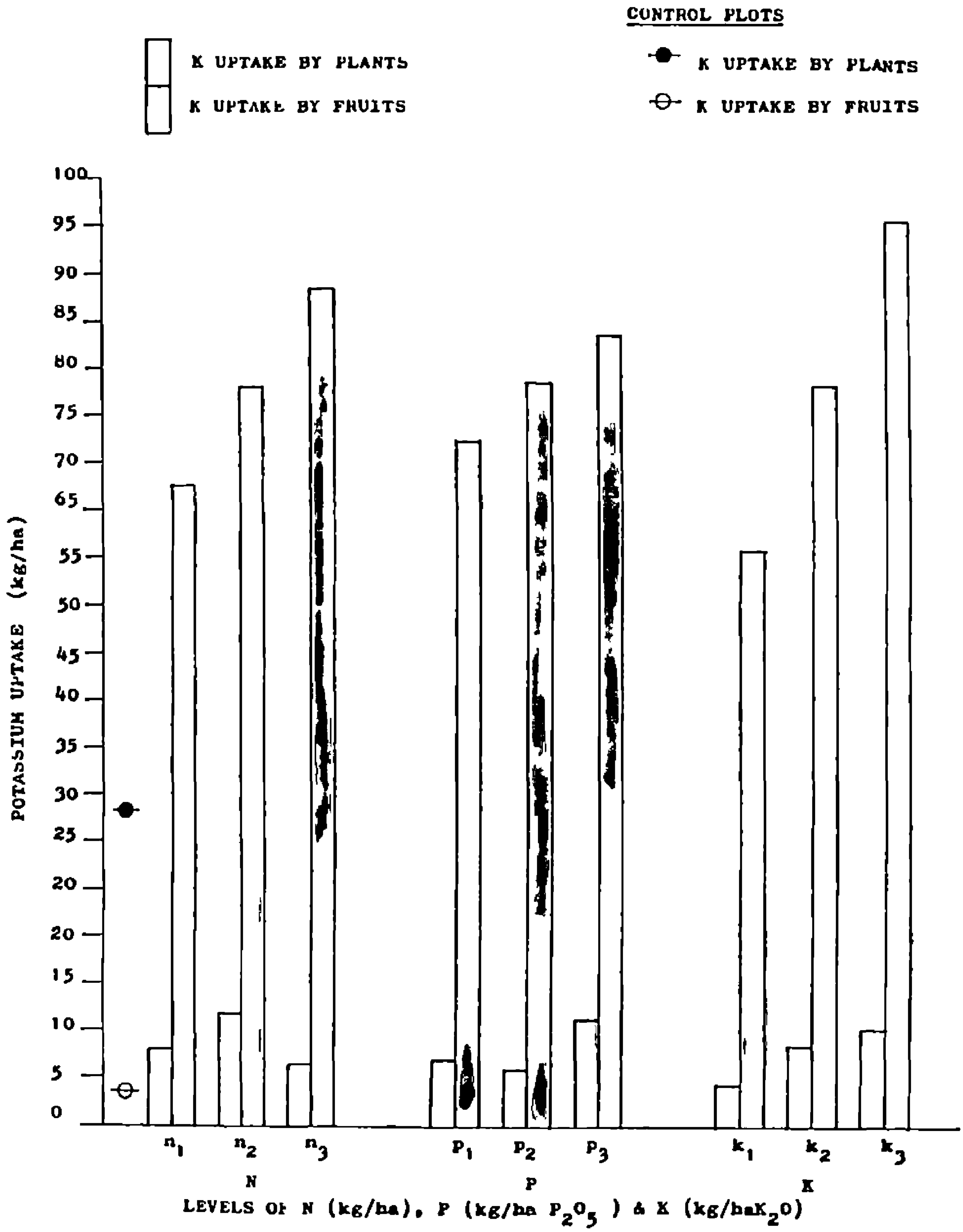


Fig 12 Effect of nitrogen ,phosphorus and potash on the potassium uptake by fruits and plants

In general, the uptake of plant nutrients at any stage of growth is mainly related to 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

5.5. Soil Analysis

The data on soil analysis after the experiment (Table 10) revealed that the available nitrogen content was significantly influenced by nitrogen and phosphorus application. As the levels of nitrogen and phosphorus were increased the available nitrogen content in the soil increased from 361.44 kg to 532.22 kg and 434.39 kg to 443 61 kg per hectare respectively. The available phosphorus in the soil after the experiment registered an increase with increasing levels of nitrogen and phosphorus. As the levels of nitrogen were increased from 50 kg N/ha to 90 kg N/ha, the available phosphorus content increased from 31.21 to 39.51 kg/ha. However, the levels 70 kg N/ha and 90 kg N/ha were found to produce almost the same effect. As the levels of phosphorus were increased from 15 kg P_2O_5/ha to 35 kg $P_2)_5$/ha the available phosphorus content increased from 29.45 to 43.42 kg/ha. Among the interactions n_3k_2 recorded the maximum effect.

It is evident from Table 10 that the effect of nitrogen, phosphorus and potassium are significant on the available potassium content of the soil after the experiment. As the levels of potassium was increased from 25 kg K_2O/ha to 75 kg K_2O/ha, the available potassium content increased from 130.94 to 150.06 kg/ha Of the three levels of nitrogen, 50 kg N/ha showed the maximum value (144.00 kg K_2O/ha), followed by 90 kg N/ha (142.72 kg K_2O/ha) and 70 kg N/ha(137.11 K_2O/ha) However 90 kg N/ha and 50 kg N/ha were found to be on par.

The increased status of available nitrogen, phosphorus and potassium at higher levels of fertilizer nutrients may be due to the direct effect of applied fertilizers nutrients over a uniform dose of farm yard manure. Moreover the farm yard manure had considerable influence on the release and availability of nitrogen, phosphorus and potassium to the plants (Venkatesa Rao, 1985, Thangavel, 1985 and Lavanya, 1986).

5.6. <u>Economics of Cultivation</u>

The abstract of economics analyis of the results are presented in Tables 11 and 12.

All the fertilizer treatments registered a significantly higher net profit than the control. It is evident from the data in Table 11 that only the highest levels of nitrogen and intermediate levels of phosphorus and potassium had significant influence on the net profit. As the level of nitrogen was increased from 50 kg/ha to 90 kg/ha the net profit increased from Rs.16569.72 to Rs.24494.97. However

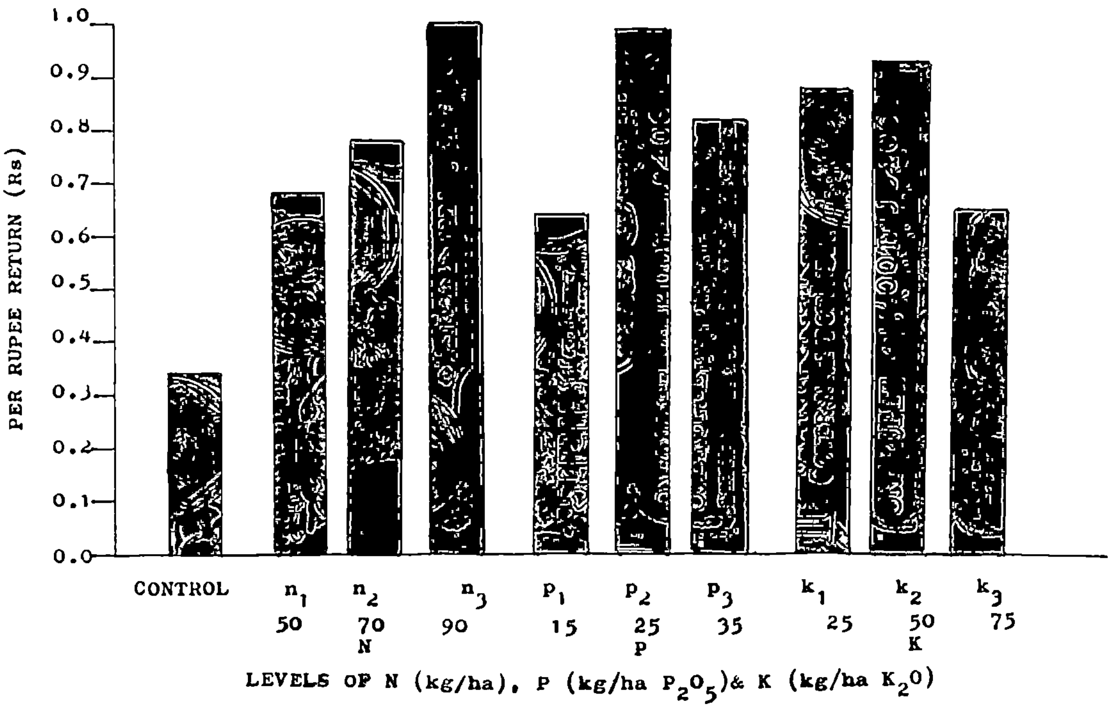


Fig. 13 Effect of nitrogen, phosphorus and potash on the per rupee returns.

the effects of 50 kg N/ha and 70 kg N/ha were found to be on par. Of the levels of phosphorus, 25 kg P_2O_5/ha recorded the highest net profit (Rs 241080 18) followed by 35 kg P_2O_5/ha (Rs.20188.52) and 15 kg P_2O_5/ha (Rs 15714 23) With regard to potassium, 50 kg K_2O/ha recorded the maximum effect (Rs.22847.26) followed by 25 kg K_2O/ha (Rs.21363.33) and 75 kg K_2O/ha (Rs 15872.43)

An appraisal of Table 11 revealed that the main effects of nitrogen, phosphorus and potassium recorded significant influence on the net return per rupee invested As seen earlier the major nutrients registered the same trend in the case of net profit also. Among the different levels of nitrogen, 90 kg N/ha recorded the maximum net returns (Rs.0.9972) followed by 70 kg N/ha (Rs.0 7779) and 50 kg N/ha (Rs.0.6794). Among the three levels of phosphorus, 25 kg P_2O_5/ha recorded the maximum net returns (Rs.0.99) followed by 35 kg P_2O_5 (Rs.0.82) and 15 kg P_2O_5/ha (Rs.0.64) With regard to potassium 50 kg K_2O/ha recorded the maximum net return (Rs.0.93) followed by 25 kg $K_2)$/ha (Rs 0.88) and 75 kg K_2O/ha (Rs.0 65)

The additive effects of the individual nutrients have resulted in the significance of the interactions N x P, N x K and Nx P x K. Among these interactions, n_3p_2, n_3k_2 and $n_3p_2k_2$ recorded the maximum net returns per rupee invested of Rs.1.34, Rs.1.32 and Rs.2.01 respectively.

PLATE IV - General view of Control plot ($n_o p_o k_o$)

PLATE V - General view of T-23 plot(best treatment)

PLATE IV

PLATE V

Thus it is seen that on the basis of economic considerations the requirements of major nutrients for bittergourd under partially shaded (40%) conditions of coconut garden can be fixed as 90 kg N, 25 kg P_2O_5 and 50 kg K_2O per hectare

SUMMARY

SUMMARY

An investigation was undertaken at the Instructional Farm of the College of Agriculture, Vellayani during March-July 1988 to find out the effect of graded doses of nitrogen (50, 70 and 90 kg N/ha), phosphorus (15, 25 and 35 kg P_2O_5/ha) and potassium (25, 50 and 75 kg K_2O/ha) on growth, yield, content and uptake of major nutrients by bittergourd cv VK-1 (Priya), under partial shade conditions of coconut gardens. 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 replication II respectively.

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

1. The days taken for the opening of the first male and female flowers were significantly delayed by application of fertilizer nutrients. Nitrogen alone had significant influence on this character. The days taken for the opening or first male and female flowers increased with increase in levels of nitrogen

2. The node at which the first male and female flowers appeared was increased by fertilizer nutrients. Increase in levels of nitrogen significantly increased the node number of

the appearance of first male flower while the main effects of nitrogen and phosphorus increased significantly the node number of appearance of first female flower However the levels 15 kg P_2O_5/ha and 25 kg P_2O_5/ha were found to be on par.

3. With fertilizer nutrient application, the inter-nodal length at 50% flowering and length of main vine were found to increase significantly. However only nitrogen had any positive significant effect on these characters. None of the interactions or main effects of phosphorus and potassium had any significant influence.

4. The total dry matter production was also markedly increased by application of fertilizer nutrients. As the levels of nitrogen and phosphorus were increased, so did the DMP. Neither the main effect of potassium nor the interaction effects of nitrogen, phosphorus and potassium exerted any significant influence on this parameter

5. None of the main effects of nitrogen, phosphorus and potassium could significantly influence the sex ratio The additive effects of the individual nutrients had resulted in the significance of the interaction effect of NxPxK in this respect.

6. The main effect of nitrogen, phosphorus and potassium had significant influence on fruit set. Maximum fruit set was observed at 90 kg N/ha, 25 kg P_2O_5/ha and at 25 kg K_2O/ha Among the interactions, NxP proved to be significant

7. The yield of fruits was significantly influenced by nitrogen and phosphorus levels. While bittergourd responded linearly to the increasing levels of nitrogen, it registered a quadratic response towards levels of phosphorus. An optimum dose of nitrogen could not be fixed on account of this effect and as such the highest level tried ie. 90 kg N/ha could be taken as an interim optimum till further studies are undertaken. In the case of phosphorus, a dose of 27.36 kg P_2O_5/ha was worked out to be the optimum level. Since potassium was found to be not significant the lowest level ie, 25 kg K_2O/ha could be considered as the optimum. Among the interactions NxPxK registered significant effect and $n_3p_2k_2$ recorded the maximum yield of 12340.63 kg/ha.

8. Even though there was significant increase in the number of fruits/plant, with increase in the levels of nutrients tried none of the main effects of nitrogen, phosphorus and potassium nor their interactions were significant.

9. Higher levels of potassium were found to increase the per fruit weight significantly. However the levels of 50 kg K_2O/ha and 75 kg K_2O/ha were found to be on par.

10. The length and girth of fruits were markedly increased by the application of fertilizer nutrients. Nitrogen was found to have a positive influence on length and girth of the fruits and increase in level of application of potash increased the girth significantly. All the inter-

actionswere found to be not significant with regard to this character.

11. The harvest index (HI) registered a significantly higher value in plots where fertilizer treatments were made. Neither main effects nor their interactions registered any profound influence on the HI.

12. Higher levels of nutrients did not influence markedly the protein, nitrogen and phosphorus content of fruits. The nitrogen and phosphorus contents of plants were also not influenced by the treatments significantly. The main effect of potassium influenced significantly the total potash content of fruits and plants. Potassium content increased with increase in level of potassium.

13. The uptake of nutrients by fruits and plants markedly increased with application of nutrients. Increasing the levels of nitrogen improved nitrogen uptake by both fruits and plants. Increasing levels of nitrogen improved phosphorus uptake by plants. Main effects of phosphorus and potassium showed significant positive influence on the potassium uptake by fruits. As levels of phosphorus and potassium were increased, the potassium uptake of fruits also increased. The potassium uptake by plants was significantly increased by increased application of nitrogen, phosphorus and potassium fertilizer.

14. Available nitrogen and phosphorus contents in the soil after the experiment were significantly influenced by nitrogen and phosphorus application. The higher levels of potassium and lower levels of nitrogen and phosphorus were seen to have a pronounced effect on the available potassium content of soil after the experiment

15. The net profit and net return per rupee invested were markedly affected by the application of fertilizer nutrients. The main effect of nitrogen, phosphorus and potassium had significant influence on these economic parameters. Net return was found to increase with increasing levels of nitrogen, but 50 kg N/ha and 70 kg N/ha were found to be on par. Among the levels of phosphorus 25 kg P_2O_5/ha recorded maximum effect followed by 35 kg P_2O_5/ha and 15 kg P_2O_5/ha. The level 50 kg K_2O/ha recorded the maximum net return followed by 25 kg K_2O/ha and 75 kg K_2O/ha, among the levels of potassium Among the interactions, NxP, NxK and NxPxK were found to have a pronounced effect on the net returns. The maximum profit and returns were obtained from the treatment combination of 90 kg N/ha, 25 kg P_2O_5/ha and 50 kg K_2O/ha.

The present investigation indicated that bittergourd cv VK-1 (Priya) requires a nutrient combination of 90 kg N, 25 kg P_2O_5 and 50 kg K_2O per hectare in the red loam soils of Vellayani under partial shade (40%) for giving reasonably higher yields and net returns.

Future line of work

Trials may be conducted with bittergourd under varying degrees of shade in comparison with open to study the effect of varying intensities of shade on this crop.

Since the residual nutrient contents in soil are found to be relatively high after the experiment and the reason being attributed to the large quantities of cowdung applied to the pits, studies may be conducted with different types and levels of organic manures, along with chemical fertilizer to standardize a proper integrated nutrient management system for bittergourd.

Since a linear response was observed with regard to nitrogen, still higher doses may be tried to fix up an optimum level.

There is at present a great void in the research on standard agronomic practices to be followed in a partial shade condition. So specific research on the cultural practices tobe followed like method of planting, spacings to be adopted, trailing, scheduling of irrigation etc. are to be carried out in bittergourd in partial shade conditions, especially in coconut gardens.

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*Originals not seen

APPENDICES

APPENDIX I

WEATHER CONDITION DURING THE CROPPING PERIOD
(Weekly Means)
25th March 1988 to 14th July 1988

Standard week	Period		Temperature (°C)		Rainfall (mm)	Relative humidity (%)
	From	To	Maximum	Minimum		
13	25-3-88	31-3-88	33.24	25 31	0	72.85
14	1-4-88	7-4-88	33 18	25.45	0	74.00
15	8-4-88	14-4-88	32.58	24.90	1.67	80.79
16	15-4-88	21-4-88	32.51	24.51	0 61	80.50
17	22-4-88	28-4-88	33 08	24.39	2.04	79.71
18	29-4-88	5-5-88	32.86	24.97	2.53	77.43
19	6-5-88	12-5-88	33.04	25.89	0.72	74.93
20	13-5-88	19-5-88	33.01	26 09	0.13	78 86
21	20-5-88	26-5-88	32.61	25.40	0.49	79.92
22	27-5-88	2-6-88	31.56	24.18	2.37	86.93
23	3-6-88	9-6-88	28.61	22.37	9.59	80.36
24	10-6-88	16-6-88	30.67	23.63	4.39	77.00
25	17-6-88	23-6-88	30 58	24 60	1.29	72 79
26	24-6-88	30-6-88	29.99	22.95	4.36	82.14
27	1-7-88	7-7-88	31.08	23.45	4.76	72.78
28	8-7-88	14-7-88	30.94	23.36	1 36	79.71

SOURCE Meteorological Observatory, College of Agriculture, Vellayani

APPENDIX II

Analysis of variance table for the effect of shade on treatments

Source	dF	Mean squares
Blocks	5	0.5338
N	2	0.9899
P	2	0.5891
K	2	0.9338
N x P	4	0.8737
P x K	4	0 6453
N x K	4	0.7014
NPK	2	0.3607
NP^2K '	2	1 4067
NPK^2	2	0.3607
NP^2K^2 '	2	1 9759
Trtd V Cntrl	1	0 1844
Error	27	1.0892

* Significant at 5% level

** Significant at 1% level

' Partially confounded effects

APPENDIX -III

Analysis of variance table for days for opening of first male and female flowers and node at which the first male & female flower appeared.

Source	df	Mean squares			
		Days for opening of first		Node of first appearance of	
		Male flower	Female flower	Male flower	Female flower
Blocks	5	0.0358	0.0045	0.0214	0.0244
N	2	0.8728**	1.5142**	1.5089**	2.7232**
P	2	0.0602	0.0518	0.0382	0.1981**
K	2	0.0026	0.0034	0.0542	0.0059
N x P	4	0.0125	0.0143	0.0196	0.0431
P x K	4	0.0044	0.0065	0.0286	0.0045
N x K	4	0.0046	0.0093	0.0108	0.0139
NPK	2	0.0043	0.0093	0.0061	0.0067
NP^2K '	2	0.0032	0.0034	0.0019	0.0021
NPK^2	2	0.0048	0.0011	0.0517	0.0059
NP^2K^2 '	2	0.0004	0.0014	0.0234	0.0011
Trtd V Cntrl	1	2816.6340**	3742.9120**	87.0849**	772.8933**
Error	27	0.0299	0.0325	0.0372	0.0136

* Significant at 5% level

** Significant at 1% level

' Partially confounded effects

APPENDIX IV

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 (cm)	Total dry matter production (g/plant)
Blocks	5	0 1435	8766 401	1303
N	2	30.3372**	20531*	74020 28**
P	2	0.8406	9416	4754.50**
K	2	0.3911	4187	2365.50
NP	4	0.3036	4938	789.50
PK	4	0.1003	1518	605.50
NK	4	0.1255	2155	928.75
NPK	2	0.0547	4006	312.75
NP^2K '	2	0.1245	6495.5	2194.75
NPK^2	2	0.4949	6747	462.75
NP^2K^2 '	2	0.0898	8635.5	39.00
Trtd V Cntrl	1	28 1206**	10166	141191**
Error	27	0.3306	5669 778	768.6296

* Significant at 5% level

** Significant at 1% level

' Partially confounded effects

APPENDIX V

Analysis of variance table for sex ratio, fruit set, yield and fruits per plant

Source	df	Mean squares			
		Sex ratio	Fruit set (%)	Yield ($kg\,ha^{-1}$)	Fruits per plant
Blocks	5	4.4550**	3.2347	1878938	0 6034
N	2	0.7270	10.3745**	1 019390**	1 2032
P	2	0 0781	8 0548*	5879680*	0 5226
K	2	2 8281	8.8038*	3570688	0 5375
NP	4	0.0286	8.4867**	2914176	0.3842
PK	4	0 2801	0.8138	1537536	0.0186
NK	4	1 4026	2.5491	2[illegible]3216	0.2055
NPK	2	3.5037*	0.2456	920[illegible]104**	0 5353
NP^2K '	2	0.8536	1 8172	969984	0 1607
NPK^2 '	2	2.2722*	2.0315	10529410**	0.3767
NP^2K^2	2	1.4428	0.2147	1105776	0.3777
Trtd V Cntrl	1	0.2078	34499.32**	25708800**	60 7288**
Error	27	0.8513	1 7403	1380303	0 4302

* Significant at 5% level

** Significant at 1% level

' Partially confounded effects

A PENDIX VI

Analysis of variance table for per fruit weight, length of fruit, girth of fruit and harvest index.

Source	df	Mean squares			
		Per fruit weight(g)	Length of fruit (cm)	Girth of fruit(cm)	Harvest Index
Blocks	5	545.0750	4.3070	2.0820	1.0244
N	2	697.8750	86.0488**	82.2378**	2 4970
P	2	268.8750	8.6621	0.4360	0.2544
K	2	1266*	8 5996	4.4097*	0 0237
NP	4	386.7188	4.3506	1.8171	0 0330
PK	4	229 8750	4.5801	6.1169**	0.0106
NK	4	274.5000	3.8740	5.6885**	0.0049
NPK	2	99	9.0723	2.0889	0.0019
NP^2K '	2	2.8750	10 1914	2.0342	0.0081
NPK^2	2	711	12.4277	1.3027	0.0012
NP^2K^2 '	2	464 1094	8.3896	0.8503	0.0031
Trtd V Cntrl	1	3513.5000**	17.1523**	75.7178**	13690.97**
Error	27	255 1076	5.4227	1.0373	1.790546

* Significant at 5% level

** Significant at 1% level

' Partially confounded effects

APPENDIX VII

Analysis of variance table for protein content of fruits (%)

Source	df	Mean squares (%)
Blocks	5	5.2242
N	2	4.3975
P	2	1 9912
K	2	5.8691
NxP	4	8.8081
PxK	4	4.6704
NxK	4	4.9893
NPK	2	1.4941
NP^2K '	2	1.1475
NPK^2	2	0.6074
NP^2K^2 '	2	0.2891
Trtd V Cntrl	1	59.2070**
Error	27	5.4040

* Significant at 5% level

** Significant at 1% level

' Partially confounded effects

APPENDIX VIII

Analysis of variance table for nitrogen, phosphorus and potassium content of fruits

Source	df	Mean squares		
		Nitrogen content(%)	Phosphorus content(%)	Potassium content(%)
Blocks	5	0.1334	0.0104	0.2029
N	2	0.1127	0.0073	0.0739
P	2	0.0512	0.0050	0.0627
K	2	0.1494	0.0099	2.3174**
NP	4	0.2250	0.0305	0.9404*
PK	4	0.1197	0.0045	0.0666
NK	4	0.1274	0.0260	0.2880
NPK	2	0.0384	0.0057	1.0696*
NP^2K '	2	0.0290	0.0242	0.4017
NPK^2	2	0.0155	0.0033	0.3384
NP^2K^2 '	2	0.0074	0.0027	0.0819
Trtd v Cntrl	1	1.5115**	0.0882*	3.4031**
Error	27	0.1383	0.0[illegible]91	0.3[illegible]09

* Significant at 5% level
** Significant at 1% level
' Partially confounded effects

APPENDIX IX

Analysis of variance table for nitrogen, phosphorus and potassium contents of plants

Source	df	Mean squares		
		Nitrogen content( )	Phosphorus content(%)	Potassium content(%)
Blocks	5	0.1662	0.0068	0.0717
N	2	0.0303	0.0263	0.2300
P	2	0.1189	0.0012	0.1704
K	2	0.0292	0.0116	5.3667**
NP	4	0.0988	0.0081	0.3012
PK	4	0.1751	0.0108	1.0109**
NK	4	0.0516	0.0037	0.5549*
NPK	2	0.0157	0.0129	1.0499**
NP^2K '	2	0.0486	0.0442*	0.4390
NPK^2	2	0.1618	0.0162	0.0504
NP^2K^2 '	2	0.0249	0.0005	0.0246
Trtd V Cntrl	1	0.5264	0.0722+	0.7353*
Error	27	0.1464	0.0117	0.1630

* Significant at 5% level

** Significant at 1% level

' Partially confounded effects.

APPENDIX X

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

Source	df	Mean squares		
		Nitrogen uptake ($kg\ ha^{-1}$)	Phosphorus uptake ($kg\ ha^{-1}$)	Potassium uptake ($kg\ ha^{-1}$)
Blocks	5	3.1517	0.6763	37.9184
N	2	15.5775**	0.4493	44.2090
P	2	2.6581	0.3649	123.0768**
K	2	3.7615	1.7348	128.7162**
NP	4	9.5519**	0.4427	41.1560
PK	4	4.7688**	0.5881	59.0323*
NK	4	2.7009	1.3326	96.1802**
NPK	2	4.7977	1.3775	88.9647*
NP^2K '	2	7.2408*	0.3433	16.6865
NPK^2	2	4.0727	0.4093	59.8035*
NP^2K^2 '	2	1.8238	0.2184	65.5595*
Trtd V Cntrl	1	15.8894**	5.6047**	58.3912
Error	27	1.6514	0.5590	16.6893

* Significant at 5% level

** Significant at 1% level

' Partially confounded effects

APPENDIX XI

Analysis of variance table for nitrogen, phosphorus and potassium uptake by plants

Source	df	Mean squares		
		Nitrogen uptake ($kg ha^{-1}$)	Phosphorus uptake ($kg ha^{-1}$)	Potassium uptake ($kg ha^{-1}$)
Blocks	5	105.1734	5.4823	148.1566
N	2	989.4062**	101 9843*	1591.0724**
P	2	143.1758	9.8427	379.0995**
K	2	13.7461	0.7804	3693.9252**
NP	4	43.5918	5.0692	248.2786*
PK	4	108.918	4.6326	421.9566**
NK	4	40.03906	8.5107	198.9038**
NPK	2	4.6797	2.4698	119.6318
NP^2K '	2	18.6172	9.7538	92 7862
NPK^2	2	98.9570	5.26316	47.2219
NP^2K^2 '	2	13.4629	0.1957	118.7007
Trtd V Cntrl	1	2219.766**	176.2675**	5391 0516**
Error	27	46.5522	3.1830	67.3572

* Significant at 5% level

** Significant at 1% level

' Partially confounded effects

APPENDIX XII

Analysis of variance table for available nitrogen, phosphorus and potassium in the experiment

Source	df	Mean squares		
		Available nitrogen (kg ha-1)	Available phosphorus (kg ha-1)	Available potash (kg ha-1)
Blocks	5	13	4.4047	23.15
N	2	134205.5**	399 1002**	241.6875**
P	2	392.5**	879.8632	425.375**
K	2	14.5	4 1016	1676.25**
NP	4	74.25**	5.9844	164.6503**
PK	4	2.75	1.0781	34.625
NK	4	10.5	10.8555*	61.9688*
NPK	2	25.5	4 4883	39.375
NP^2K '	2	7.25	6.5664	32.125
NPK^2	2	3.5	13.4648*	47.375
NP^2K^2 '	2	18	5 8398	20.125
Trtd V Cntrl	1	49600	780.9531**	2.75
Error	27	11.2407	3 8857	16 2778

* Significant at 5% level

** Significant at 1% level

' Partially confounded effects

APPENDIX XIII

Analysis of variance table for net profit and net return per rupee invested

Source	df	Mean squares	
		Net profit (Rs.)	Net return per rupee invested
Block	5	27391590	0.0458
N	2	296390700**	0.4764**
P	2	322867200**	0.5325**
K	2	242991100**	0.4114**
NP	4	99107320	0.1619*
PK	4	24311810	0.0407
K	4	153274400	0.2500**
NPK	2	258157600	0.4301**
NP^2K '	2	34915840	0.0568
NPK^2	2	344657900	0.5689*
NP^2K^2 '	2	6820352	0.0107
Trtd V Cntrl	1	758493300**	1.2260**
Error	27	33778050	0.0566

* Significant at 5% level
** Significant at 1% level
' Partially confounded effects

ABSTRACT

A field experiment was conducted at the College of Agriculture, Vellayani during 1988 to study the influence of three levels of each 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, content and uptake of major nutrients in bittergourd VK-1 (Priya) under partially shaded conditions of coconut gardens. The trial was conducted as 3^3+1 partially confounded factorial experiment in Randomised Block Design with two replications.

Higher levels of nitrogen had profound influence on growth characters like days for opening of first male and female flowers and their node of emergence, internodal length, length of main vine and total dry matter production. Application of phosphorus of 35 kg/ha had significant positive effect on the node of emergence of first female flower and total dry matter production.

Yield attributes like sex ratio, fruits per plant and harvest index were not influenced significantly by the main and interaction effects of the major nutrients. However the control plots registered a significant reduction in values for these parameters. The fruit set was maximum at 90 kg/ha of nitrogen, 25 kg/ha of phosphorus and 25 kg/ha of potash. Application of 90 kg N/ha, 25 kg P_2O_5/ha and

50 kg K_2O/ha recorded the maximum yield. The response of bittergourd to nitrogen levels was linear and that to phosphorus levels was quadratic. Application of potassium at 75 kg K_2O/ha was found to significantly increase the fruit weight. The length and girth of the fruits were positively influenced by the application of nitrogenous fertilizer. Potassium at the rate of 75 kg K_2O/ha recorded the maximum girth of fruits signifying its effect on this character.

The nitrogen and phosphorus content of fruits and plants and protein content of fruits were found to be unaffected by the main effects of nitrogen, phosphorus and potash. An increase in potash level increased the potassium content of fruits and plants Nitrogen at 90 kg/ha significantly increased the nitrogen uptake by plants and fruits and phosphorus uptake by plants as compared to other levels. Maximum potassium uptake by fruits was obtained by application of 35 kg P_2O_5/ha and 75 kg K_2O/ha and uptake of potassium by plants was maximum at 90 kg N/ha, 35 kg P_2O_5/ha and 75 kg K_2O/ha.

The study indicated that application of 90 kg N/ha 25 kg P_2O_5/ha and 50 kg K_2O/ha recorded the maximum yield and net returns from bittergourd cv. VK-1(Priya) under partially shaded conditions of coconut gardens in the red loam soils of Vellayani.