STUDIES ON THE EFFECTS OF GRADED DOSES OF NITROGEN, PHOSPHORUS AND POTASSIUM ON GROWTH, YIELD AND QUALITY OF BHINDI (*Abelmoschus esculentus* (L.) Moench.) VARIETY Co. 1

BY

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THESIS

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D E C L A R A T I O N

I hereby declare that this thesis entitled "Studies on the effect of graded doses of nitrogen, phosphorus and potassium on growth, yield and quality of bhindi (*Abelmoschus esculentus* (L.) Moench.)" 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.

Vellanikkara,
March, 1980.

(SUBRAMANIAN, K.V.)

C E R T I F I C A T E

Certified that this thesis is a record of research work done by Shri. Subramanian, K.V. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associate-ship to him.

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INTRODUCTION

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

With considerable break-through in the evolution and development of high yielding agronomic techniques which has resulted in the "quantum jumb" in productivity of cereal crops, there remains an urgent need to develop such agronomic techniques to raise the productivity of vegetable crops. The importance of such a strategy to develop an appropriate agronomic practice resulting in higher productivity is all the more relevant in a country like ours where the majority of people are vegetarians. Bhindi (Abelmoschus esculentus (L.) Moench.) is a warm season pod vegetable. Originated in the Abezenian centre of crop origin and introduced to our country by the western navigators and explorers the crop is now being cultivated throughout the country in different agro-climatic regions. Advances in food technology have given further boost to the cultivation of bhindi with the export of dehydrated pods to foreign countries. The bhindi seed has been identified as a nutritious cattle feed.

The yield of bhindi per unit of land and per unit of time has remained very low in our country. A galaxy of reasons - poor genetic potential of the

existing genotypes to manufacture and store the photosynthate, incidence of many parasitic and non-parasitic diseases and above all lack of an appropriate agronomic package of practices - have been attributed to the poor performance of Indian bhindi. Recently a good number of varieties (Pusa Sawani Co.I, Selection-2 etc.) have been evolved.

There remains an urgent need to chalk out a fertilizer schedule for the high yielding varieties like Co.I which is very popular in Kerala.

No work seems to have been done to find out optimum and economic doses of nitrogen, phosphorus and potassium to raise the productivity of bhindi crop above 100 q/ha. The present study was designed to find out optimum and economic levels of the three major nutrients (nitrogen, phosphorus and potassium) which would give a yield level above 100 q/ha.

The effect of different levels of nitrogen, phosphorus and potassium on pod yield and its components were also studied.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Formulation of economic levels of fertilizer required for maximisation of crop profits is a vital step in any crop management programmes. Christioned as manurial trials, the experiments on deciding the economic levels are rather limited and few in number in vegetables in general and bhindi in particular. The available literature on the effects of nitrogen, phosphorus and potassium on growth, yield, quality and their components in bhindi are reviewed below.

1. Effects of nitrogen, phosphorus and potassium on growth, yield and quality of bhindi.

1.1 Effects of nitrogen.

Randhawa (1962) conducted a trial on bhindi with three levels of nitrogen (34, 68 and 102 kg/ha) and found 68 kg N/ha to be the most effective dose for increasing the number of branches, leaves, flowers and fruits per plant. Chonkar and Singh (1963) in a sand culture experiment observed that for the best growth bhindi requires 210 ppm of nitrogen, 237 ppm of phosphorus and 78 ppm of potassium. The height of

plant, number of leaves and pods could be increased considerably due to the application of nitrogen (Aron, 1943; Wadleigh, 1957; Burris, 1959; Sutton, 1963; Singh and Singh 1966; Kamalanathan et al. 1970 and Bid et al. 1971). According to Choudhury (1967) for raising a good crop of bhindi a dose of 61 kg of nitrogen, 27 kg of phosphorus and 30 kg of potassium per ha. had to be applied. In Kerala, under Vellayani conditions, nitrogen level above 84 kg/ha was found to be detrimental (Chandrasekharan and George, 1971). The optimum dose of nitrogen for bhindi was reported to be 54 kg/ha (Asif and George, 1972 and Sharma and Shukla, 1973), whereas Singh (1979) reported that bhindi gave better response even upto 75 kg/ha. But contradictory to the above results a linear response to applied nitrogen even upto 100 kg/ha was reported from Nesserghatta, Sabour, Rahuri, Bhubaneswar and Jabalpur (Anon., 1972-74, 1974-76 and 1977-78.

1.2 Effects of phosphorus.

Sharma and Shukla (1973) in a two year trial noticed that 34.8 kg P_2O_5/ha gave better growth and yield when compared to 17.4 and 52.32 kg P_2O_5/ha. In a

pot culture experiment on bhindi upto 60 ppm of phosphorus gave higher plant height and yield (Randhawa, et al.1977). The same effect was noticed by Saimbhi et al.1977) also. Singh and Singh, 1966 and Singh et al.1967 in a fertilizer trial conducted on bhindi for three seasons observed a considerable decrease in plant height and yield at 50 kg P_2O_5/ha level as compared to 25 kg P_2O_5/ha level. But it was reported that bhindi gave better response upto 60 kg P_2O_5/ha in respect of yield and yield components (Chonkar and Singh, 1963 and Singh 1979, Anon., 1972-74, 1974-76 and 1977-78.

1.3 Effects of potassium.

Sutton (1963) observed that application of potassium had no significant effect on vegetative growth and yield of bhindi when the available potassium content in soil was high. Detrimental effect on growth and yield of bhindi due to higher doses of added potassium was also reported by Sing and Singh (1966), Sing et al. (1967) and Bid et al.(1971). The result obtained in a sand culture experiment on bhindi conducted by Chonkar and Singh (1963) was also found to agree with it.

Kamalanathan et al.(1970) reported that potassium at 30 kg K_2O/ha was favourable to the yield of bhindi and when increased to 60 kg K_2O/ha was detrimental. This result also came in line with that of Chandrasekharan and George (1971) that bhindi crop responded only upto 56 kg K_2O/ha. Singh (1979) also noted that even though there was increase in growth and yield characters due to the application of potassium at 60 kg K_2O/ha level, further increase in potassium level was not significantly different from this level of potassium. Linear response to added potassium upto 60 kg K_2O/ha was also reported from Hasserghatta, Bhubaneswar and Sabour (Anon., 1977-78).

1.4 Interaction effect of nitrogen, phosphorus and potassium on growth, yield and quality of bhindi.

Bid et al. (1971) reported that the best growth in Okra was obtained when all the three major nutrients were applied. They noticed that among the first order interactions, 60 kg N x 30 kg K_2O/ha was the most effective combination and it was followed by the combination of 60 kg N x 30 kg P_2O_5/ha and 30 kg P_2O_5 x 30 kg K_2O/ha. Effect of N x P interaction had also been reported by many workers (Saimbhi and Padda, 1967-68; Sharma and Shukla 1973). According to Saimbhi

and Padda (1970) and Saimbhi et al. (1975) application of nitrogen above 60 kg/ha could not give any significant result on growth and yield unless the phosphorus is applied. Singh (1979) in a fertilizer trial on bhindi var. Pusa Sawani, found that, all the first order interactions increased the plant height, number of leaves, pod length and pods/plant. But the number of branches was significantly effected by nitrogen x potassium and phosphorus x potassium interactions only. Among the nitrogen and phosphorus combinations, 150 kg N/ha with the control of phosphorus (0 kg P_2O_5/ha) also gave the maximum number of pods and maximum yield/plant.

2. Effect of levels of nitrogen, phosphorus and potassium on the content of nutrients in bhindi.

Asif and Grieg (1972) reported that in bhindi, application of phosphorus and potassium could increase the content of these nutrients in the plant. Application of nitrogen increased nitrogen and copper content but decreased phosphorus, calcium and zinc content Saimbhi et al. (1975) also agreed with the above finding. He further observed that the application of phosphorus did not affect the nitrogen, potassium, calcium, magnisium, zinc and copper content of plant. But it increased manganese and iron content and decreased the content of sodium. In the case of nitrogen application also they could observe the increase in magnesium content of the plant.

MATERIALS AND METHODS

MATERIALS AND METHODS

The experiment was conducted in the main campus, Kerala Agricultural University, Vellanikkara with the objective of studying the effect of graded doses of nitrogen, phosphorus and potassium on growth, yield and quality of bhindi (*Abelmoschus esculentus* (L.) Moench) Var. Co.1.

1. Materials

1.1 Site, climate and soil

The area is situated at 10.32°N lattitude and 76.16°E longitude at an altitude of 22.25 metres, with a typical humid tropical climate.

The soil of the experimental area is a deep, well drained sandy loam. The chemical characteristics of the soil are presented in Table I.

1.2 Cropping history

The area was under vegetables in the previous season before which it was under rubber.

1.3 Season and weather conditions

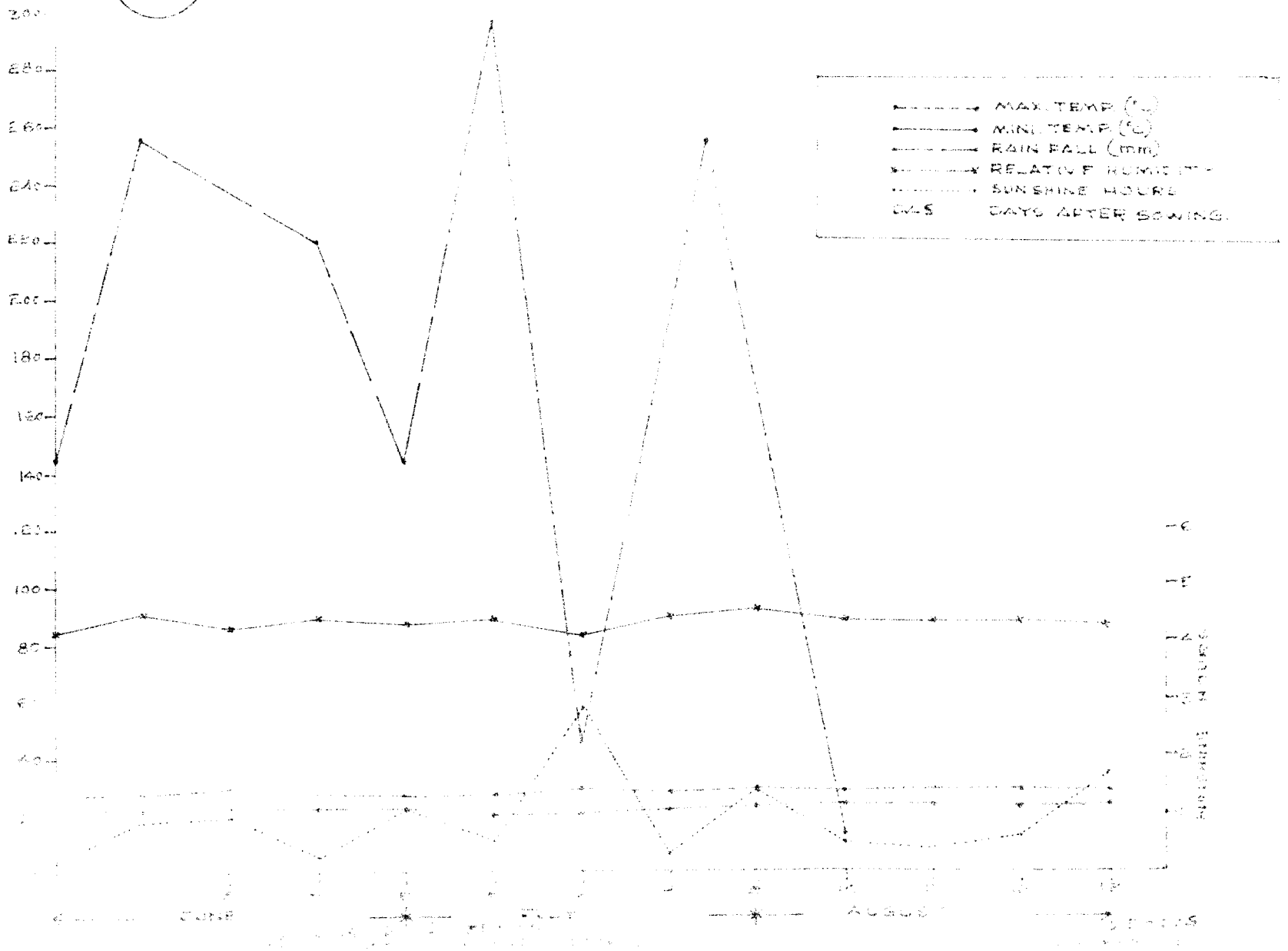
The experiment was conducted during the period

Table - 1

Chemical characteristics of soil

Constituents	Content in soil (per cent)
Total nitrogen	0.115
Total phosphorus	0.0339
Total potassium	0.201
Available phosphorus	0.0034
Extractable potassium	0.0026
p^H	5.1 (1 : 2 soil-water ratio)

FIG-8 METEOROLOGICAL DATA FOR THE PERIOD FROM JULY TO AUGUST 1978



from May to August 1978. The details of the meteorological observations for this period are presented in Appendix I and Fig. I.

1.4 Seeds

Seeds of variety Co.I, released from Tamil Nadu Agricultural University (Arumugan and Muthukrishnan, 1977) based on its better performance compared to Pusa Sawani in the experiments conducted in Tamil Nadu was selected for this study.

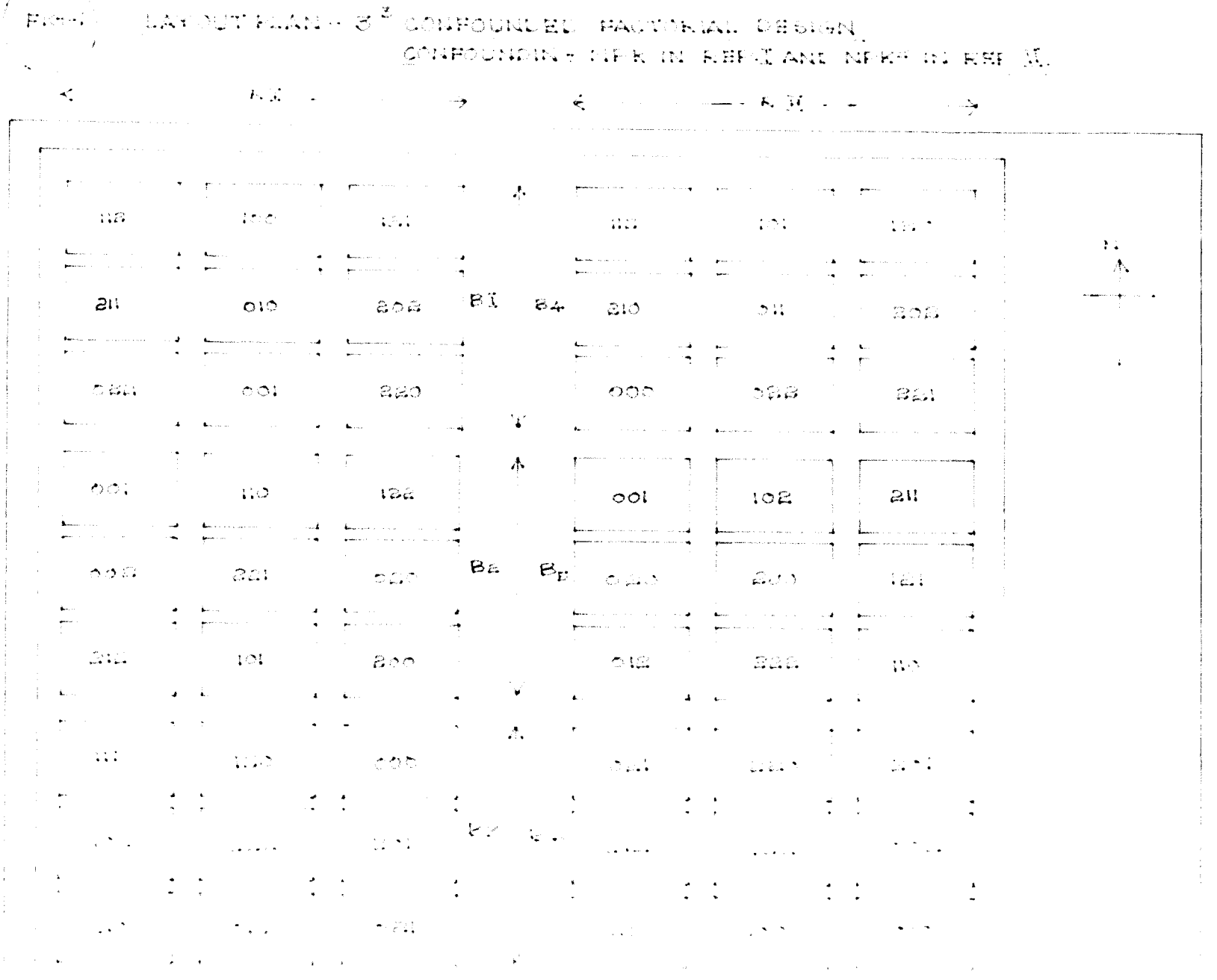
1.5 Manures and fertilizers

Farm yard manure at the rate of 10 tonnes/ha. was applied uniformly prior to the preparation of ridges and furrows. The fertilisers viz. ammonium sulphate, super-phosphate and muriate of potash were used to supply required quantities of nitrogen, phosphorus and potassium.

2. Methods

2.1 Lay out

The experiment was laid out in 3^3 confounded factorial design with two replications. The higher



order interactions NPK and NPK^2 were partially confounded in replications I and II respectively.

The details of the lay out are furnished below:-

1.	Total number of treatments	- 27
2.	No. of replications	- 2
3.	No. of plots	- 54
4.	No. of blocks	- 6
5.	Spacing	- 60 x 45 cm^2.
6.	Total No. of plants/plot	- 42
7.	No. of experimental plants	- 18
8.	Gross plot size	- 11.34 M^2
9.	Net plot size	- 5.4 M^2
10.	Total experimental area	- 612.36 M^2

2.2 Treatments

Treatments consisted of combinations of three levels each of nitrogen phosphorus and potassium.

2.2.1 Levels of nitrogen

1.	n_o	0.0	Kg N/ha.
2.	n_1	30.0	Kg N/ha.
3.	n_2	60.0	Kg N/ha.

2.2.2 Levels of phosphorus

1.	P_0	0.0	Kg P_2O_5/ha
2.	P_1	25.0	Kg P_2O_5/ha
3.	P_2	50.0	Kg P_2O_5/ha

2.2.3 Levels of potassium

1.	K_0	0.0	Kg K_2O/ha
2.	K_1	25.0	Kg K_2O/ha
3.	K_2	50.0	Kg K_2O/ha

2.3 Field operations

The cultivation practices recommended for bhindi by Kerala Agricultural University were followed.

2.3.1 Preparation of field

The area was ploughed thrice and weeds were removed. The blocks marked and each block was divided into 9 plots. Then organic manure was uniformly spread. Small ridges were taken keeping a spacing of 60 cm. from ridge to ridge.

2.3.2 Basal application of fertilizers

The fertilizers, ammonium sulphate, super phosphate

and muriate of potash were applied on the ridge as per the schedule given in the package of practices recommendation, Kerala Agricultural University, Anon.(1977).

2.3.3 Sowing

Seeds were soaked in water for four hours before sowing. These seeds were taken out, drained and sown at a rate of two seeds per hole with a spacing of 45 cm from plant to plant within the row. Thinning was done 10 days after sowing, retaining only one healthy plant.

2.3.4 Weeding

The plots were hand weeded frequently to keep them free of weeds.

2.3.5 Top-dressing and earthing up

The top-dressing using remaining half of the nitrogen dose was done after 30 days of sowing along with earthing up.

2.3.6 Plant protection

The crop was almost free from pests and deseases. However, a prophylatic spray of malathion was given after 20 days of sowing.

2.3.7 Harvest

At one month stage, almost all plants came to flowering. Harvesting was done 7 days after flower opening. The first harvest was made on 38th day after sowing. Thereafter harvesting was done on every alternate day. The period of reproductive phase was 2 months and the final harvest was made on 30th August, 1978.

2.4 Observations

2.4.1 Growth components

(i) Height of plant

This observation was taken on 12 plants selected randomly in each plot after leaving the border lines on four sides. This observation was taken at fortnightly intervals, till the end of the crop season.

(ii) Number of leaves

The plants selected for the observations on plant height were used for this. The number of functional leaves, including the fully opened topmost leaf, was recorded every fortnight. The total number of leaves produced per plant was also noted.

(iii) Number of flowers

Flower production of the plants were noted daily after flowering and total number of flowers/plant was also recorded. The plants on which observations on height and number of leaves were recorded were used for this character also.

(iv) Date of flowering

The number of days taken from sowing to flowering of 50% plants, in each plot, was recorded.

(v) Number of branches

Number of branches per plant was observed at the end of the crop season.

(vi) Leaf area index

Leaf area index was taken at two stages, 30 days after sowing and 60 days after sowing. Leaf samples of 6 leaves (2 from top, 2 from middle and 2 from bottom) were collected from the plants uprooted for analysing nutrient uptake at these two stages.

The leaf area index was calculated by using

'paper-weight' method. Six paper sheets of uniform size were taken and a factor was worked out in order to get a ratio between the area and weight of the paper sheets. The leaf area of those 6 leaves were marked on the paper sheets and that portions were cut and weighed. Then the area of the paper cuts were worked out which would be the leaf area of the six sample leaves. This leaf area was then related with the dry weight of these six leaves. The total dry weight of the whole leaves was multiplied by the ratio obtained before in order to get the leaf area of the entire leaves. Then to get the L.A.I. the total leaf area was divided by the land area occupied by the two selected plants.

vii) Net assimilation rate

Total dry weight of two plants at 30th day and total dry weight, including dry weight of fruits, at 60th day were observed in each treatment. (At a time two plants were taken from each plot - the same plants used for L.A.I. calculation). N.A.R. was calculated using the formula given below (Watson, 1958).

$$NAR = \frac{(W2 - W1)}{(A2 - A1)} \frac{(\ln A2 - \ln A1)}{(t2 - t1)}$$

Where, W2 = Total dry weight of plants after 2 months.

W1 = Total dry weight of plants after one month.

A2 = L.A.I. at 2nd month.

A1 = L.A.I. at 1st month.

ln A2 and ln A1 are natural logarithms of A2 and A1 respectively. The t2 and t1 are the time of sampling in days.

2.4.2 Yield components

i) Number of flowers per plant

Number of flowers was observed, in 12 randomly selected plants from each plot, in every alternate day.

ii) Total number of fruits produced per plant

At each harvest total number of fruits was recorded, separately from each plot and these numbers were added to get a total number of fruits per plot . Then, this number was divided by total number of plants in order to get the number of fruits per plant.

iii) Percentage of fruit-set

From the above two data percentage of fruit set was calculated.

iv) Length of fruit

To get the mean fruit length, ten fruits from each plot and from randomly selected plants, were harvested exactly on the 7th day of flower opening and the mean length was worked out.

v) Weight of fruits

Total weight of fruits was devided by total number of fruits to get the average fruit weight.

vi) Percentage of dry weight

30 fruits from each plot were dried to constant weight at 70°C and dry matter percentage was calculated.

vii) Total yield

Fruits from the net plot (twelve plants) were harvested together and the total weight was also recorded each time, these weights of each harvest were added to get total yield/plot.

2.4.3 Quality (Crude protein content of fruits)

To find out the crude protein content the nitrogen percentage of fruits (Jackson, 1973) was multiplied by 6.25.

3. Uptake of nutrients

Nutrient uptake by plants was studied at 3 stages.

1. 30 days after sowing.
2. 60 days after sowing.
3. 90 days after sowing (at the end of the crop).

At 30th day 2 plants from each plot were pulled out randomly with root system, washed and dried at 70°C to constant weight. Samples of leaf and stem, were analysed separately for their N, P and K content. At 60th day also 2 randomly selected plants, from each plot, were pulled out washed and dried to constant weight. In this case leaf, stem and fruits were analysed separately. At the end of the crop also the same procedure was followed. At each stage fallen leaves were also collected and added to the respective leaf samples.

For each stage uptake of nitrogen, phosphorus and potassium per plant was calculated for each treatment. Per hectare removal of nitrogen, phosphorus and potassium was calculated from these values.

3.1 Chemical analysis

3.1.1 Nitrogen content

Nitrogen content of plant material was estimated by the microkjeldahl procedure as given by Jackson,(1973).

3.1.2 Phosphorus content

Phosphorus content of plant material was estimated colorimetrically (Jackson, 1973).

3.1.3 Potassium content

Potassium content was estimated using flame photometer (Jackson, 1973).

4. Soil analysis

4.1 Soil analysis before crop

A representative soil sample of experimental area was prepared by collecting soils from different parts of the area and was analysed for its total nitrogen, phosphorus and potassium and available phosphorus and potassium. The pH was also measured.

5. Statistical analysis

The data relating to each character were analysed by applying the analysis of variance technique as given by Panse and Sukhatme (1967) for confounded factorial experiment.

5.1 Response

The response to both phosphorus and potassium was found to be linear. But the response to nitrogen was quadratic. The response curve fitted to nitrogen is $Y = a + bx + cX^2$, where $X = \frac{N - 30}{30}$.

The optimum dose of nitrogen was estimated by using the equation (optimum dose of $N = \frac{-b}{2c}$) and the economic optimum of nitrogen level was worked out using the equation, $X = \frac{\frac{q}{p} - b}{2c}$ (Snedecor and Cochran, 1967)

where, q = price for 1 kg of nitrogen and

p = price for 1 tonne of produce.

RESULTS

R E S U L T S

The present investigation was undertaken to study the effects of graded doses of nitrogen, phosphorus and potassium on growth, yield and quality of bhindi, variety Co.I. The experimental findings are presented below.

1. Vegetative characters

1.1 Height of plants

a) Main effects:- Observations on plant height were taken at 15 days intervals and the data on main effects are presented in Table 2 and Fig. 3 and the analysis of variance in Appendix II.

Effect of nitrogen on plant height was significant at all stages. After 15 days of sowing, plant height increased with every increase in nitrogen levels, N_1 and N_2 levels being at par with each other. At later stages, plant height increased significantly with increasing levels of nitrogen.

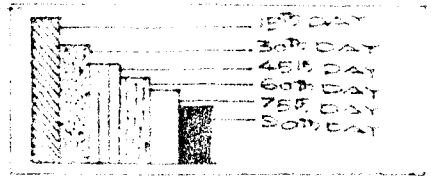
At all stages, P_1 and P_2 levels of phosphorus recorded higher plant height than control. The P_2 level

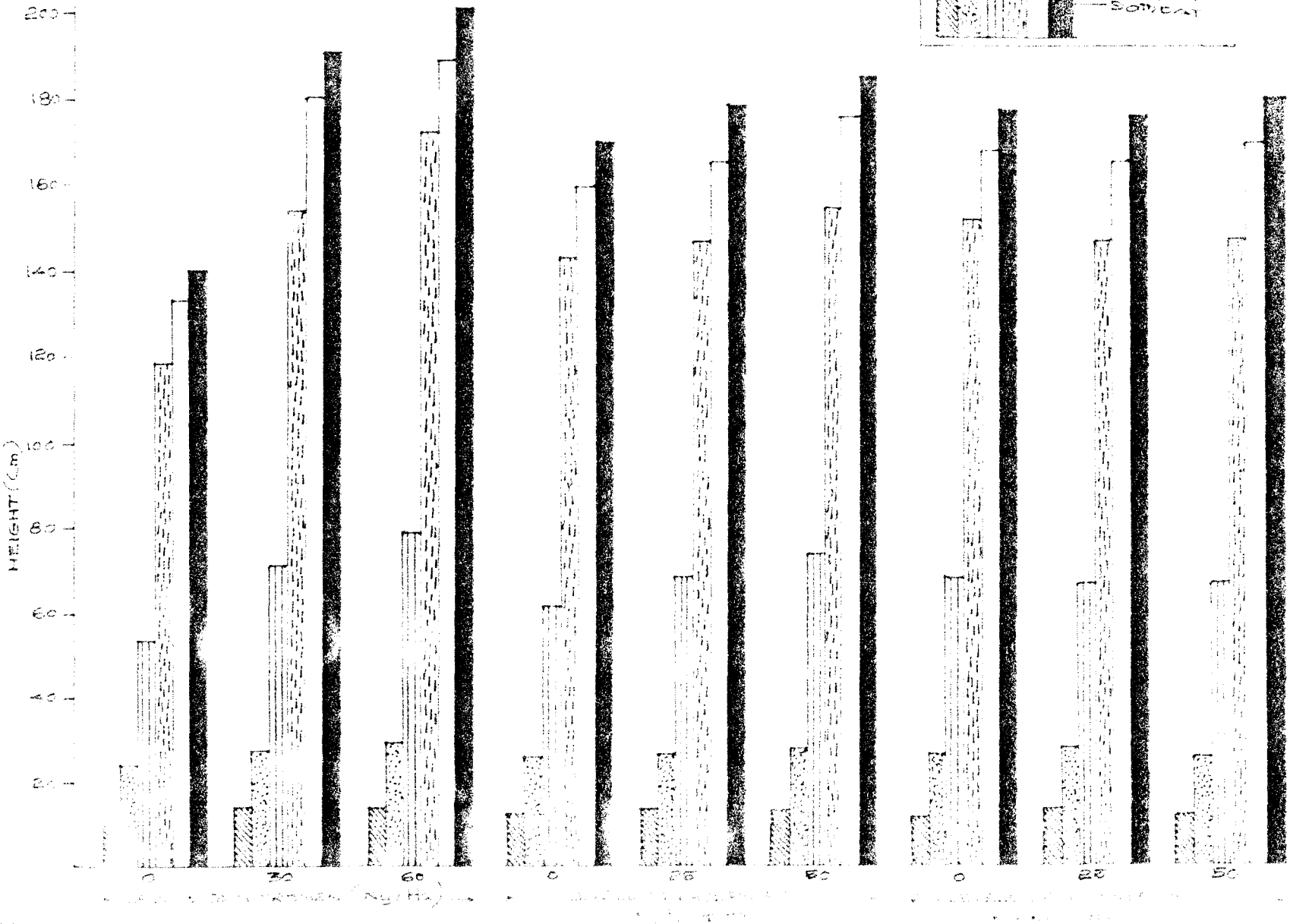
Table - 2

Effect of nitrogen, phosphorus and potassium on the height of plant (cm) at 15 days interval and the number of branches

Treatments	Height of plant — Days after sowing						Number of branches
	15	30	45	60	75	90	
Levels of N Kg/ha.							
0	11.36	23.66	53.38	118.63	132.90	139.89	0.777
30	13.03	27.01	70.97	153.37	180.13	191.77	1.244
60	13.48	29.89	78.35	171.81	189.14	201.81	1.672
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SEM ±	0.170	0.700	2.060	2.790	2.530	2.140	0.100
CD(0.05)	0.470	2.059	6.030	8.179	7.406	6.268	0.324
Levels of P_2O_5 Kg/ha.							
0	11.90	25.27	61.43	143.11	160.62	169.62	1.178
25	12.69	27.37	68.07	146.47	165.72	178.63	1.332
50	13.21	27.93	73.19	154.22	175.84	185.21	1.183
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	NS.
SEM ±	0.170	0.700	2.060	2.790	2.530	2.140	0.100
CD (0.05)	0.470	2.059	6.030	8.179	7.406	6.268	-
Levels of K_2O Kg/ha.							
0	12.22	26.29	68.31	150.23	167.40	177.22	1.202
25	13.00	28.48	67.21	146.68	165.43	176.04	1.233
50	12.57	25.79	67.18	146.89	169.34	180.21	1.258
'F' test	Sig.	Sig.	NS	NS	NS	NS	NS
SEM ±	0.170	0.700	2.060	2.790	2.530	2.140	0.100
CD (0.05)	0.470	2.059	-	-	-	-	-

FIG-3 HEIGHT OF PLANTS AT VARIOUS STAGES OF GROWTH





was significantly superior to P_1 only at 15th, 75th and 90th days after sowing.

Potassium levels showed significant differences only at the 15th and 30th days after sowing. At both these stages, the highest plant height was observed under K_1 level. It was significantly superior to control and at par with K_2 at the first stage. There was no significant difference between K_0 and K_2. But at the second stage, K_1 was significantly superior to K_0 and it was at par with K_2.

The general trend of the main effects on plant height indicates that there was increase in this character with increasing levels of nitrogen and phosphorus. In the case of nitrogen application this increase was statistically significant, except in the first stage. Only at 15th, 75th and 90th day stages, P_2 level of 50 kg P_2O_5/ha showed significance over P_1 and P_0. In the case of potassium, significant increase was noticed only at the first two stages and in these cases also, only upto the intermediate level of 25 kg K_2O/ha.

Over the stages, there was a steady increase in

plant height upto the 60th day after sowing and thereafter the rate of increase was slow. This trend was noticed in all the treatments.

b) Interaction effects:- Nitrogen and phosphorus interactions were significant at all stages of crop growth (Table 3). After 15 days of sowing, N_2P_2 combination recorded the highest plant height and it was at par with N_1P_2. The combination of N_0P_0 gave the minimum plant height. After 30 days also N_2P_2 recorded significantly higher value than other combinations and N_0P_0 recorded the lowest value (Table 4). The combination of N_2P_2 recorded the highest plant height on the 45th day also (Table 5). As the data given in Table 6 indicates at 60th day stage the highest plant height was recorded by N_2P_2 combination and it was at par with N_2P_1. At the 75th day also N_2P_2 recorded the highest plant height and was at par with N_1P_2 and N_2P_1 (Table 7). As in earlier stages, at 90th day also N_2P_2 combination recorded the highest plant height and it was at par with N_1P_2 and N_2P_1 (Table 8).

The general trend of nitrogen and phosphorus interactions on plant height may be summarised as follows. When nitrogen was not applied, there was no

Table - 3

Effect of nitrogen and phosphorus interaction on the plant height after 15 days of sowing.

Levels of N Kg/ha.	Levels of P_2O_5 Kg/ha. 0	25	50	Mean
0	10.93	12.08	11.07	11.36
30	11.98	13.12	13.98	13.03
60	13.02	12.87	14.57	13.48
Mean	11.90	12.69	13.21	
SEM ±	0.22			
CD (0.05)	0.81			

Table - 4

Effect of nitrogen and phosphorus interaction on the plant height after 30 days of sowing.

Levels of N Kg/ha.	Levels of P_2O_5 Kg/ha. 0	25	50	Mean
0	23.20	24.48	23.30	23.66
30	24.43	29.52	27.08	27.01
60	28.17	28.10	33.40	29.89
Mean	25.27	27.37	27.93	
SEM ±	0.99			
CD (0.05)	3.57			

Table - 5

Effect of nitrogen and phosphorus interaction on the plant height after 45 days of sowing

Levels of N Kg/ha.	Levels of P_2O_5 Kg/ha. 0	25	50	Mean
0	54.82	51.75	53.57	53.38
30	63.83	75.42	73.67	70.97
60	65.64	77.05	92.35	78.35
Mean	61.43	68.07	73.19	
SEM ±	2.91			
CD (0.05)	10.44			

Table - 6

Effect of nitrogen and phosphorus interaction on the plant height after 60 days of sowing.

Levels of N Kg/ha.	Levels of P_2O_5 Kg/ha. 0	25	50	Mean
0	124.48	113.33	118.08	118.63
30	141.65	154.97	163.48	153.37
60	163.20	171.12	181.10	171.81
Mean	143.11	146.47	154.22	
SEM ±	3.94			
CD (0.05)	14.17			

Table - 7

Effect of nitrogen and phosphorus interaction on the plant height after 75 days of sowing.

Levels of N Kg/ha.	Levels of P_2O_5 Kg/ha. 0	25	50	Mean
0	134.90	130.95	132.90	132.85
30	166.33	177.47	196.58	180.13
60	180.62	188.73	198.08	189.14
Mean	160.62	165.72	175.84	
SEM ±	3.57			
CD (0.05)	12.83			

Table - 8

Effect of nitrogen and phosphorus interaction on the plant height after 90 days of sowing.

Levels of N Kg/ha.	Levels of P_2O_5 Kg/ha. 0	25	50	Mean
0	142.02	136.10	141.55	139.89
30	175.40	190.78	209.12	191.77
60	191.45	209.02	204.97	201.81
Mean	169.62	178.63	185.21	
SEM ±	3.02			
CD (0.05)	10.86			

Table - 9

Effect of nitrogen and potassium interaction on the plant height after 15 days of sowing.

Levels of N Kg/ha.	Levels of K_2O Kg/ha. 0	25	50	Mean
0	11.03	12.00	11.05	11.36
30	12.40	13.95	12.73	13.03
60	13.23	13.05	14.17	13.48
Mean	12.22	13.00	12.57	
SEM ±	0.22			
CD (0.05)	0.81			

Table - 10

Effect of nitrogen/potassium interaction on the plant height after 75 days of sowing.

Levels of N Kg/ha.	Levels of K_2O Kg/ha 0	25	50	Mean
0	129.10	125.67	143.93	132.90
30	172.90	182.22	185.27	180.13
60	200.20	188.42	178.82	189.14
Mean	167.40	165.43	169.34	
SEM ±	3.57			
CD (0.05)	12.83			

Table - 11

Effect of nitrogen and potassium interaction on the plant height after 90 days of sowing.

Levels of N Kg/ha.	Levels of K_2O Kg/ha. 0	25	50	Mean
0	135.42	134.18	150.07	139.89
30	181.87	194.53	198.90	191.77
60	214.38	199.40	191.65	201.81
Mean	177.22	176.04	180.21	
SEM ±	3.02			
CD (0.05)	10.86			

Table - 12

Effect of phosphorus and potassium interaction on the plant height after 15 days of sowing.

Levels of P_2O_5 Kg/ha.	Levels of K_2O Kg/ha. 0	25	50	Mean
0	12.68	11.52	11.50	11.90
25	12.20	13.47	12.40	12.69
50	11.78	14.02	13.82	13.21
Mean	12.22	13.00	12.57	
SEM ±	0.22			
CD (0.05)	0.81			

significant difference between phosphorus levels at any of the stages. When nitrogen was applied both at 30 kg N/ha and 60 kg N/ha levels, plant height increased with increasing levels of phosphorus, except on the 30th and 45th days. At all the levels of phosphorus, increasing levels of nitrogen showed tendency to increase plant height. However, on the 15th and 30th days, at 25 kg P_2O_5/ha level, increase was noticed only upto 30 kg N/ha. Similarly on the 90th day, at 50 kg P_2O_5/ha level also the increase was noticed only upto the intermediate level of 30 kg N/ha.

Nitrogen and potassium interactions were significant only on the 15th, 75th and 90th days after sowing. After 15 days, N_2K_2 combination recorded the highest plant height and it was at par with N_1K_1. The N_0K_0 combination recorded the lowest value (Table 9). On the 75th day, N_2K_0 recorded the highest plant height and it was at par with N_2K_1. The N_0K_1 combination recorded the lowest value (Table 10). After 90 days of sowing, the combination N_2K_0 recorded the highest plant height and it was at par with N_2K_1.

The combination, N_0K_1 recorded the lowest value, as on the 75th day (Table 11).

Nitrogen and potassium interactions on the plant height can be summarised as follows. Nitrogen and potassium interactions were significant only on the 15th, 75th and 90th days after sowing. The general trend on the 15th day was different from those of 75th and90th days. However, in general, there was increase in plant height with increasing levels of nitrogen, the extent of increase being more or less similar at all levels of potassium. The interaction effects between nitrogen and potassium were not steady and consistent enough to draw out general conclusions.

Phosphorus and potassium interactions on plant height were significant only on the 15th day after sowing (Table 12). Among the phosphorus and potassium combinations, P_2K_1 and P_0K_1 recorded maximum and minimum plant heights respectively.

The general trend of interaction effects were as follows. When phosphorus was not applied, plant height decreased with increasing rates of potassium. When applied at 25 kg and 50 kg P_2O_5/ha, plant height

increased upto the intermediate level of 25 kg K_2O/ha of potassium. A further increase in the level of potassium resulted in decrease in height of the plant. When potassium was not applied, plant height decreased with increasing levels of phosphorus and when applied at 25 kg and 50 kg K_2O/ha, plant height increased with increasing levels of phosphorus.

1.2 Number of branches

There was no significant difference between treatments in respect of number of branches except in the case of nitrogen levels (Table 2). The analysis of variance is presented in Appendix III.

Branching was increased with increasing levels of nitrogen. The maximum number of branches per plant (1.67) was recorded at 60 kg N/ha. The interaction effects were not significant.

1.3 Number of functional leaves

a) Main effects:- The data on the main effects are presented in Table 13 and the analysis of variance for the same in Appendix III.

There was no significant difference between the

Table - 13

Effect of levels of nitrogen, phosphorus and potassium on the number of functional leaves at 15 days interval and the total leaf production.

Treatments	Number of functional leaves — Days after sowing					Total leaf production
	15	30	45	60	75	
Levels of N Kg/ha.						
0	4.12	6.20	10.32	14.32	9.22	19.63
30	4.22	6.57	13.17	16.03	10.45	24.72
60	4.17	6.85	14.71	15.37	10.18	26.34
'F' test	NS	Sig.	Sig.	Sig.	Sig.	Sig.
SEM ±	0.10	0.10	0.20	0.17	0.22	0.22
CD (0.05)	-	0.27	0.61	0.52	0.68	0.64
Levels of P_2O_5 Kg/ha.						
0	4.21	6.29	12.04	16.02	9.88	23.40
25	4.06	6.67	12.72	15.02	9.95	23.45
50	4.24	6.66	13.43	14.68	10.02	23.97
'F' test	NS	Sig.	Sig.	Sig.	NS	NS
SEM ±	0.10	0.10	0.20	0.17	0.22	0.22
CD (0.05)	-	0.27	0.61	0.52	-	-
Levels of K_2O Kg/ha						
0	4.04	6.48	12.59	14.68	9.94	23.06
25	4.38	6.71	12.09	15.42	9.36	23.37
50	4.08	6.42	13.51	15.62	10.54	24.21
'F' test	NS	NS	Sig.	Sig.	Sig.	Sig.
SEM ±	0.10	0.10	0.20	0.17	0.22	0.22
CD (0.05)	-	-	0.61	0.52	0.68	0.64

levels of nitrogen, at 15th day after sowing, with regard to the number of functional leaves. At 30th and 45th days, increasing levels of nitrogen produced significantly higher number of leaves. But at 60th and 75th days, N_1 level recorded the highest number of functional leaves. After 60 days of sowing, N_1 was significantly superior to N_2 and N_0, whereas at 75th and 90th days, N_1 was at par with N_2. At all these three stages, N_0 was significantly inferior to N_1 and N_2.

At 15th and 75th days after sowing, number of leaves was not found to be influenced by phosphorus levels. After 30 days, phosphorus application increased the number of leaves but P_1 and P_2 were at par with each other. At 45th day, P_2 was significantly superior to P_0 and P_1, whereas at 60th day, P_0 was found to have more leaves than P_1 and P_2, these two being at par.

Application of potassium had no significant influence at 15th and 30th days of sowing. Leaf number of K_2 on the 45th day was significantly higher than K_0 and K_1 levels. The levels, K_0 and K_1 were at par. After 60 days of sowing, leaf number of K_2 was

significantly higher than K_0 and was at par with K_1. At 75th day, K_2 was significantly different from K_1 and was at par with K_0.

The general trend of the main effects on the number of functional leaves indicates that there was significant increase in this character with increasing levels of all the three nutrients. There was statistically significant increase only upto the intermediate levels of 30 kg N, 25 kg P_2O_5 and 25 kg K_2O per hectare.

Over the stages, there was a steady increase in the number of functional leaves upto 60th day after which there was a conspicuous decrease during the next stage of observation (75th day). The trend remains the same in all the treatments.

b) <u>Interaction effects</u>:- The interactions between nitrogen and phosphorus were significant at all stages of observation except 15th and 30th days after sowing. At 45th day, the combinations, N_2P_2, N_2P_1 and N_1P_2 recorded higher number of functional leaves. These three combinations were at par with each other and significantly superior to all other

combinations. N_0P_1 recorded the lowest value (Table 14). After 60 days, N_1P_2, and N_2P_1 and N_2P_0 recorded higher number of functional leaves and they were at par with each other. The combination N_2P_2 recorded the lowest value (Table 15). At 75th day also, N_1P_2 was found to be significantly superior to all other combinations and N_0P_2 recorded the lowest mean value (Table 16).

The interaction effects between nitrogen and phosphorus may be summarised as follows. There was significant interaction at all the stages except on the 15th and 30th days. Without nitrogen application, increasing levels of phosphorus did not show any increase in the number of functional leaves. At the intermediate level of nitrogen (30 kg/ha), increasing levels of phosphorus tended to result in a steady increase in the number of functional leaves. At the highest level of 60 kg N/ha, there was increase in leaf number with increasing levels of phosphorus only upto 25 kg P_2O_5/ha. Further increase in phosphorus application significantly decreased the leaf number. Comparing the effect of increasing levels of nitrogen at each level of applied phosphorus, it may be noted

Table - 14

Effect of nitrogen and phosphorus interaction on the number of functional leaves after 45 days of sowing.

Levels of N Kg/ha.	Levels of P_2O_5 Kg/ha. 0	25	50	Mean
0	10.38	10.28	10.30	10.32
30	12.10	12.73	14.67	13.17
60	13.65	15.15	15.32	14.71
Mean	12.04	72.72	13.43	
SEM ±	0.30			
CD (0.05)	1.06			

Table - 15

Effect of nitrogen and phosphorus interaction on the number of functional leaves after 60 days of sowing.

Levels of N Kg/ha.	Levels of P_2O_5 Kg/ha. 0	25	50	Mean
0	15.85	13.18	13.93	14.32
30	15.83	14.98	17.27	16.03
60	16.38	16.88	12.85	15.37
Mean	16.02	15.02	14.68	
SEM ±	0.06			
CD (0.05)	0.89			

Table - 16

Effect of nitrogen and phosphorus interaction on the number of functional leaves after 75 days of sowing.

Levels of N Kg/ha.	Levels of P_2O_5 Kg/ha. 0	25	50	Mean
0	10.50	8.92	8.23	9.22
30	8.85	10.12	12.38	10.45
60	10.28	10.82	9.42	10.18
Mean	9.88	9.95	10.02	
SEM ±	0.33			
CD (0.05)	1.18			

Table - 17

Effect of nitrogen and potassium interaction on the number of functional leaves after 60 days of sowing.

Levels of N Kg/ha.	Levels of K_2O Kg/ha. 0	25	50	Mean
0	13.23	14.92	14.82	14.32
30	12.57	16.78	18.73	16.03
60	18.25	14.55	13.32	15.37
Mean	14.68	15.42	15.62	
SEM ±	0.06			
CD (0.05)	0.90			

Table - 18

Effect of nitrogen and potassium interaction on the number of functional leaves after 75 days of sowing.

Levels of N Kg/ha.	Levels of K_2O kg/ha. 0	25	50	Mean
0	8.60	9.73	9.32	9.22
30	8.43	10.15	12.77	10.45
60	12.80	8.18	9.55	10.18
Mean	9.94	9.36	10.54	
SEM ±	0.33			
CD (0.05)	1.18			

Table - 19

Effect of phosphorus and potassium interaction on the number of functional leaves after 45 days of sowing.

Levels of P_2O_5 Kg/ha.	Levels of K_2O Kg/ha 0	25	50	Mean
0	11.03	11.12	13.98	12.04
25	12.65	12.68	12.83	12.72
50	14.08	12.48	13.72	13.43
Mean	12.59	12.09	13.51	
SEM ±	0.30			
CD (0.05)	1.06			

Table - 20

Effect of phosphorus and potassium interaction on the number of functional leaves after 60 days of sowing.

Levels of P_2O_5 Kg/ha.	Levels of K_2O Kg/ha 0	25	50	Mean
0	13.53	17.53	17.00	16.02
25	13.95	16.18	14.92	15.02
50	16.57	12.53	14.95	14.68
Mean	14.68	15.42	15.62	
SEM ±	0.06			
CD (0.05)	0.90			

Table - 21

Effect of nitrogen and phosphorus interaction on leaf production.

Levels of N Kg/ha.	Levels of P_2O_5 Kg/ha. 0	25	50	Mean
0	20.91	18.86	19.12	19.63
30	22.70	23.18	28.27	24.72
60	26.21	28.30	24.51	26.34
Mean	23.40	23.45	23.97	
SEM ±	0.320			
CD (0.05)	1.110			

Table - 22

Effect of nitrogen and potassium interaction on the leaf production

Levels of N Kg/ha.	Levels of K_2O Kg/ha. 0	25	50	Mean
0	17.90	20.43	20.56	19.63
30	22.12	24.94	27.09	24.72
60	29.29	24.73	25.00	26.34
Mean	23.06	23.37	24.21	
SEM ±	0.320			
CD (0.05)	1.110			

Table - 23

Effect of phosphorus and potassium interaction on leaf production.

Levels of P_2O_5 Kg/ha.	Levels of K_2O Kg/ha. 0	25	50	Mean
0	22.00	22.10	25.73	23.40
25	23.44	24.42	22.35	23.45
50	23.75	23.58	24.57	23.97
Mean	23.06	23.37	24.21	
SEM ±	0.320			
CD (0.05)	1.110			

that at all levels of phosphorus, there was a tendency for increase in the number of leaves with increasing levels of nitrogen. However, at the highest phosphorus level (60 kg P_2O_5/ha) this increasing tendency was there only upto 30 kg N/ha. Further increase in nitrogen application to 60 kg/ha resulted in a significant decrease in leaf number.

The combined effects of nitrogen and potassium levels on the number of functional leaves were not significant upto 45th day after sowing. At 60th day, the combinations N_1K_2 and N_2K_0 recorded maximum number of functional leaves and they were at par with each other. The combination, N_1K_0 was found to produce lower number of leaves (Table 17). After 75 days of sowing, N_2K_0 and N_1K_2 recorded maximum values and were at par with each other. N_2K_1 recorded minimum value (Table 18).

To summarise the interaction effects, it was found that there were significant interactions at the last two stages (60th, 75th days). Without nitrogen application, there was increase in the functional leaf number with increasing levels of potassium upto

the intermediate level of 25 kg K_2O/ha. When nitrogen was applied at 30 kg/ha there was steady increase in the number of functional leaves with increasing levels of potassium upto the highest level. When nitrogen was supplied at 60 kg/ha, application of potassium tended to decrease the leaf number. Comparing the effect of increasing levels of nitrogen at each level of applied potassium, it may be concluded that when potassium was not applied, there was increase in the number of functional leaves with increasing levels of nitrogen. When potassium was applied at 25 and 50 kg K_2O/ha, increasing levels of nitrogen resulted in increased leaf number upto 30 kg N/ha, there being a decrease with further increase in the level of applied nitrogen.

Combined effect of phosphorus and potassium showed significant difference only at 45th and 60th days after sowing. At 45th day of sowing, P_2K_0, P_0K_2 and P_2K_2 recorded maximum values and these were at par with each other. The combination P_0K_0 recorded the lowest value (Table 19). After 60 days of sowing, P_0K_1 and P_0K_2 recorded maximum values and were at par

with each other. At the same time, P_0K_2 was also at par with P_2K_0 and P_1K_1. The P_2K_1 combination recorded the minimum value (Table 20).

The interaction effects may be summarised as follows. The interaction between phosphorus and potassium was significant only on the 45th and 60th days after sowing. But even at these two stages, the trend was not steady and consistant, making it difficult to draw general conclusions. Though not consistent, there was a tendency for negative interactions of phosphorus and potassium.

1.4 Leaf production

a) Main effects:- Total number of leaves was significantly increased with increasing levels of nitrogen (Table 13 and Appendix IV). Effects of various levels of phosphorus on leaf production were not significantly different. In the case of potassium, total leaf number increased with increasing levels but K_1 and K_0 were at par with each other.

b) Interaction effects:- In the case of nitrogen and phosphorus interactions, N_2P_1 and N_1P_2 recorded maximum values and were at par with each other.

The combinations N_0P_1 and N_0P_2 recorded minimum values and were also at par with each other (Table 21).

The interaction effects are as follows. When nitrogen was not applied total number of leaves was found to decrease with increasing levels of phosphorus. When nitrogen was applied at 30 kg/ha, increasing levels of phosphorus significantly increased the leaf production. At the highest level of nitrogen (60 kg/ha), the response to phosphorus application was observed upto the intermediate level (25 kg P_2O_5/ha) and further application reduced the leaf number considerably. Comparing the effects of nitrogen levels at varying rates of phosphorus application, a steady increase in leaf production was noted with increasing levels of nitrogen, when phosphorus was not applied and also when phosphorus was applied at the intermediate level of 25 kg P_2O_5/ha. At the highest level of phosphorus (50 kg P_2O_5/ha), nitrogen increased the leaf production upto the intermediate level of 30 kg N/ha and when increased to 60 kg N/ha a decrease was noticed.

Among nitrogen and potassium combinations, N_2K_0 was significantly superior to all other combinations and it was followed by N_1K_2. The N_0K_0 combination

recorded the minimum number of leaves (Table 22).

A summary of interaction effects may be done as follows. Without application of nitrogen, there was increase in leaf production when potassium was applied at 25 kg K_2O/ha, beyond which there was no substantial increase. But at the intermediate level of nitrogen (30 kg N/ha), increasing levels of potassium increased the leaf number upto the highest level of 50 kg K_2O/ha. The trend was just reverse in the case of nitrogen application at 60 kg N/ha. The effect of nitrogen levels, when potassium was not applied, was that of a significant increase with increasing levels of nitrogen upto 60 kg/ha. When potassium was added at both 25 kg and 50 kg K_2O/ha, increase was noticed upto the intermediate level of nitrogen (30 kg N/ha) and further addition decreased the leaf production especially at the highest level of potassium.

In the case of phosphorus and potassium interactions, P_0K_2 was significantly superior to other combinations. The combination of P_0K_0 recorded the minimum and was at par with P_0K_1 and P_1K_2 (Table 23).

An overall evaluation of the interaction effect would indicate that the results were not consistent.

1.5 Leaf area index (L.A.I.)

a) Main effects:- At both stages of observation, the leaf area index was found to be significantly increased with increasing levels of nitrogen (Table 24, Fig. 4, Appendix IV). In the case of phosphorus, at both stages, P_2 recorded the highest values of L.A.I. At 30th day, P_1 and P_0 were at par with each other and significantly inferior to P_2 whereas at 60th day, P_2 was at par with P_0 and these were significantly superior to P_1. The data on the effects of potassium revealed that at 30th day, K_0 recorded significantly higher L.A.I. and K_1 and K_2 were at par with each other. Just contrary to that, at the 60th day, K_2 level recorded significantly higher L.A.I. and K_0 and K_1 were at par with each other.

The result can be summarised as follows. L.A.I. increased with increasing levels of nitrogen. In the case of phosphorus also the same effect was noticed. There was increase in L.A.I. at higher levels of potassium also during the second stage of observation,

Table - 24

Effect of levels of nitrogen, phosphorus and potassium on leaf area index, net assimilation rate and dry matter production.

Treatments	Leaf area index (Days after sowing)		N.A.R. ($g/m^2/day$)	Dry matter production (Kg/ha) (Days after sowing)		
	30	60		30	60	90
Levels of N Kg/ha.						
0	0.227	1.031	10.087	290.450	2487.078	3494.189
30	0.482	1.496	11.913	638.872	4285.706	5279.839
60	0.664	1.840	11.327	703.872	4496.506	5163.406
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SEM ±	0.007	0.019	0.200	6.568	124.708	104.995
CD (0.05)	0.021	0.026	0.551	19.266	365.779	307.959
Levels of P_2O_5 Kg/ha.						
0	0.420	1.512	12.549	461.922	3755.456	4593.617
25	0.423	1.314	11.534	535.311	3740.372	4676.122
50	0.529	1.541	9.264	635.961	3773.461	4667.694
'F' test	Sig.	Sig.	Sig.	Sig.	NS	NS
SEM ±	0.007	0.019	0.200	6.568	124.708	104.995
CD (0.05)	0.021	0.026	0.551	19.266	-	-
Levels of K_2O Kg/ha.						
0	0.506	1.383	11.176	593.656	3532.422	4760.283
25	0.434	1.399	11.351	510.606	3796.510	4314.144
50	0.432	1.585	10.820	568.933	3940.367	4863.006
'F' test	Sig.	Sig.	NS	Sig.	NS	Sig.
SEM ±	0.007	0.019	0.200	6.568	124.708	104.995
CD (0.05)	0.021	0.026	-	19.266	-	307.959

FIG-4 LEAF AREA INDEX AT 30th AND 60th DAYS AFTER SOWING

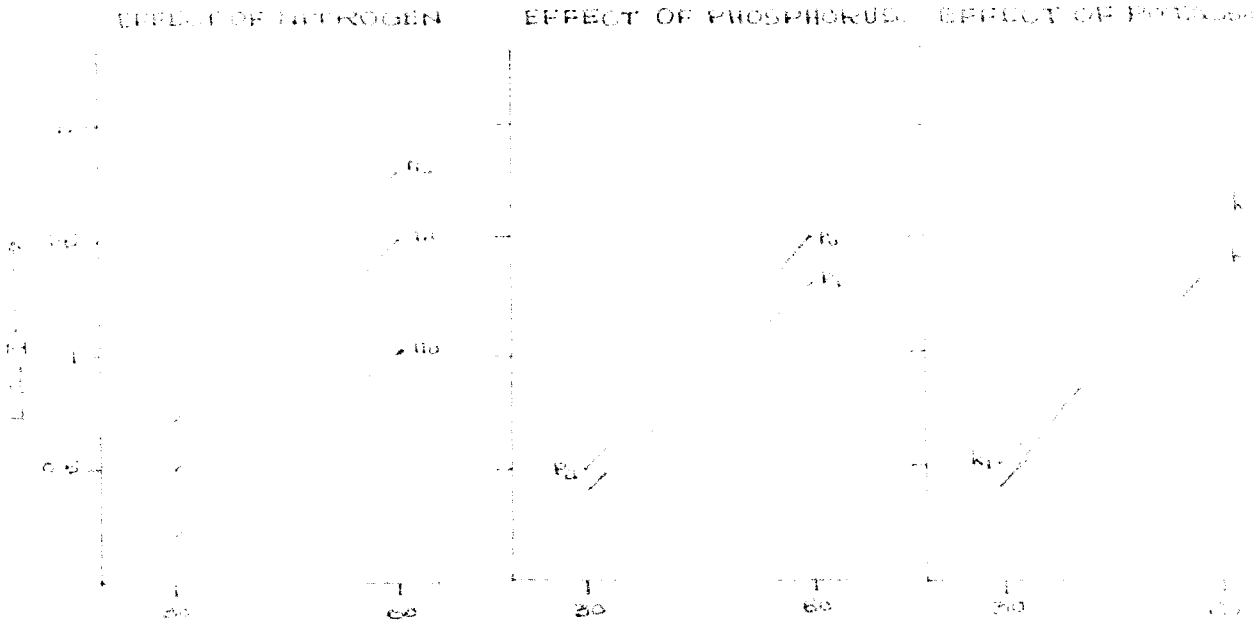
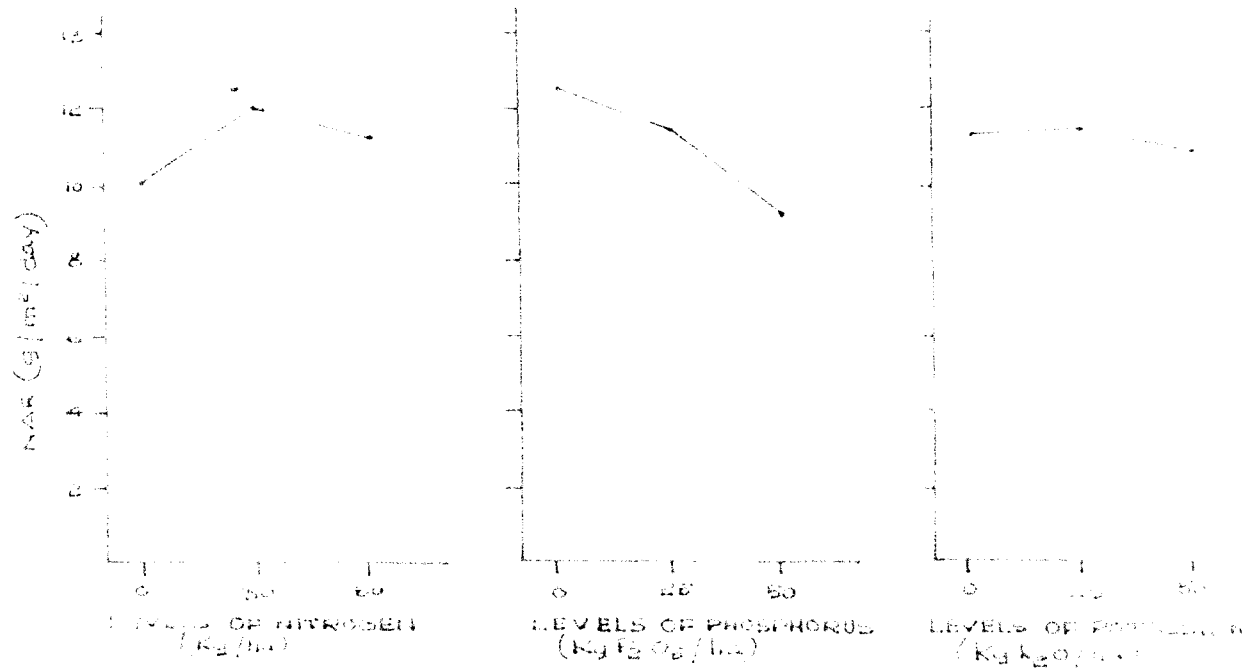


FIG-5 NET ASSIMILATION RATE BETWEEN 30th AND 60th DAYS AFTER SOWING.



even though the trend was reverse during the first stage.

Over the stages, there was a steady increase in the L.A.I., the extent of increase being more or less the same in all the treatments.

b) Interaction effects:- Among the combinations of nitrogen and phosphorus, at both the stages, N_2P_2 was significantly superior to all other combinations. The combinations N_0P_0 and N_0P_1 recorded lowest values after 30 days and N_0P_1 and N_0P_2 after 60 days of sowing (Tables 25, 26).

To summarise the trend of interaction, there was increase in L.A.I. with increasing levels of nitrogen at all the levels of phosphorus, the extent of increase being more conspicuous at higher levels of phosphorus. A similar trend of increase with increasing levels of phosphorus was also noted at all the levels of nitrogen; but the treatment effects were not consistent.

After 30 days of sowing, N_2K_0 combination was significantly superior to all other combinations and

it was immediately followed by N_2K_2 (Table 27). After 60 days of sowing, N_2K_2 combination was significantly superior to all other combinations (Table 28). At both stages combination of potassium levels with N_0 recorded minimum leaf area indices.

The interaction effects were as follows. There was increase in L.A.I. with increasing levels of nitrogen at all the levels of potassium. On the contrary, there was increase in this character with increasing levels of potassium only upto the intermediate level of 25 kg K_2O/ha when nitrogen was supplied upto 30 kg/ha. When nitrogen application was enhanced to 60 kg/ha, there was significant increase in L.A.I. upto the highest level of 50 kg K_2O/ha.

A perusal of the data indicates that the interaction effects between phosphorus and potassium were not steady and consistent during the two stages of observation (Tables 29, 30).

1.6 Net assimilation rate ($g/m^2/day$)

a) Main effects:- Data of the main effects on the net assimilation rate are given in Table 24 and Fig. 5 and analysis of variance is presented in Appendix IV.

Table - 25

Effect of nitrogen and phosphorus interaction on the leaf area index after 30 days of sowing

Levels of N Kg/ha.	Levels of P_2O_5 Kg/ha. 0	25	50	Mean
0	0.212	0.202	0.267	0.227
30	0.458	0.496	0.490	0.482
60	0.590	0.572	0.830	0.664
Mean	0.420	0.423	0.529	
SEM ±	0.010			
CD (0.05)	0.037			

Table - 26

Effect of nitrogen and phosphorus interaction on the leaf area index after 60 days of sowing

Levels of N Kg/ha.	Levels of P_2O_5 Kg/ha. 0	25	50	Mean
0	1.310	0.915	0.868	1.031
30	1.557	1.313	1.617	1.496
60	1.670	1.713	2.138	1.840
Mean	1.512	1.314	1.541	
SEM ±	0.027			
CD (0.05)	0.098			

Table - 27

Effect of nitrogen and potassium interaction on the leaf area index after 30 days of sowing

Levels of N Kg/ha.	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.223	0.212	0.245	0.227
30	0.463	0.538	0.443	0.482
60	0.830	0.553	0.608	0.664
Mean	0.506	0.434	0.432	
SEM ±	0.010			
CD (0.05)	0.037			

Table - 28

Effect of nitrogen and potassium interaction on the leaf area index after 60 days of sowing

Levels of N Kg/ha.	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.955	1.218	0.920	1.031
30	1.422	1.622	1.443	1.496
60	1.773	1.357	2.392	1.840
Mean	1.383	1.399	1.585	
SEM ±	0.027			
CD (0.05)	0.098			

Table - 29

Effect of phosphorus and potassium interaction on the leaf area index after 30 days of sowing

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha. 0	25	50	Mean
0	0.425	0.415	0.420	0.420
25	0.492	0.395	0.383	0.423
50	0.600	0.493	0.493	0.529
Mean	0.506	0.434	0.432	
SEM ±	0.010			
CD (0.05)	0.037			

Table - 30

Effect of phosphorus and potassium interaction on the leaf area index after 60 days of sowing

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	1.275	1.532	1.730	1.512
25	1.122	1.277	1.543	1.314
50	1.753	1.388	1.482	1.541
Mean	1.383	1.399	1.585	
SEM ±	0.027			
CD (0.05)	0.098			

Table - 31

Effect of nitrogen and phosphorus interaction on the net assimilation rate.

Levels of N Kg/ha.	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	9.593	10.692	9.975	10.087
30	13.762	12.068	9.908	11.913
60	14.292	11.842	7.908	11.347
Mean	12.549	11.534	9.264	
SEM ±	0.260			
CD (0.05)	0.954			

Table - 32

Effect of nitrogen and potassium interaction on the net assimilation rate.

Levels of N Kg/ha.	Levels of K_2O Kg/ha 0	25	50	Mean
0	10.292	10.638	9.330	10.087
30	12.472	10.787	12.480	11.913
60	10.763	12.628	10.650	11.347
Mean	11.176	11.351	10.820	
SEM ±	0.260			
CD (0.05)	0.954			

Table - 33

Effect of phosphorus and potassium interaction on the net assimilation rate.

Levels of P_2O_5 Kg/ha.	Levels of K_2O Kg/ha. 0	25	50	Mean
0	14.625	10.027	12.995	12.549
25	9.642	14.228	10.732	11.534
50	9.260	9.800	8.733	9.264
Mean	11.176	11.351	10.820	
S.E.M ±	0.260			
CD (0.05)	0.954			

Table - 34

Effect of nitrogen and phosphorus interaction on the dry matter production (Kg/ha) after 30 days of sowing

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	265.433	260.233	345.683	290.450
30	521.583	675.917	719.117	638.872
60	598.750	669.783	843.083	703.872
Mean	461.922	535.311	635.961	
S.E.M ±	9.289			
CD (0.05)	33.369			

Table - 35

Effect of nitrogen and phosphorus interaction on the dry matter production (Kg/ha) after 90 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	3873.450	3214.050	3395.067	3494.189
30	5086.433	5212.967	5540.117	5279.839
60	4820.967	5601.351	5067.900	5163.406
Mean	4593.617	4676.122	4667.694	
S.E.M ±	148.486			
CD (0.05)	533.401			

Table - 36

Effect of nitrogen and potassium interaction on the dry matter production Kg/ha) after 30 days of sowing.

Levels of N Kg/ha.	Levels of K_2O Kg/ha. 0	25	50	Mean
0	327.867	226.283	317.900	290.450
30	580.217	863.567	672.833	638.872
60	753.583	641.967	716.067	703.872
Mean	553.922	510.606	568.933	
SEM ±	9.289			
CD (0.05)	33.369			

Table - 37

Effect of nitrogen and potassium interaction on the dry matter production (Kg/ha) after 60 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2420.383	2508.017	2532.833	2487.078
30	4139.817	4707.433	4009.867	4295.706
60	4037.067	4174.050	5278.400	4496.506
Mean	3532.422	3796.510	3940.367	
SEM ±	176.364			
CD (0.05)	633.547			

Table - 38

Effect of nitrogen and potassium interaction on the dry matter production (Kg/ha) after 90 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	3145.050	3677.000	3660.517	3494.189
30	5086.433	4882.733	5870.350	5279.839
60	6049.367	4382.700	5058.150	5163.406
Mean	4760.283	4314.144	4863.006	
SEM ±	148.486			
CD (0.05)	533.401			

Table -. 39

Effect of phosphorus and potassium interaction on the dry matter production (Kg/ha) after 30 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	459.86	388.883	537.017	461.922
25	595.667	504.067	506.200	535.311
50	605.433	638.867	663.583	635.961
Mean	553.656	510.606	568.933	
SEM ±	9.289			
CD (0.05)	33.369			

Table - 40

Effect of phosphorus and potassium interaction on the dry matter production after 60 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	3353.400	3296.300	4616.667	3755.456
25	3095.700	4331.467	3793.950	3740.372
50	4148.167	3761.733	3410.483	3773.461
Mean	3532.422	3796.510	3940.367	
SEM ±	176.364			
CD (0.05)	633.547			

Table - 41

Effect of phosphorus and potassium interaction on the dry matter production after 90 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	4858.033	3972.217	4950.600	4593.617
25	4114.183	4513.433	5400.750	4676.122
50	5308.633	4456.783	4237.667	4667.694
Mean	4760.283	4314.144	4863.006	
SEM ±	148.486			
CD (0.05)	533.401			

The N_1 level of nitrogen recorded significantly higher net assimilation rate than N_2 and N_0. The control level was inferior to N_1 and N_2. In the case of phosphorus levels, control was found to be significantly superior to other levels. Phosphorus at P_2 level recorded the lowest value. The differences between the potassium levels were not significant.

b) Interaction effects:- Among the nitrogen and phosphorus combinations, N_2P_0 recorded highest value of N.A.R. and it was on par with N_1P_0. These combinations were significantly superior to all other combinations. The N_2P_2 combination recorded lowest value (Table 31).

To summarise the interaction effects, when nitrogen was not applied, net assimilation rate increased upto the intermediate level of phosphorus, and when nitrogen was applied both at 30 kg and 60 kg N/ha, net assimilation rate decreased with increasing levels of phosphorus. Increase in N.A.R. was noticed upto the highest level of nitrogen, at P_0 level of phosphorus. When phosphorus was applied at 25 kg P_2O_5/ha increase in N.A.R. was noticed upto the intermediate level of nitrogen, whereas when phosphorus

was applied at 50 kg P_2O_5/ha N.A.R. was found to decrease with increasing levels of nitrogen.

Among the nitrogen and potassium combinations N_2K_1 recorded highest N.A.R. and it was at par with N_1K_2 and N_1K_0. The combination N_0K_2 recorded the lowest value. There was no significant difference between other combinations (Table 32).

The nitrogen and potassium interaction can be summarised as follows. When nitrogen was not applied and also when applied at 60 kg N/ha, increase in N.A.R. was noticed upto the intermediate level of potassium. When nitrogen was applied at 30 kg N/ha, application of potassium upto the intermediate level decreased the N.A.R., but increased when potassium application was raised to 50 kg K_2O/ha. When potassium was at K_0 and K_2 levels, there was increase in N.A.R. only upto the intermediate level of nitrogen. A steady increase in N.A.R. was noticed at K_1 level of potassium.

Among the phosphorus and potassium combinations P_0K_0 and P_1K_1 recorded higher values. They were at par with each other and significantly superior to other combinations. The P_2K_2 combination recorded the lowest value (Table 33).

The trend of interaction was as follows. Without added phosphorus and potassium, the N.A.R. was maximum and this was followed by P_1K_1. When phosphorus was applied both at 25 kg P_2O_5 and 50 kg P_2O_5/ha increase in N.A.R. was noticed upto the intermediate level of potassium (25 kg K_2O/ha). Both in the control and at 50 kg K_2O/ha, P_0 recorded the maximum N.A.R. and further addition of phosphorus reduced the value. At 25 kg K_2O/ha, increase in N.A.R. was noticed upto 25 kg P_2O_5/ha only.

1.7 Dry matter production (kg/ha)

a) Main effects:- Regarding the effect of nitrogen levels on the dry matter production, it was found that N_1 and N_2 levels registered higher values than N_0. The N_2 level showed significant difference as compared to N_1 only at the first stage. On the 2nd and 3rd month stages, N_1 and N_2 were at par with each other (Table 24, Appendix VIII). In the case of phosphorus levels, significant difference was noticed only at the 30th day after sowing. Increasing levels of phosphorus recorded significant increase in the dry matter production at this stage. Potassium levels showed significant difference only at the 30th and

90th days of sowing. At both stages, K_2 and K_0 recorded higher values than K_1 and these two were at par with each other.

Over the stages, there was a steady increase in dry matter production with advancing age upto the last stage of observation.

b) Interaction effects:- Nitrogen and phosphorus interaction was significant at 30th and 90th days after sowing. After 30 days, N_2P_2 recorded maximum dry matter production whereas at 90th day, maximum dry matter production was recorded by N_2P_1. At both stages, N_0P_1 recorded the lowest value (Tables 34, 35).

After 30 days, among the nitrogen and potassium combinations, N_2K_1 recorded the highest value. The data are presented in the Table 36 . At 60th day, the N_2K_2 combination gave the highest dry matter production (Table 37). But at 90th day N_2K_0 recorded the highest value and it was at par with N_1K_2(Table 38).

The interaction between phosphorus and potassium was also significant at all the stages. The maximum values of dry matter production were recorded by P_2K_2, P_0K_2 and P_1K_2 combinations at 30th, 60th and 90th days

after sowing (Tables 39, 40, 41). At 90th day there was no significant difference between other combinations.

The effects of nitrogen, phosphorus and potassium levels on the dry matter production can be summarised as follows. There was, in general, increase in dry matter production with increasing levels of nitrogen. This trend was consistent. However, there was statistically significant increase only upto the intermediate level of 30 kg N/ha. A similar increase with increasing levels of phosphorus was also noticed. But this effect was significant only at the first stage of observation. In the case of potassium, the response was not consistent.

The interaction between nitrogen and phosphorus was significant at first and last stages of observation and the general trend was that of a positive interaction between the two nutrients. The interaction between nitrogen and potassium, though was significant at all the three stages of observation, the results were not consistent. However, the trend was towards positive interaction, though it was generally significant only upto the intermediate level of both nitrogen and potassium. A similar trend was noticed in the case of

phosphorus and potassium interaction also. Even though the interaction was of a positive trend, significance was noticed only upto the intermediate levels.

2. Yield and its components

2.1 Days to 50 per cent flowering

a) **Main effects:-** Among the nitrogen levels, N_1 level took minimum days to flower (28.3) and there was no significant difference between N_1 and N_2 levels (Table 42 and Appendix V). At the N_0 level, there was significant delay in flowering. It may be noted that though the differences were statistically significant, the actual difference in the mean number of days taken for flowering is only less than 3 days. In the case of phosphorus, there was significantly earlier flowering at P_2 level (29.4). There was no significant difference between P_0 and P_1. Potassium application was found to delay the flowering significantly and there was no significant difference between K_2 and K_1.

b) **Interaction effects:-** Among the nitrogen and phosphorus combinations N_2P_2, N_1P_1 and N_1P_2 recorded earlier flowering and they were at par with each other.

Table - 42

Effect of levels of nitrogen, phosphorus and potassium on the date of flowering of 50% of the plants, total number of flowers per plant, total number of fruits per plant, percentage of fruit set and length of fruits.

TREATMENTS	Days taken for 50% flowering	Number of flowers/ plant	Number of fruits/ plant	% of fruit set	Length of fruits (cm)
Levels of N Kg/ha					
0	32.333	13.311	11.222	67.101	14.883
30	28.333	18.321	15.173	67.253	15.728
60	29.500	20.167	16.532	64.465	16.411
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.
SEM ±	0.294	0.253	0.130	0.761	0.087
CD (0.05)	0.862	0.742	0.382	2.232	0.254
Levels of P_2O_5 Kg/ha.					
0	31.111	16.848	13.778	64.461	15.500
25	30.333	17.223	15.144	66.217	15.800
50	29.444	17.727	14.003	68.142	15.722
'F' test	Sig.	NS	Sig.	Sig.	NS
SEM ±	0.294	0.253	0.130	0.761	0.087
CD (0.05)	0.862	-	0.382	2.232	-
Levels of K_2O Kg/ha					
0	29.000	17.047	14.036	66.796	15.122
25	30.722	16.824	13.743	64.980	15.667
50	31.167	17.927	15.148	67.036	16.233
'F' test	Sig.	Sig.	Sig.	NS	Sig.
SEM ±	0.294	0.253	0.130	0.761	0.087
CD (0.05)	0.862	0.742	0.382	-	0.254

The combinations N_0P_1 and N_0P_0 were at par with each other and showed maximum delay in flowering (Table 43). In the case of nitrogen and potassium combinations N_2K_0 showed significantly earlier flowering (28.3 days) and it was at par with most of the combinations. The N_0K_2 combination recorded the maximum number of days for flowering (34.7 days) (Table 44). The phosphorus and potassium combination,(P_2K_0) recorded minimum days (28.2) and P_0K_1 recorded maximum days to flowering (34.2) (Table 45).

To summarise, application of nitrogen and phosphorus led to early flowering and application of potassium resulted in significant delay. All these effects were significant only upto the intermediate level of the respective nutrients. The interaction of nitrogen and phosphorus was significant and the trend in general, was positive though it was significant upto the intermediate levels of nitrogen and phosphorus only. There was a significant interaction between nitrogen and potassium also. When nitrogen was not applied, there was significant delay in flowering and this effect was noticed upto the highest level of potassium. This effect of potassium could be arrested

Table - 43

Effect of nitrogen and phosphorus interaction on the time taken for 50% flowering (days).

Levels of N Kg/ha.	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	32.167	33.000	31.833	32.333
30	30.333	28.000	28.333	28.333
60	30.833	30.000	27.667	29.500
Mean	31.111	30.333	29.777	
SEM ±	0.416			
CD (0.05)	1.493			

Table - 44

Effect of nitrogen and potassium interaction on the time taken for 50% flowering (days).

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	30.333	32.000	34.667	32.333
30	28.333	29.500	29.333	29.055
60	28.333	30.667	29.500	29.500
Mean	28.999	30.722	31.167	
SEM ±	0.416			
CD (0.05)	1.493			

Table - 45

Effect of phosphorus and potassium interaction on the time taken for 50% flowering (days).

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	28.667	34.167	30.500	31.111
25	30.167	28.833	32.000	30.333
50	28.167	29.167	31.000	29.445
Mean	29.000	30.722	31.167	
SEM ±	0.416			
CD (0.05)	1.493			

Table - 46

Effect of nitrogen and phosphorus interaction on the number of flowers/plant.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	14.18	12.69	13.06	13.31
30	16.28	16.68	22.00	18.32
60	20.08	22.30	18.13	20.17
Mean	16.85	17.23	17.73	
SEM ±	0.358			
CD (0.05)	1.284			

Table - 47

Effect of nitrogen and potassium interaction on the number of flowers/plant.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	12.09	13.93	13.92	13.31
30	15.91	18.06	21.00	18.32
60	23.16	18.48	18.86	20.17
Mean	17.05	16.82	17.93	
SEM ±	0.358			
CD (0.05)	1.284			

Table - 48

Effect of phosphorus and potassium interaction on the number of flowers/plant.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	15.93	15.75	18.87	16.85
25	17.52	17.72	16.43	17.23
50	17.70	17.00	18.49	17.73
Mean	17.05	16.82	17.93	
SEM ±	0.358			
CD (0.05)	1.284			

Table - 49

Effect of nitrogen and phosphorus interaction on the number of fruits/plant.

Levels of N Kg/ha.	Levels of P_2O_5 Kg/ha. 0	25	50	Mean
0	11.54	10.60	11.48	11.22
30	13.61	16.99	14.92	15.17
60	16.14	16.85	15.61	16.53
Mean	13.78	15.14	14.00	
SEM ±	0.184			
CD (0.05)	0.662			

Table - 50

Effect of nitrogen and potassium interaction on the number of fruits per plant.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	10.32	10.54	12.81	11.22
30	12.93	15.73	16.86	15.17
60	18.86	14.96	15.78	16.53
Mean	14.04	13.74	15.14	
SEM ±	0.184			
CD (0.05)	0.662			

Table - 51

Effect of nitrogen and phosphorus interaction on the percentage of fruit set.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	61.13	68.67	71.51	67.10
30	68.06	69.00	64.70	67.25
60	64.19	60.99	68.21	64.47
Mean	64.46	66.22	68.14	
SEM ±	1.076			
CD (0.05)	3.87			

Table - 52

Effect of phosphorus and potassium interaction on the percentage of fruit set.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	68.66	63.19	61.53	64.46
25	66.32	63.81	68.52	66.22
50	65.40	67.96	71.06	68.14
Mean	66.80	64.99	67.04	
SEM ±	1.076			
CD (0.05)	3.87			

when nitrogen was applied both at 30 kg and 60 kg N/ha. The trend of phosphorus and potassium interaction also indicated a conspicuous delay in flowering when potassium was applied upto the intermediate level of 25 kg K_2O/ha. As in the case of nitrogen, this trend could be arrested by the application of phosphorus. However, when potassium was added at the highest level, there was further delay in flowering (31 days) even when phosphorus was applied.

2.2 Flowers per plant

a) Main effects:- Nitrogen and potassium application showed significant effect on flower production, whereas phosphorus application had no significant effect (Table 42 and Appendix V).

Flower production was significantly increased with increasing levels of nitrogen. In the case of potassium K_1 produced minimum number of flowers (29) and was at par with K_0. The K_2 level showed significant difference as compared to K_0 and K_1.

b) Interaction effects:- Of the combinations

of nitrogen and phosphorus, N_2P_1 and N_1P_2 were at par with each other and significantly superior to the other combinations. The combinations of P_1 and P_2 with N_o recorded minimum number of flowers (14.2 and 12.7 respectively) (Table 46). Among the combinations of nitrogen and potassium N_2K_o was significantly superior to all other combinations (23.2) and N_oK_o recorded the lowest value (12.1) (Table 47). Of the phosphorus and potassium combinations, P_oK_2 recorded maximum value (18.9) and it was statistically at par with P_2K_2 and P_1K_1. Lower values were recorded by P_oK_1, P_oK_o, P_1K_2 and P_2K_o (Table 48).

To summarise the interaction effects, when nitrogen was not applied, intermediate level of phosphorus reduced the flower production, but increased with the highest level. Regarding the potassium application flower production was increased upto the intermediate level. When nitrogen was added at 30 kg N/ha increasing levels of both phosphorus and potassium increased the flower production. With the highest level of nitrogen, increase in flower production was noticed upto the intermediate level of phosphorus, whereas potassium application reduced the flower production.

All levels of phosphorus and potassium showed significant increase in this character with increasing levels of nitrogen, except in the case of phosphorus at 50 kg P_2O_5/ha, where increase was noticed only upto the intermediate level of nitrogen. In the case of phosphorus and potassium interaction, with both the control and the highest levels of phosphorus, intermediate level of potassium decreased the value and then increased with the highest level. With the intermediate level of phosphorus, increase was noticed upto the intermediate level of potassium. When potassium was not added, flower production increased with increasing levels of phosphorus and when added at 25 kg K_2O/ha, increase was noticed upto the intermediate level of phosphorus, whereas the value was reduced with the intermediate level of phosphorus and then increased with higher level when potassium level was at 50 kg K_2O/ha.

2.3 Fruits per plant

a) Main effects:- Fruits per plant increased significantly with increasing levels of nitrogen (Table 42 and Appendix V). But in the case of phosphorus, P_2 and P_1 recorded higher number of fruits

than P_0 but these two levels were at par with each other. In the case of potassium, K_1 recorded lower value and was at par with K_0. The level, K_2 was significantly superior to K_0 and K_1.

b) Interaction effects:- Among the combinations of nitrogen and phosphorus, N_2P_1 recorded maximum fruits per plant and N_0P_1 recorded the lowest mean value (Table 49). The treatment combination, N_2K_0 was significantly superior to all other combinations of nitrogen and potassium and N_0K_0 recorded the minimum value (Table 50).

An overall evaluation of the trend of interaction will indicate that when nitrogen was not added, fruit production decreased with the intermediate level of phosphorus, then increased with the highest level. With the intermediate level of nitrogen, fruit production increased upto the intermediate level of phosphorus; and upto the highest level of potassium. When nitrogen application was raised to 60 kg N/ha, the intermediate level of phosphorus recorded the highest value but that of potassium reduced the value. Increasing levels of nitrogen increased the fruit production at the control level of both phosphorus and potassium, but their intermediate levels increased the value upto the

intermediate level of nitrogen. With the highest level of phosphorus, fruit production increased with the increasing levels of nitrogen, but in the case of potassium, it was only upto the intermediate level.

2.4 Fruit set (per cent)

a) Main effects:- Increasing levels of application of nitrogen tended to reduce the percentage of fruit set and N_2 gave significantly lower values as compared to N_0 and N_1 which were at par with each other (Table 42 and Appendix V). Setting percentage increased with increasing levels of phosphorus but P_0 and P_1 were at par with each other. There was no significant difference between potassium levels.

b) Interaction effects:- Among the treatment combinations of nitrogen and phosphorus N_0P_2 recorded the highest percentage of fruit set (71.5) and N_2P_1 recorded the lowest value (61) (Table 51). Between phosphorus and potassium the combination, P_2K_2 gave the highest percentage of fruit set (71.1) and it was statistically at par with P_0K_0, P_1K_2 and P_2K_1. The lowest value was recorded by P_0K_2 (61.5) (Table 52).

The treatment effects may be summarised as follows.

The percentage of fruit set was found to decrease with higher levels of nitrogen, whereas increasing levels of phosphorus increased the fruit set. In both the cases, the control and the intermediate levels were statistically at par with each other. Potassium levels showed no significant difference.

Among the two-factor combinations, only nitrogen x phosphorus and phosphorus x potassium interactions were significant. When nitrogen was not applied, percentage of fruit set increased with increasing levels of phosphorus. At 30 kg N/ha, the increase was noticed upto the intermediate level of phosphorus. But when the dose of nitrogen was raised to 60 kg N/ha, the intermediate level of phosphorus decreased the value and then increased with the highest level. With no added phosphorus, intermediate level of nitrogen reduced the value, but it increased with the highest level. Regarding the potassium levels, the value decreased with increasing levels. When phosphorus level was increased to 25 kg P_2O_5/ha, the fruit set was increased upto the intermediate level of nitrogen, but that of potassium reduced the value and further addition tended to increase the fruit set.

With the highest level of phosphorus the intermediate level of nitrogen decreased the value, but increased with the highest level. Regarding the potassium levels, a steady increase was noticed upto the highest level. When potassium was not applied, the fruit set was reduced with increasing phosphorus levels whereas with other levels of potassium, the value was increased with increasing levels of phosphorus.

2.5 Length of fruit (cm.)

a) Main effects:- Nitrogen application showed significant increase in the fruit length with increasing levels (Table 42 and Appendix V). Application of phosphorus had no significant effect. In the case of potassium also, there was significant increase in fruit length at higher levels. Though there was statistical significance between all the sets of treatments, the actual differences in fruit length was in the range from 0.6 - 1.5 cm only.

b) Interaction effects:- Among the combinations of nitrogen and phosphorus N_2P_1 recorded the highest fruit length (16.5) and N_0P_2 recorded the lowest mean value (14.4) (Table 53). Between combinations of

Table - 53

Effect of nitrogen and phosphorus interaction on the length of fruits.

Levels of N Kg/ha.	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	15.07	15.15	14.43	14.88
30	15.71	15.27	16.17	15.73
60	15.72	16.98	16.53	16.41
Mean	15.50	15.80	15.72	
SEM ±	0.12			
CD (0.05)	0.44			

Table - 54

Effect of nitrogen and potassium interaction on the length of the fruits.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	14.55	14.33	16.77	14.88
30	15.05	15.78	16.35	15.74
60	15.77	16.78	16.23	16.38
Mean	15.12	15.63	16.45	
SEM ±	0.12			
CD (0.05)	0.44			

Table - 55

Effect of phosphorus and potassium interaction on the length of fruits.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	15.20	15.33	15.97	15.50
25	15.23	15.65	16.52	15.80
50	14.93	16.02	16.22	15.73
Mean	15.12	15.67	16.23	
SEM ±	0.12			
CD (0.05)	0.44			

nitrogen and potassium the highest fruit length was recorded by the combination N_2K_1 (16.8) and it was at par with N_2K_2. The lowest value was recorded by the combination N_0K_1 (14.3) (Table 54). Regarding interaction between phosphorus and potassium the higher length of fruits was given by the combinations P_1K_2 and P_2K_2 and the lowest value was recorded by P_2K_0 (Table 55).

To summarise, in the cases of both nitrogen and potassium levels, there was significant increase in fruit length with higher levels, though the actual difference was in the range from 0.6 - 1.5 cm. Potassium levels had no significant effect. When nitrogen was not applied, the fruit length increased upto the intermediate level of phosphorus, but that of potassium reduced the value, which increased with further addition of potassium at 50 kg K_2O/ha. When nitrogen level was raised to 30 kg N/ha the intermediate level of phosphorus reduced the fruit length, though it was increased with 50 kg P_2O_5/ha level. At the same level of nitrogen, increasing levels of potassium increased the fruit length. With the highest level of nitrogen, increase was noticed upto the intermediate levels of both phosphorus and potassium. With all levels of phosphorus, increasing levels of both

nitrogen and potassium increased the fruit length. When potassium was not applied, the fruit length increased with increasing levels of nitrogen, but it was only upto the intermediate level of phosphorus. A steady increase was noticed with increasing levels of both nitrogen and phosphorus when potassium was at the intermediate level. When potassium level was raised to 50 kg K_2O/ha, the increase in fruit length was noticed upto the intermediate level of both nitrogen and phosphorus.

2.6 Weight of fruit (g.)

a) Main effects:- There was significant difference between the levels of nitrogen, phosphorus and potassium with respect to the average fruit weight (Table 56 and Appendix VI). Among the levels of nitrogen, N_2 recorded the highest fruit weight (19.5) and was followed by N_1. The differences between the levels were significant. In the case of phosphorus also, P_2 and P_1 recorded higher values than P_o but P_1 and P_2 were at par with each other. In the case of potassium, K_2 recorded the highest value (19.4), K_1 recorded the lowest (18.2) and it was at par with K_o.

Table - 56

Effect of levels of nitrogen, phosphorus and potassium on mean weight, yield (Kg/ha), dry matter percentage and content of crude protein of fruits and the harvest index.

Treatments	Mean weight of fruit (g)	Yield (Kg/ha)	Dry matter of fruits (per-cent)	Crude protein content of fruits (per-cent)	Harvest index
Levels of N Kg/ha					
0	18.028	7604.398	11.733	1.798	0.226
30	18.322	10588.478	11.616	1.787	0.242
60	19.540	11639.918	11.562	1.830	0.239
'F' test	Sig.	Sig.	NS	Sig.	NS
SEM ±	0.094	163.27	0.064	0.010	0.022
CD (0.05)	0.274	475.31	-	0.027	-
Levels of P_2O_5 Kg/ha					
0	18.128	9243.827	11.677	1.828	0.240
25	18.790	10039.095	11.956	1.838	0.257
50	18.972	10551.441	11.278	1.748	0.210
'F' test	Sig.	Sig.	Sig.	Sig.	NS
SEM ±	0.094	163.27	0.064	0.010	0.022
CD (0.05)	0.274	475.31	0.188	0.027	-
Levels of K_2O Kg/ha					
0	18.306	9679.984	11.467	1.844	0.224
25	18.161	9281.893	11.894	1.778	0.253
50	19.424	10874.486	11.549	1.803	0.229
'F' test	Sig.	Sig.	Sig.	Sig.	NS
SEM ±	0.094	163.27	0.064	0.010	0.022
CD (0.05)	0.274	475.31	0.188	0.027	-

b) Interaction effects:- Of the combinations of nitrogen and phosphorus, N_2P_2 recorded maximum weight of fruits (20) and it was at par with N_2P_1. The combination, N_1P_0 recorded the minimum value (17.6) and it was at par with N_0P_0 and N_0P_2 (Table 57). Among the nitrogen and potassium combinations, N_2K_1 recorded the highest value (19.9) and N_0K_1 recorded the lowest value (17.9) (Table 58). Among the interactions of phosphorus and potassium P_1K_2 recorded significantly higher value (20.9) and P_1K_1 recorded the lowest value (17.1) (Table 59).

The overall treatment effects may be summarised as follows. In the case of nitrogen and potassium, there was increase in fruit weight upto the highest level and in the case of phosphorus only upto the intermediate level. The interactions were in general positive, though the levels upto which this trend was noticed was different in the three nutrients. In the case of nitrogen and phosphorus, it was upto the highest levels(N_2P_2),in the case of nitrogen and potassium, upto the intermediate level of potassium and highest level of nitrogen (N_2K_1) and in the case of phosphorus

Table - 57

Effect of nitrogen and phosphorus interaction on the weight of fruit (g).

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	17.750	18.333	18.000	18.030
30	17.550	18.500	18.917	18.320
60	18.083	19.540	20.000	19.530
Mean	18.128	18.790	18.972	
SEM ±	0.132			
CD (0.05)	0.474			

Table - 58

Effect of nitrogen and potassium interaction on the weight of fruit (g).

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	17.917	17.250	18.917	18.028
30	17.833	17.300	19.833	18.322
60	19.167	19.893	19.523	19.528
Mean	18.302	18.128	19.444	
SEM ±	0.132			
CD (0.05)	0.474			

Table - 59

Effect of phosphorus and potassium interaction on the weight of fruit (g).

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	17.333	18.467	18.583	18.128
25	18.333	17.123	20.917	18.790
50	19.250	18.833	18.833	18.972
Mean	18.302	18.128	18.777	
SEM ±	0.132			
CD (0.05)	0.474			

Table - 60

Effect of nitrogen and phosphorus interaction on the yield of fruit (Kg/ha).

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	7478.395	7641.975	7697.531	7604.938
30	9145.062	10246.914	12373.457	10588.478
60	11108.025	12228.395	11583.334	11639.918
Mean	9243.827	10039.095	10551.441	
SEM ±	229.012			
CD (0.05)	824.074			

Table - 61

Effect of nitrogen and potassium interaction on the yield of fruits (Kg/ha)

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	7253.087	6743.827	8817.901	7604.938
30	8675.926	10157.408	12935.185	10588.478
60	13104.939	10944.445	10870.371	11639.918
Mean	9677.984	9281.893	10874.486	
SEM ±	229.012			
CD (0.05)	824.074			

Table - 62

Derived yield at various levels of nitrogen

Levels of N Kg/ha	Cost of N Rs.4/-/Kg	Other expenditure	Yield Kg/ha	Income/ha Rs.0.80/Kg Rs.	Profit Rs.
0	000.00	4700.00	7605	6084.00	1381.00
30	120.00	4700.00	10590	8472.00	3772.00
60	240.00	4700.00	11639	9311.00	4611.00
75	300.00	4700.00	11419*	9136.00	4436.00
90	360.00	4700.00	10750*	8600.00	3900.00

* These are estimated from the response function.

and potassium interaction, upto the intermediate level of phosphorus.

2.7 Fruit yield

a) Main effects:- In the case of nitrogen, N_2 level (60 kg N/ha) recorded the highest yield of 11.639 tonnes/ha followed by N_1 with 10.590 tonnes/ha and N_0 with 7.605 tonnes/ha (Table 56, Fig. 6 and Appendix VI). Among the phosphorus levels, P_2 recorded the highest yield of 10.77 tonnes/ha and this was followed by P_1 and P_0 with 10.040 and 9.244 tonnes/ha respectively. In the case of potassium, K_2 recorded the highest value of 10.873 tonnes/ha and this was followed by K_0 and K_1, these two being at par with each other.

b) Interaction effects:- Among the nitrogen and phosphorus combinations N_1P_2 recorded the highest yield but it was at par with N_2P_1 and N_2P_2. The lowest values were recorded by the combinations of N_0 with phosphorus levels (Table 60). Among the interactions between nitrogen and potassium the combination N_2K_0 recorded the highest fruit yield (13.105 tonnes/ha) and it was at par with N_1K_2. The combination N_0K_1 recorded the lowest value (8.818 tonnes/ha) (Table 61).

FIG-6 EFFECT OF LEVELS OF NITROGEN, PHOSPHORUS AND POTASSIUM ON THE YIELD OF BHINDI (TONNES/Ha.)

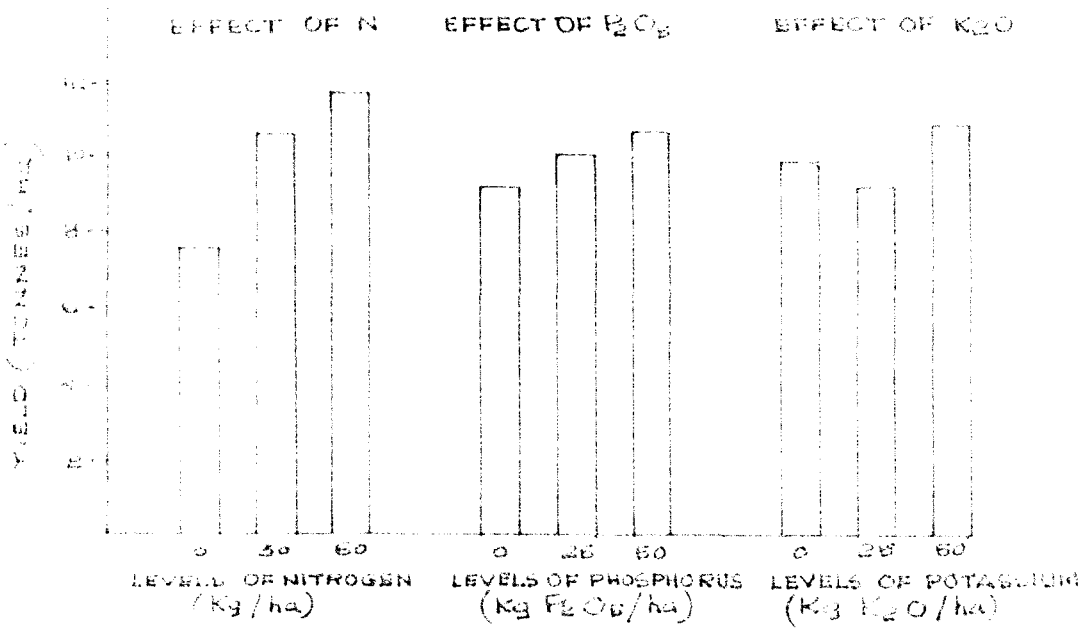
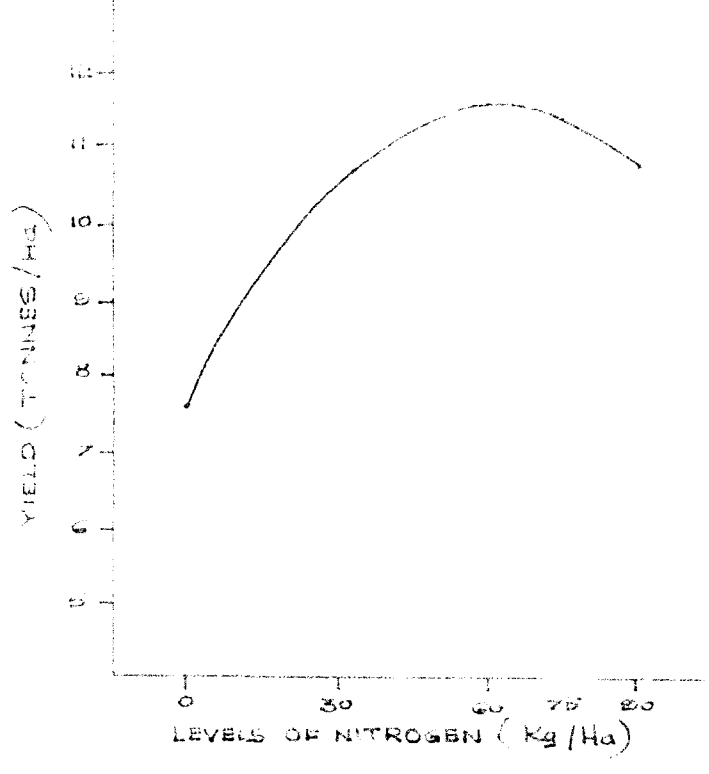


FIG-7 RESPONSE CURVE FITTED FOR NITROGEN.



To summarise, there was significant increase in the yield due to application of all nutrients. Among the interactions, nitrogen x phosphorus and nitrogen x potassium were significant. Both these interactions were, in general, positive and in the case of nitrogen x potassium, a consistent effect was noticed upto the intermediate level of nitrogen.

iv) Response of bhindi crop to various levels of nitrogen, phosphorus and potassium

Analysis of variance for the response of bhindi to different levels of nitrogen, phosphorus and potassium are presented in Appendix VII. The response to both phosphorus and potassium was found to be linear. But the response to nitrogen was found to be quadratic (Fig.7). The optimum dose of nitrogen was calculated as 61.23 kg N/ha. The economic dose was worked out to be 61 kg N/ha. From Table 62 also it is clear that, if the nitrogen level increased to 75 kg N/ha the yield would decrease considerably. So the calculated value of 61 kg N/ha is proved to be most profitable dose of nitrogen.

2.8 Dry matter percentage of fruits

a) Main effects:- The effects of levels of nitrogen were not significant, whereas those of phosphorus and potassium were significant (Table 56 and Appendix VI).

There was significant difference among the levels of phosphorus. Of these, P_1 recorded the highest and P_2 the lowest percentages (11.26). In the case of potassium K_1 recorded significantly higher value than K_2 and K_0 and these were at par with each other. Though the effect was not significant, increasing levels of nitrogen gave decreasing percentage of dry matter upto 60 kg N/ha.

b) Interaction effects:- The data on the nitrogen and phosphorus interactions indicated that N_1P_1 recorded the highest dry matter percentage of fruit (12.45) and it was on par with N_0P_0. The combination, N_1P_0 recorded the lowest value (11.11) (Table 63). Between nitrogen and potassium, the combination N_0K_1 recorded the highest dry matter per cent and it was at par with N_2K_1. The N_2K_2 combination recorded the lowest value and it was at par with N_0K_0 (Table 64). Among the phosphorus and

potassium combinations, P_1K_1 recorded the highest dry matter percentage of fruit and it was significantly superior to all other combinations. The combination P_2K_2 recorded the lowest value (Table 65).

It may be concluded from the result that application of both phosphorus and potassium increased the percentage of dry matter of fruits, though it was significant only upto the intermediate level. The effect of nitrogen was not significant, but the trend was towards decrease in the percentage of dry matter with increasing levels of this nutrient . The interactions, nitrogen x phosphorus, nitrogen x potassium and phosphorus x potassium were significant. However, in none of these interactions the result was consistent enough to draw out any general conclusions.

2.9 Crude protein (Green weight basis)

a) Main effects:- There was significant difference between the levels of all the three nutrients (Table 56 and Appendix VIII). At the N_2 level, crude protein content of the fruits was significantly higher than N_0 and N_1 and these levels, N_0 and N_1 were at par with each other. In the case of phosphorus, P_1 recorded higher value than P_2. However there was no significant difference

Table - 63

Effect of nitrogen and phosphorus interaction on the dry matter percentage of fruit.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	12.350	11.067	11.183	11.733
30	11.113	12.450	11.283	11.615
60	11.567	11.750	11.367	11.561
Mean	11.676	11.956	11.278	
S.E.M ±	0.091			
CD (0.05)	0.325			

Table - 64

Effect of nitrogen and potassium interaction on the dry matter percentage of fruit.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	11.017	12.267	11.917	11.733
30	11.650	11.467	11.730	11.616
60	11.733	11.950	11.000	11.561
Mean	11.467	11.895	11.549	
S.E.M ±	0.091			
CD (0.05)	0.325			

Table - 65

Effect of phosphorus and potassium interaction on the dry matter percentage of fruit.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	11.650	11.583	11.797	11.673
25	11.067	13.017	11.783	11.956
50	11.683	11.083	11.067	11.278
Mean	11.467	11.894	11.549	
S.E.M ±	0.091			
CD (0.05)	0.325			

Table - 66

Effect of nitrogen and phosphorus interaction on the crude protein content (per cent) of the fruit.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	1.968	1.763	1.663	1.798
30	1.675	1.865	1.820	1.787
60	1.842	1.867	1.762	1.830
Mean	1.828	1.838	1.748	
S.E.M ±	0.014			
CD (0.05)	0.047			

Table - 67

Effect of nitrogen and potassium interaction on the crude protein content (per cent) of the fruit.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	1.840	1.663	1.872	1.792
30	1.925	1.718	1.717	1.787
60	1.768	1.922	1.800	1.830
Mean	1.844	1.768	1.796	
SEM ±		0.014		
CD (0.05)		0.047		

Table - 68

Effect of phosphorus and potassium interaction on the crude protein content (per cent) of the fruit.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	1.893	1.725	1.867	1.828
25	1.802	1.968	1.745	1.838
50	1.838	1.610	1.797	1.738
Mean	1.844	1.734	1.803	
SEM ±		0.014		
CD (0.05)		0.047		

Table - 69

Effect of nitrogen and potassium interaction on the harvest index.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.237	0.160	0.280	0.226
30	0.247	0.243	0.237	0.242
60	0.190	0.357	0.172	0.239
Mean	0.224	0.253	0.229	
SEM ±		0.033		
CD (0.05)		0.117		

between P_1 and P_0. The K_0 level of potassium was significantly superior to K_2 and K_1 and the latter two were at par with each other.

b) Interaction effects:- The combination N_0P_0 recorded markedly higher percentage of crude protein (1.97) than other combinations of nitrogen and phosphorus. It was immediately followed by N_2P_1 and N_1P_1. The lowest value was recorded by N_0P_2 (Table 66). In the case of nitrogen and potassium interaction, N_1K_0 recorded the highest value (1.93) and it was at par with N_2K_1. The N_0K_1 combination recorded the lowest value (1.66) (Table 67). Among the phosphorus and potassium combinations, P_1K_1 recorded significantly higher value (1.97) and P_2K_1 recorded the lowest value (1.61) (Table 68).

The treatment effect on the crude protein content of fruit is summarised below. Application of nitrogen increased the protein content of fruit and phosphorus application decreased it. The effect of K was not consistent. In the case of interactions, there was, in general, a decrease in the content of protein with increased levels of phosphorus application. However with the intermediate level of nitrogen, a reverse trend was noticed upto the intermediate level of nitrogen, a

reverse trend was noticed upto the intermediate level of phosphorus. Nitrogen application, in general, resulted in an increase in protein content except at the highest and the lowest levels of phosphorus. Though significant, the results on nitrogen x potassium and phosphorus x potassium interactions were not consistent.

2.10 Harvest index

a) Main effects:- The main effects were not significant in any of the three nutrients (Table 56 and Appendix VIII).

b) Interaction effects:- Among the first order interactions, only nitrogen and potassium interaction showed significance (Table 69). Among the combinations, N_2K_1 recorded the highest value (0.253) and N_0K_1 gave the lowest value (0.160).

To summarise, the effects of nitrogen, phosphorus and potassium levels were not significant, with respect to the harvest index. The interaction, N x K was significant. The trend is however, erratic and it is difficult to arrive at any general conclusion.

3. Nutrient content of plant parts

3.1 Leaf

3.1.1 Nitrogen content (per cent)

a) Main effects:- On the 30th day of sowing, there was significant increase in the per cent of nitrogen in the leaf due to increasing doses of nitrogen (Table 70 and Appendix IX). But at 60th day, even though there was increase in mean values with increasing levels of nitrogen, N_1 and N_0 were statistically at par with each other. At 90th day, N_0 recorded significantly higher value and it was followed by N_2 and N_1. At all the three stages, there were significant differences between the phosphorus levels. The phosphorus level, P_0 recorded the highest nitrogen content and it was followed by P_2 and then by P_1 at all stages. In the case of potassium, K_2 level recorded significantly higher per cent of nitrogen after 30 days of sowing and K_0 and K_1 were at par with each other. After 60th and 90th days, K_1 recorded markedly higher value and K_0 and K_2 were at par with each other. Over the stages, nitrogen content decreased with advancing age.

Table - 70

Effect of levels of nitrogen, phosphorus and potassium on the percentage of these nutrients in the leaf at monthly intervals.

Treatments	Nitrogen(per cent)			Phosphorus(per cent)			Potassium(per cent)		
	30th day	60th day	90th day	30th day	60th day	90th day	30th day	60th day	90th day
Levels of N Kg/ha									
0	3.008	2.849	2.765	0.474	0.487	0.452	3.734	2.634	2.110
30	3.648	2.857	2.465	0.441	0.434	0.414	3.938	2.333	1.962
60	3.734	2.945	2.594	0.393	0.455	0.431	3.553	2.739	2.117
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	NS	Sig.	Sig.
SEM ±	0.012	0.010	0.007	0.004	0.005	0.009	0.076	0.012	0.015
CD (0.05)	0.035	0.029	0.022	0.012	0.014	0.025	-	0.034	0.043
Levels of P_2O_5 Kg/ha									
0	3.622	2.992	2.684	0.426	0.449	0.418	3.708	2.592	2.065
25	3.307	2.785	2.552	0.429	0.437	0.420	4.019	2.518	2.010
50	3.462	2.874	2.588	0.454	0.489	0.460	3.498	2.596	2.114
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	NS	Sig.	Sig.
SEM ±	0.012	0.010	0.007	0.004	0.005	0.009	0.076	0.012	0.015
C.D (0.05)	0.035	0.029	0.022	0.012	0.014	0.025	-	0.034	0.043
Levels of K_2O Kg/ha									
0	3.459	2.860	2.598	0.397	0.423	0.395	3.548	2.578	1.997
25	3.435	2.949	2.704	0.450	0.466	0.439	3.588	2.476	2.242
50	3.497	2.842	2.522	0.463	0.486	0.463	4.088	2.653	1.950
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	NS	Sig.	Sig.
SEM ±	0.012	0.010	0.007	0.004	0.005	0.009	0.076	0.012	0.015
CD (0.05)	0.035	0.029	0.022	0.012	0.014	0.025	-	0.034	0.043

b) Interaction effects:- Among the interactions of nitrogen and phosphorus, after 30 days of sowing, N_2P_0 recorded the highest value (3.867) and N_0P_1 recorded the lowest (2.820) (Table 71). After 60 days of sowing, N_0P_0 recorded significantly higher value and the lowest value was recorded by N_0P_1 (Table 72). At 90th day also N_0P_0 recorded the highest value (2.970) and the lowest value (2.198) was given by N_1P_2 (Table 73).

Among the combinations of nitrogen and potassium, after 30 days of sowing, the highest per cent of nitrogen in leaf was recorded by the combination N_2K_1 (3.837) and N_0K_1 recorded the lowest value (2.925) (Table 74). After 60 days, the combination N_1K_1 recorded the highest value and the lowest value by N_1K_2 (Table 75). After 90 days of sowing, N_0K_1 recorded the highest per cent of nitrogen in leaf (2.882) and the lowest value was recorded by N_1K_2(2.237) (Table 76).

The results of the phosphorus and potassium interactions were as follows. At 30th day, P_0K_0 recorded the highest nitrogen per cent in leaf (3.707) and the lowest value was at P_1K_0 (3.100) (Table 77).

Table - 71

Effect of nitrogen and phosphorus interaction on the percentage of nitrogen content in the leaf after 30 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	3.300	2.820	2.905	3.008
30	3.700	3.602	3.643	3.648
60	3.867	3.498	3.838	3.734
Mean	3.622	3.307	3.462	
SEM ±	0.017			
CD (0.05)	0.060			

Table - 72

Effect of nitrogen and phosphorus interaction on the percentage of nitrogen in the leaf after 60 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	3.075	2.545	2.927	2.849
30	2.934	2.827	2.710	2.857
60	2.967	2.883	2.985	2.945
Mean	2.992	2.785	2.874	
SEM ±	0.014			
CD (0.05)	0.051			

Table - 73

Effect of nitrogen and phosphorus interaction on the percentage of nitrogen in the leaf after 90 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	2.970	2.400	2.922	2.765
30	2.539	2.658	2.198	2.465
60	2.542	2.595	2.645	2.594
Mean	2.684	2.552	2.588	
SEM ±	0.011			
CD (0.05)	0.038			

Table - 74

Effect of nitrogen and potassium interaction on the percentage of nitrogen in the leaf after 30 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2.973	2.925	3.127	3.008
30	3.717	3.543	3.685	3.648
60	3.638	3.837	3.678	3.734
Mean	3.459	3.435	3.497	
SEM ±	0.017			
CD (0.05)	0.060			

Table - 75

Effect of nitrogen and potassium interaction on the percentage of nitrogen in the leaf after 60 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2.765	2.910	2.872	2.849
30	2.802	3.045	2.725	2.857
60	3.013	2.892	2.930	2.945
Mean	2.860	2.949	2.842	
SEM ±	0.014			
CD (0.05)	0.051			

Table - 76

Effect of nitrogen and potassium interaction on the percentage of nitrogen in the leaf after 90 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2.657	2.882	2.755	2.765
30	2.391	2.768	2.237	2.465
60	2.748	2.462	2.572	2.594
Mean	2.598	2.704	2.522	
SEM ±	0.011			
CD (0.05)	0.038			

Table - 77

Effect of phosphorus and potassium interaction on the percentage of nitrogen in the leaf after 30 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	3.707	3.695	3.465	3.622
25	3.100	3.377	3.443	3.307
50	3.572	3.233	3.582	3.462
Mean	3.459	3.435	3.497	
SEM ±	0.017			
CD (0.05)	0.060			

Table - 78

Effect of phosphorus and potassium interaction on the percentage of nitrogen in the leaf after 60 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2.967	3.000	3.010	2.992
25	2.663	2.952	2.740	2.785
50	2.950	2.895	2.777	2.874
Mean	2.860	2.949	2.842	
SEM ±	0.014			
CD (0.05)	0.051			

After 60 days P_0K_2 recorded the maximum nitrogen per cent and P_1K_0 recorded the lowest value (Table 78). After 90 days also, P_0K_2 recorded the highest value (2.804), but the lowest value (2.369) was recorded by P_2K_2, (Table 79).

The effect of the three nutrients may be summarised as follows:-

i) Application of nitrogen resulted in an increase in nitrogen content of leaf at all stages. The only exception was in the case of the last stage, 90 days after sowing, when control (0 kg N/ha) recorded higher nitrogen content than the other two treatments receiving 30 and 60 kg N/ha.

ii) Phosphorus application tended to decrease nitrogen per cent in leaf though the extent of decrease was small. Again, there are a few exceptions of a further increase in the content of this nutrient at the highest level of phosphorus (50 kg P_2O_5/ha) as compared to the intermediate level of 25 kg P_2O_5/ha.

iii) The variation in nitrogen content with increasing levels of potassium was small and highly

inconsistent though the treatment effects were significant at all the stages.

iv) There was a steady decrease in nitrogen per cent of leaf with advancing age in all the treatments.

v) A large number of interactions were significant but the trend was so much different at varying levels and at different stages, that arriving a general pattern of response to interaction between different nutrients is difficult.

3.1.2 Phosphorus content (per cent)

a) Main effects:- At 30th day of sowing, phosphorus content of leaf significantly decreased with increasing levels of nitrogen (Table 70 and Appendix IX). After 60 days, N_2 level recorded significantly higher percentage of phosphorus than N_1 but N_2 was inferior to N_0. At 90th day also, N_0 recorded highest value but it was at par with N_2 which was also at par with N_1.

At all stages, phosphorus content in the leaf at P_2 level was significantly higher than at P_1 and P_0, these two being at par.

After 30 and 60 days, increasing levels of

Table - 79

Effect of phosphorus and potassium interaction on the percentage of nitrogen in the leaf after 90 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2.595	2.654	2.804	2.684
25	2.514	2.748	2.392	2.552
50	2.686	2.710	2.369	2.588
Mean	2.598	2.704	2.522	
SEM ±	0.011			
CD (0.05)	0.038			

Table - 80

Effect of nitrogen and phosphorus interaction on the percentage of phosphorus in the leaf after 30 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	0.438	0.505	0.480	0.474
30	0.430	0.440	0.451	0.441
60	0.409	0.343	0.428	0.393
Mean	0.426	0.429	0.454	
SEM ±	0.006			
CD (0.05)	0.021			

Table - 81

Effect of nitrogen and phosphorus interaction on the percentage of phosphorus in the leaf after 60 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	0.532	0.435	0.490	0.487
30	0.409	0.435	0.459	0.434
60	0.406	0.440	0.518	0.455
Mean	0.449	0.437	0.489	
SEM ±	0.007			
CD (0.05)	0.025			

Table 82

Effect of nitrogen and phosphorus interaction on the percentage of phosphorus in the leaf after 90 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	0.468	0.439	0.450	0.452
30	0.381	0.389	0.473	0.414
60	0.404	0.434	0.456	0.431
Mean	0.418	0.420	0.460	
SEM ±	0.012			
CD (0.05)	0.043			

Table - 83

Effect of nitrogen and potassium interaction on the percentage of phosphorus in the leaf after 30 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.375	0.548	0.500	0.474
30	0.443	0.425	0.455	0.441
60	0.372	0.375	0.433	0.393
Mean	0.397	0.450	0.463	
SEM ±	0.006			
CD (0.05)	0.021			

Table - 84

Effect of nitrogen and potassium interaction on the percentage of phosphorus in the leaf after 60 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.500	0.430	0.525	0.487
30	0.325	0.475	0.500	0.434
60	0.442	0.497	0.428	0.455
Mean	0.423	0.466	0.486	
SEM ±	0.007			
CD (0.05)	0.025			

Table - 85

Effect of nitrogen and potassium interaction on the percentage of phosphorus in the leaf after 90 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.448	0.425	0.484	0.452
30	0.311	0.449	0.481	0.414
60	0.425	0.444	0.426	0.431
Mean	0.395	0.439	0.463	
SEM ±	0.012			
CD (0.05)	0.043			

Table - 86

Effect of phosphorus and potassium interaction on the percentage of phosphorus in the leaf after 30 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.353	0.492	0.432	0.426
25	0.370	0.423	0.495	0.429
50	0.467	0.433	0.462	0.454
Mean	0.397	0.450	0.463	
SEM ±	0.006			
CD (0.05)	0.021			

potassium increased the phosphorus content of leaf, whereas at 90th day, even though there was increase in the percentage content of phosphorus with increasing levels, K_2 and K_1 were at par.

Over the stages, there was a general increase in phosphorus content of leaf upto the second stage followed by a decrease thereafter. The only exception was when nitrogen was applied at 30 kg/ha in which case there was a steady decrease in phosphorus content with advancing age.

b) Interaction effects:- After 30 days of sowing, among the combinations of nitrogen and phosphorus N_0P_1 combination recorded the highest phosphorus percentage of leaf (0.505) and N_2P_1 recorded the lowest value (0.343) (Table 80). After 60 days, N_0P_0 combination recorded the highest phosphorus percentage (0.532) and it was at par with N_2P_2. The combination N_2P_0 recorded the lowest value (0.406) (Table 81). After 90 days, the combination, N_1P_2 recorded the highest value (0.473) and N_1P_0 recorded the lowest value (0.381) (Table 82).

In the case of interaction between nitrogen and

potassium, after 30 days of sowing, N_0K_1 recorded the highest percentage of phosphorus in leaf (0.548). The lowest value was recorded by the combination N_2K_0 (0.372) (Table 83). After 60 days, N_0K_2 recorded the maximum phosphorus content of the leaf and N_2K_0 recorded the lowest value (Table 84). After 90 days also, N_0K_2 recorded the highest value but the lowest value was recorded by N_0K_1 (Table 85).

The phosphorus and potassium interactions were significant only at 30th and 60th days. On the 30th day, the combination, P_1K_2 recorded the highest phosphorus content of leaf (0.495) and P_0K_0 recorded the lowest value (0.353) (Table 86). After 60 days, P_2K_1 recorded the highest value and P_0K_0 recorded the lowest value (Table 87).

A summary of the results on the effect of different treatments on the phosphorus content of leaf is given below.

1) Applied nitrogen had a depressing effect on the phosphorus content. This effect was especially marked upto the intermediate level of nitrogen (30 kg/ha). However, this pattern was not very regular and consistent.

ii) There was a consistent, significant and marked increase in phosphorus content of leaf with increasing levels of applied phosphorus at all the stages.

iii) Application of potassium also tended to increase the phosphorus content of leaf tissue. This trend is also consistent at all the stages of observation.

iv) As in the case of nitrogen content of leaves, a number of interactions were statistically significant. However, the trend is not regular and it is difficult to draw meaningful conclusions out of these protracted results.

3.1.3 Potassium content (percentage)

a) Main effects:- After 30 days, none of the main effects showed significant difference (Table 70 and Appendix X). After 60 days, there was significant difference in potassium content between nitrogen levels. At this stage, N_2 level recorded significantly higher value than N_0 and N_1. The lowest value was recorded by N_1. The trend after 90 days was also similar but N_2 and N_0 levels were at par. In the case of phosphorus,

Table - 87

Effect of phosphorus and potassium interaction on the percentage of phosphorus in the leaf after 60 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.400	0.489	0.458	0.449
25	0.403	0.408	0.499	0.437
50	0.465	0.502	0.500	0.489
Mean	0.423	0.466	0.486	
SEM ±	0.007			
CD (0.05)	0.025			

Table - 88

Effect of nitrogen and phosphorus interaction on the percentage of potassium in the leaf after 60 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	2.780	2.350	2.773	2.634
30	2.228	2.437	2.333	2.333
60	2.768	2.768	2.682	2.739
Mean	2.592	2.518	2.596	
SEM ±	0.016			
CD (0.05)	0.058			

Table - 89

Effect of nitrogen and phosphorus interaction on the percentage of potassium in the leaf after 90 days of sowing.

Levels of N Kg/ha.	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	2.067	1.940	2.323	2.110
30	1.895	2.032	1.958	1.962
60	2.233	2.058	2.060	2.117
Mean	2.065	2.010	2.114	
SEM ±	0.021			
CD (0.05)	0.074			

Table - 90

Effect of nitrogen and potassium interaction on the percentage of potassium in the leaf after 60 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2.518	2.793	2.592	2.634
30	2.275	2.470	2.253	2.333
60	2.960	2.095	2.583	2.739
Mean	2.598	2.476	2.653	
SEM ±	0.016			
CD (0.05)	0.058			

Table - 91

Effect of nitrogen and potassium interaction on the percentage of potassium in the leaf after 90 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2.057	2.340	1.933	2.110
30	1.757	2.127	2.002	1.962
60	2.177	2.260	1.915	2.117
Mean	1.997	2.942	1.950	
SEM ±	0.021			
CD (0.05)	0.074			

Table - 92

Effect of phosphorus and potassium interaction on the percentage of potassium in the leaf after 60 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2.513	2.737	2.527	2.592
25	2.857	2.425	2.273	2.518
50	2.363	2.797	2.628	2.596
Mean	2.578	2.476	2.653	
SEM ±	0.016			
CD (0.05)	0.058			

Table - 93

Effect of phosphorus and potassium interaction on the percentage of potassium content of leaf after 90 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2.012	2.255	1.930	2.065
25	2.075	2.025	1.928	2.010
50	1.903	2.447	1.992	2.114
Mean	1.997	2.242	1.950	
SEM ±	0.021			
CD (0.05)	0.074			

after 60 and 90 days, P_2 recorded higher value and it was followed by P_0 and P_1 and at the former stage P_2 and P_0 were at par. In the case of potassium, there was significant difference between the levels at 60th day stage, the highest value being recorded by K_1 and the lowest value by K_2. The same trend was noticed at 90th day also. Over the stages, at all levels of the three nutrients there was decrease in potassium content in leaf with advancing growth upto the 90th day.

b) Interaction effects:- After 30 days, the interaction between nitrogen and phosphorus was not significant. After 60 days, N_0P_0 recorded the highest value (2.780) and N_1P_0 recorded the lowest (2.228) (Table 88). After 90 days of sowing, N_0P_2 recorded the highest value (2.592) and N_1P_0 recorded the lowest value (2.275) (Table 89).

The interaction between nitrogen and potassium was not significant on the 30th day. After 60th day, N_2K_0 recorded the highest percentage of potassium in the leaf and the lowest value was recorded by N_1K_2 (Table 90). After 90 days, N_0K_1 gave the highest value and N_1K_0 gave the lowest value (Table 91).

The effect of phosphorus and potassium interaction was not significant after 30 days. At 60th day, P_1K_0 recorded the highest value and P_1K_2 recorded the lowest (Table 92). After 90 days, P_2K_1 recorded the highest value and P_2K_0 gave the lowest potassium content (Table 93).

The results may be summarised as follows:-

i) The effects of applied nitrogen and phosphorus on the potassium content of leaf were not consistent though the treatment effects were statistically significant at the second and third stages.

ii) Though not very regular and consistent, there was a trend towards increase in potassium content of leaf with increasing doses of potassium fertilizer.

iii) Though quite a few interaction effects were significant, the results showed no regular trend in the variation of potassium content.

3.2 Stem

3.2.1 Nitrogen content (per cent)

a) Main effects:- There was significant increase

in the nitrogen content of stem due to the higher doses of nitrogen at 30th day after sowing, whereas at 60th day, higher doses decreased the value and the difference between N_0 and N_1 was not significant.(Table 94 and Appendix X). But the trend after 90 days was quite different. At this stage, N_0 recorded the highest value and N_1 the lowest.

The effect of phosphorus levels was also significant at all the stages. On 30th day, increasing levels of phosphorus decreased the nitrogen content of stem but P_1 and P_2 were at par. After 60 days, even-though the value increased with the higher doses, P_0 and P_1 were not statistically different. At 90th day, there was significant difference between the levels, P_0 recording the highest value. The lowest value was recorded by P_1 at this stage.

The potassium levels showed significant differences only at the first and third stages. At the first stage, nitrogen content significantly decreased with the increasing levels whereas after 90 days K_1 recorded significantly higher value. There was no significant difference between K_2 and K_0 even though K_0 recorded the lowest value.

Table - 94

Effect of levels of nitrogen, phosphorus and potassium on the percentage of these nutrients in the stem at monthly intervals.

Treatments	Nitrogen (per cent)			Phosphorus (per cent)			Potassium(per cent)		
	30th day	60th day	90th day	30th day	60th day	90th day	30th day	60th day	90th day
Levels of N (Kg/ha)									
0	1.316	0.742	0.882	0.452	0.338	0.315	5.161	2.513	2.132
30	1.686	0.733	0.639	0.395	0.281	0.268	4.374	2.255	1.759
60	1.826	0.663	0.827	0.390	0.289	0.348	4.476	1.924	1.672
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SEM ±	0.022	0.005	0.005	0.007	0.003	0.005	0.008	0.005	0.037
CD (0.05)	0.064	0.014	0.013	0.022	0.010	0.014	0.024	0.016	0.109
Levels of P_2O_5 Kg/ha									
0	1.761	0.689	0.907	0.413	0.331	0.312	4.809	2.299	1.823
25	1.561	0.694	0.678	0.441	0.259	0.317	4.597	2.073	1.909
50	1.506	0.756	0.762	0.377	0.318	0.303	4.604	2.316	1.824
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	NS	Sig.	Sig.	NS
SEM ±	0.022	0.005	0.005	0.007	0.003	0.005	0.008	0.005	0.037
CD (0.05)	0.064	0.014	0.013	0.022	0.010	-	0.024	0.016	-
Levels of K_2O Kg/ha									
0	1.733	0.705	0.732	0.381	0.339	0.328	4.821	2.349	1.868
25	1.581	0.719	0.872	0.450	0.289	0.292	4.660	2.197	1.782
50	1.813	0.718	0.743	0.401	0.279	0.311	4.531	2.145	1.913
'F' test	Sig.	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SEM ±	0.022	0.005	0.005	0.007	0.003	0.005	0.008	0.005	0.037
CD (0.05)	0.064	-	0.013	0.022	0.010	0.014	0.024	0.016	0.109

Over the stages, there was a marked drop in the content of nitrogen from 30th day to 60th day, in most cases to less than half. From 60th to 90th day, the nitrogen content remained practically unchanged. The above pattern of stage-wise variation did not appear to be appreciably affected by the different treatments.

b) <u>Interaction effects</u>:- After 30 days, among the combinations of nitrogen and phosphorus N_2P_0 and N_1P_0 recorded the higher values and they were at par. The combinations of N_0 with different phosphorus levels recorded the lowest values and they were also at par (Table 95). After 60 days, N_0P_2 recorded the highest value and N_2P_1 recorded the lowest (Table 96). After 90 days also, N_2P_0 recorded the highest value as in the first case. The lowest value was recorded by the N_1P_1 combination (Table 97).

In the case of interaction between nitrogen and potassium after 30 days, N_2K_0 recorded the highest value and N_0K_2 recorded the lowest value (Table 98). After 60 days, N_1K_0 recorded the highest value and N_2K_0 recorded the lowest value (Table 99). After 90 days

Table - 95

Effect of nitrogen and phosphorus interaction on the percentage of nitrogen in the stem after 30 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	1.368	1.297	1.282	1.316
30	1.945	1.593	1.518	1.686
60	1.970	1.792	1.717	1.826
Mean	1.761	1.561	1.506	
SEM ±	0.032			
CD (0.05)	0.112			

Table - 96

Effect of nitrogen and phosphorus interaction on the percentage of nitrogen in the stem after 60 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	0.605	0.775	0.847	0.742
30	0.763	0.707	0.730	0.733
60	0.698	0.600	0.692	0.663
Mean	0.689	0.694	0.756	
SEM ±	0.007			
CD (0.05)	0.023			

Table - 97

Effect of nitrogen and phosphorus interaction on the percentage of nitrogen in the stem after 90 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	1.022	0.807	0.813	0.882
30	0.603	0.547	0.766	0.639
60	1.098	0.681	0.702	0.827
Mean	0.907	0.678	0.762	
SEM ±	0.007			
CD (0.05)	0.023			

Table - 98

Effect of nitrogen and potassium interaction on the percentage of nitrogen in the stem after 30 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	1.348	1.303	1.295	1.316
30	1.783	1.552	1.522	1.686
60	2.068	1.887	1.723	1.826
Mean	1.733	1.581	1.813	
SEM ±	0.032			
CD (0.05)	0.112			

Table - 99

Effect of nitrogen and potassium interaction on the percentage of nitrogen in the stem after 60 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.733	0.751	0.738	0.742
30	0.640	0.675	0.695	0.733
60	0.547	0.723	0.720	0.663
Mean	0.705	0.719	0.718	
SEM ±	0.007			
CD (0.05)	0.023			

Table - 100

Effect of nitrogen and potassium interaction on the percentage of nitrogen in the stem after 90 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.817	0.991	0.838	0.882
30	0.657	0.746	0.614	0.639
60	0.823	0.880	0.778	0.827
Mean	0.732	0.872	0.743	
SEM ±	0.009			
CD (0.05)	0.023			

Table - 101

Effect of phosphorus and potassium interaction on the percentage of nitrogen in the stem after 30 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	1.995	1.777	1.512	1.761
25	1.457	1.715	1.510	1.561
50	1.748	1.250	1.518	1.506
Mean	1.733	1.581	1.813	
SEM ±	0.032			
CD (0.05)	0.112			

Table - 102

Effect of phosphorus and potassium interaction on the percentage of nitrogen in the stem after 60 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.777	0.602	0.688	0.689
25	0.600	0.810	0.672	0.694
50	0.738	0.737	0.793	0.756
Mean	0.705	0.719	0.718	
SEM ±	0.007			
CD (0.05)	0.023			

N_0K_1 recorded the highest value and N_1K_0 recorded the lowest value (Table 100).

After 30 days, among the combinations of phosphorus and potassium P_0K_0 recorded the highest nitrogen percentage of stem and the lowest value was given by P_2K_1 (Table 101). At 60th day after sowing, the P_1K_1 combination recorded the highest value and P_1K_0 recorded the lowest value (Table 102). After 90 days P_0K_1 recorded the highest value and P_2K_2 recorded the lowest value (Table 103).

The summary of the above results on the effect of graded doses of fertiliser nutrients on the nitrogen content of stem is given below.

i) The main effects were highly variable and no persistant trend of treatment variation in nitrogen content was observed. Even application of nitrogen did not appear to bring about a steady increase in the content of nitrogen in this plant part. However application of phosphorus tended to decrease the nitrogen content. Effect of applied potassium was inconsistent.

ii) Over the stages, there was a conspicuous

drop in nitrogen content from 30th to 60th day. The change in the content of this nutrient with further advance in growth was not appreciable. The above stage-wise trend did not appear to be affected very much by the different treatments.

iii) Though a large number of interactions were statistically significant, the treatment effects were found to be highly variable making it difficult to arrive at a general trend of interaction.

3.2.2 Phosphorus content (per cent)

a) Main effects:- At the first two stages, the phosphorus content of stem progressively decreased with increasing nitrogen levels and N_1 and N_2 were at par (Table 94 and Appendix XI). But at the third stage N_2 recorded the highest value and N_1 recorded the lowest.

Regarding the effect of phosphorus, the effects were significant only at 30th and 60th days. The P_1 and P_0 levels recorded highest values and P_2 and P_1 recorded lowest values at 30th and 60th days, respectively.

In the case of potassium, K_1 and K_2 recorded higher values than K_0, but K_2 and K_0 were at par, on

the 30th day. At 60th day, there was a decrease in phosphorus content of stem with increasing levels of potassium and K_1 and K_2 were at par. At 90th day, K_0 recorded the highest value and K_1, the lowest.

With advancing age, there was a general trend of decrease in phosphorus content though the extent of decrease was, in general, small. Also, the different treatments differed in the pattern, there being even an increase in phosphorus content with time in some cases.

b) <u>Interaction effects</u>:- At 30th day, among the combinations of nitrogen and phosphorus N_0P_0 recorded the highest percentage of phosphorus in stem and N_1P_2 recorded the lowest value (Table 104). After 60 days, N_0P_2 recorded the highest value and N_2P_1 recorded the lowest value (Table 105). At 90th day, N_2P_1 registered significantly higher value than all other combinations and N_1P_2 recorded the lowest value (Table 106).

The nitrogen and potassium interaction was significant only at 30th and 60th days. At 30th day, N_0K_1 recorded the highest value and N_1K_0 recorded the lowest value (Table 107). After 60 days, N_0K_0 recorded

Table - 103

Effect of phosphorus and potassium interaction on the percentage of nitrogen in the stem after 90 days of sowing.

Levels P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.813	1.053	0.857	0.907
25	0.656	0.640	0.739	0.678
50	0.728	0.924	0.634	0.762
Mean	0.732	0.872	0.743	
SEM ±	0.007			
CD (0.05)	0.023			

Table - 104

Effect of nitrogen and phosphorus interaction on the percentage of phosphorus in the stem after 30 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	0.500	0.490	0.365	0.452
30	0.383	0.433	0.353	0.395
60	0.357	0.400	0.413	0.390
Mean	0.413	0.441	0.377	
SEM ±	0.011			
CD (0.05)	0.038			

Table - 105

Effect of nitrogen and phosphorus interaction on the percentage of phosphorus in the stem after 60 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	0.353	0.302	0.357	0.338
30	0.300	0.258	0.282	0.281
60	0.335	0.217	0.317	0.289
Mean	0.331	0.259	0.318	
SEM ±	0.005			
CD (0.05)	0.018			

Table - 106

Effect of nitrogen and phosphorus interaction on the percentage of phosphorus in the stem after 90 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	0.320	0.296	0.330	0.315
30	0.277	0.287	0.242	0.268
60	0.337	0.370	0.337	0.348
Mean	0.312	0.317	0.303	
SEM ±	0.007			
CD (0.05)	0.025			

Table - 107

Effect of nitrogen and potassium interaction on the percentage of phosphorus in the stem after 30 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.440	0.523	0.392	0.452
30	0.320	0.415	0.435	0.395
60	0.383	0.412	0.375	0.390
Mean	0.381	0.450	0.401	
SEM ±	0.011			
CD (0.05)	0.038			

Table - 108

Effect of nitrogen and potassium interaction on the percentage of phosphorus in the stem after 60 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.378	0.360	0.273	0.338
30	0.322	0.210	0.312	0.281
60	0.317	0.300	0.255	0.289
Mean	0.339	0.289	0.279	
SEM ±	0.005			
CD (0.05)	0.018			

Table - 109

Effect of phosphorus and potassium interaction onthe percentage of phosphorus in the stem after 30 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.413	0.468	0.358	0.413
25	0.393	0.458	0.472	0.441
50	0.337	0.423	0.372	0.377
Mean	0.381	0.450	0.401	
SEM ±	0.011			
CD (0.05)	0.038			

Table - 110

Effect of phosphorus and potassium interaction on the percentage of phosphorus in the stem after 60 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.392	0.322	0.280	0.331
25	0.273	0.212	0.291	0.259
50	0.355	0.335	0.265	0.318
Mean	0.339	0.289	0.279	
SEM ±	0.005			
CD (0.05)	0.018			

the highest value and N_1K_1 recorded the lowest phosphorus content of stem (Table 108).

The interaction between phosphorus and potassium was significant at all stages. After 30 days, P_1K_2 recorded the highest value and P_2K_0 recorded the lowest phosphorus content of stem (Table 109). After 60 days, P_0K_0 recorded the highest phosphorus content and P_1K_1 recorded the lowest value (Table 110). At 90th day, P_1K_2 recorded the highest value and P_2K_2 recorded the lowest (Table 111).

The data on the phosphorus content of stem are summarised below.

i) With increasing levels of nitrogen, phosphorus and potassium, the phosphorus content in stem varied only slightly though the differences were significant at all the stages. Further, there was no distinct trend of variation in the percentage content of phosphorus because of the different treatments. Even application of graded levels of phosphorus failed to register a corresponding increase in the phosphorus content of stem.

ii) With advancing age, there was a trend of decrease in phosphorus content, though the extent of decrease was not appreciable. The different treatments tended to differ in the nature of variation in phosphorus content with time.

iii) As in the case of nitrogen content, a number of interactions were significant in the case of phosphorus content also. However, the results showed no regular pattern and it may not be possible to draw meaningful conclusions.

3.2.3 Potassium content (per cent)

a) Main effects:- At all stages, control level of nitrogen gave maximum potassium content of stem (Table 94 and Appendix XI). The lowest value was recorded by N_1 at 30th and by N_2 at other stages. There was significant difference between the levels except between N_1 and N_2 at 90th day. Effect of phosphorus was significant only at 30th and 60th days. At 30th day, P_0 recorded the highest value and P_1 and P_2 were at par. At 60th day, P_2 recorded the highest value and it was at par with P_0. The phosphorus level P_1 recorded

Table - 111

Effect of phosphorus and potassium interaction on the percentage of phosphorus in the stem after 90 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.328	0.292	0.313	0.312
25	0.328	0.265	0.352	0.317
50	0.328	0.212	0.268	0.303
Mean	0.328	0.256	0.311	
SEM ±	0.007			
CD (0.05)	0.025			

Table - 112

Effect of nitrogen and phosphorus interaction on the percentage of potassium in the stem after 30 days of sowing

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	5.535	4.723	5.225	5.161
30	4.630	4.548	3.945	4.374
60	4.263	4.520	4.643	4.476
Mean	4.809	4.597	4.604	
SEM ±	0.011			
CD (0.05)	0.041			

Table - 113

Effect of nitrogen and phosphorus interaction on the percentage of potassium in the stem after 60 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	2.528	2.123	2.887	2.513
30	2.235	2.207	2.323	2.255
60	2.135	1.882	1.748	1.924
Mean	2.299	2.073	2.316	
SEM ±	0.008			
CD (0.05)	0.027			

Table - 114

Effect of nitrogen and phosphorus interaction on the percentage of potassium in the stem after 90 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	2.023	2.208	2.165	2.132
30	1.695	1.748	1.835	1.759
60	1.772	1.772	1.472	1.672
Mean	1.823	1.909	1.824	
SEM ±	0.053			
CD (0.05)	0.189			

Table - 115

Effect of nitrogen and potassium interaction on the percentage of potassium in the stem after 30 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	4.775	5.387	5.322	5.161
30	4.793	4.555	3.775	4.374
60	4.893	4.038	4.495	4.476
Mean	4.821	4.660	4.531	
SEM ±	0.011			
CD (0.05)	0.041			

Table - 116

Effect of nitrogen and potassium interaction on the percentage of potassium in the stem after 60 of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2.555	2.655	2.328	2.513
30	2.363	1.895	2.507	2.255
60	2.130	2.042	1.600	1.924
Mean	2.349	2.197	2.145	
SEM ±	0.008			
CD (0.05)	0.027			

Table - 117

Effect of nitrogen and potassium interaction onthe percentage of potassium in the stem after 90 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	1.964	2.030	2.402	2.132
30	1.867	1.763	1.648	1.759
60	1.775	1.553	1.688	1.672
Mean	1.868	1.782	1.913	
SEM ±	0.053			
CD (0.05)	0.189			

Table - 118

Effect of phosphorus and potassium interaction on the percentage of potassium in the stem after 30 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	4.603	4.943	4.882	4.809
25	4.465	4.637	4.690	4.597
50	5.393	4.400	4.020	4.604
Mean	4.821	4.660	4.531	
SEM ±	0.011			
CD (0.05)	0.041			

Table - 119

Effect of phosphorus and potassium interaction on the percentage of potassium in the stem after 60 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2.405	2.348	2.145	2.299
25	2.252	1.783	2.183	2.073
50	2.392	2.460	2.107	2.316
Mean	2.349	2.197	2.145	
SEM ±	0.008			
CD (0.05)	0.027			

Table - 120

Effect of phosphorus and potassium interaction on the percentage of potassium in the stem after 90 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	1.753	1.979	1.920	1.823
25	2.004	1.530	2.193	1.909
50	1.848	2.020	1.623	1.824
Mean	1.868	1.732	1.913	
SEM ±	0.053			
CD (0.05)	0.189			

the lowest value. In the case of potassium levels, the content of potassium significantly decreased with increasing levels at the first two stages. At 90th day, K_2 recorded highest value and it was at par with K_0 which was also at par with K_1.

Between the stages, there was decrease in the content of potassium in stem with time, the extent of decrease being most conspicuous between 30 and 60 days. It further decreased on the 90th day though the magnitude of decrease was not that substantial. This decreasing trend was common for all the treatments.

b) Interaction effects:- The effect of nitrogen and phosphorus interaction was significant at all stages (Table 112). The highest value was recorded by N_0P_0 and the lowest by N_1P_2 combinations. After 60 days, the highest value was recorded by N_0P_2 and the lowest value was recorded by N_2P_2 combinations (Table 113). After 90th day, the N_0P_1 combination gave the highest value and N_2P_2 recorded the lowest value (Table 114).

Nitrogen and potassium interactions were also significant at all stages. After 30 days, N_0K_1 recorded

the highest potassium content of stem and N_1K_2 recorded the lowest value (Table 115). At 60th day also, N_0K_1 recorded the highest value, but N_2K_2 combination recorded the lowest value (Table 116). At 90th day, N_0K_2 and N_2K_1 recorded the highest and the lowest values respectively (Table 117).

The phosphorus and potassium interactions were significant at all stages. After 30 days, P_2K_0 recorded the highest potassium content of stem and P_2K_2 recorded the lowest value (Table 118). At 60th day, P_2K_1 recorded the highest value and P_1K_1 recorded the lowest (Table 119). After 90 days, P_1K_2 and P_1K_1 recorded the highest and the lowest values respectively (Table 120).

The results on the potassium content of stem are summarised as follows.

i) Application of nitrogen tended to lower the potassium content of stem.

ii) Phosphorus application though had statistically significant effect, the data showed no consistent pattern of variation in potassium content with varying levels of application of phosphorus.

iii) Application of potassium also did not show any persistent effect on potassium content. At the first two stages, potassium contents of treatments receiving potassium application were even lower than the control.

iv) Between the stages, there was decrease in the content of potassium in stem with time, the extent of decrease being most conspicuous between 30 and 60 days. It further decreased on the 90th day though the magnitude of decrease was not that substantial. The different treatments did not affect the above decreasing trend.

v) As in the case of nitrogen and phosphorus contents, most of the two-way interactions were significant. Yet, they followed no regular trend and it is difficult to draw useful conclusions out of them.

3.3 Fruit

3.3.1 Nitrogen content (per cent)

a) Main effects:- Nitrogen levels were not significant at 60th day of sowing whereas at 90th day, N_0 recorded significantly higher value and N_1 recorded

the lowest value and was inferior to N_2 and N_0 (Table 121 and Appendix XII). Effect of phosphorus was also not significant after 60 days, but at 90th day, P_1 and P_0 were at par and superior to P_2 level. In the case of potassium at 60th day, K_0 recorded the highest nitrogen percentage and it was at par with K_2. The lowest value was recorded by K_1 level. At 90th day also, K_0 was superior to K_1 and K_2 and these two were at par.

Over the stages, there was no appreciable change in the nitrogen content of fruits.

b) Interaction effects:- The interaction between nitrogen and phosphorus was significant at both stages (Table 122). The treatment N_2P_1 recorded the highest value and the N_0P_2 recorded the lowest. At 90th day, N_0P_1 combination gave the highest value and the N_1P_1 recorded the lowest value (Table 123).

The interaction between nitrogen and potassium was also significant at both the stages. The combination N_0K_0 gave the highest nitrogen content of fruit at 60th day of sowing. The lowest value was recorded by N_0K_1 (Table 124). After 90 days also, the highest value was recorded by N_0K_0, but the lowest value was in N_1K_2 combination (Table 125).

Table - 121

Effect of levels of nitrogen, phosphorus and potassium on the percentage of these nutrients in the fruit at monthly intervals.

Treatments	Nitrogen (per cent)		Phosphorus (per cent)		Potassium (per cent)	
	60th day	90th day	60th day	90th day	60th day	90th day
Levels of N Kg/ha						
0	2.444	2.560	0.540	0.553	3.072	2.977
30	2.462	2.441	0.542	0.569	3.136	3.015
60	2.533	2.491	0.552	0.554	3.035	2.970
'F' test	NS	Sig.	NS	Sig.	Sig.	NS
SEM ±	0.027	0.006	0.004	0.002	0.011	0.013
CD (0.05)	-	0.019	-	0.008	0.031	-
Levels of P_2O_5 Kg/ha						
0	2.522	2.513	0.531	0.528	2.992	2.936
25	2.489	2.513	0.565	0.564	3.042	2.971
50	2.428	2.466	0.576	0.584	3.209	3.051
'F' test	NS	Sig.	Sig.	Sig.	Sig.	Sig.
SEM ±	0.027	0.006	0.004	0.002	0.011	0.013
CD (0.05)	-	0.019	0.011	0.008	0.031	0.040
Levels of K_2O Kg/ha						
0	2.543	2.545	0.540	0.544	3.039	2.961
25	2.396	2.479	0.565	0.573	3.099	2.984
50	2.500	2.469	0.560	0.559	3.104	3.018
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SEM ±	0.027	0.006	0.004	0.002	0.011	0.013
CD (0.05)	0.079	0.019	0.011	0.008	0.031	0.040

The interaction between phosphorus and potassium was significant. The combination P_1K_0 recorded the highest value and P_1K_2 recorded the lowest value at both stages (Tables 126 and 127).

The results on the nitrogen content of fruits may be summarised as follows:

i) The direct effects of graded levels of the three nutrients were highly inconsistent though statistically significant in most cases. Even application of nitrogen failed to give a persistent increase in the nitrogen content of fruits.

ii) Over the stages, there was no appreciable change in nitrogen content of fruits.

iii) Interaction effects were significant in most cases but the results were inconsistant.

3.3.2 Phosphorus content (per cent)

a) Main effects:- The effect of nitrogen was not significant at 60th day, but at 90th day, it was significant and N_1 and N_0 recorded the highest and lowest values respectively (Table 121 and Appendix XII). The N_2 level was at par with N_0 level in the case phosphorus,

Table - 122

Effect of nitrogen and phosphorus interaction on the percentage of nitrogen in fruits after 60 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	2.585	2.442	2.305	2.444
30	2.453	2.422	2.512	2.462
60	2.528	2.602	2.465	2.533
Mean	2.522	2.489	2.428	
SEM ±	0.038			
CD (0.05)	0.137			

Table - 123

Effect of nitrogen and phosphorus interaction on the percentage of nitrogen in fruits after 90 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	2.574	2.606	2.502	2.560
30	2.485	2.371	2.469	2.441
60	2.483	2.562	2.426	2.491
Mean	2.513	2.513	2.466	
SEM ±	0.009			
CD (0.05)	0.032			

Table - 124

Effect of nitrogen and potassium interaction on the percentage of nitrogen in fruits after 60 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2.665	2.093	2.573	2.444
30	2.543	2.522	2.322	2.462
60	2.422	2.572	2.605	2.533
Mean	2.543	2.396	2.500	
SEM ±	0.038			
CD (0.05)	0.137			

Table - 125

Effect of nitrogen and potassium interaction on the percentage of nitrogen in fruits after 90 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2.626	2.500	2.556	2.560
30	2.593	2.412	2.318	2.441
60	2.417	2.525	2.532	2.491
Mean	2.545	2.479	2.469	
SEM ±	0.009			
CD (0.05)	0.032			

Table - 126

Effect of phosphorus and potassium interaction on the percentage of nitrogen in fruits after 60 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2.562	2.442	2.563	2.522
25	2.642	2.455	2.290	2.489
50	2.428	2.370	2.565	2.428
Mean	2.543	2.396	2.500	
SEM ±	0.038			
CD (0.05)	0.137			

Table - 127

Effect of phosphorus and potassium interaction on the percentage of nitrogen in fruits after 90 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2.594	2.438	2.509	2.513
25	2.608	2.601	2.332	2.513
50	2.432	2.400	2.565	2.566
Mean	2.545	2.479	2.469	
SEM ±	0.009			
CD (0.05)	0.032			

Table - 128

Effect of nitrogen and phosphorus interaction on the percentage of phosphorus in fruits after 60 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	0.518	0.582	0.575	0.540
30	0.528	0.578	0.577	0.542
60	0.545	0.535	0.577	0.552
Mean	0.531	0.565	0.576	
SEM ±	0.006			
CD (0.05)	0.020			

Table - 129

Effect of nitrogen and phosphorus interaction on the percentage of phosphorus in fruits after 90 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	0.508	0.578	0.573	0.553
30	0.532	0.573	0.602	0.569
60	0.545	0.540	0.577	0.554
Mean	0.528	0.564	0.584	
SEM ±	0.003			
CD (0.05)	0.014			

Table - 130

Effect of nitrogen and potassium interaction on the percentage of phosphorus in fruits after 60 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.515	0.587	0.573	0.540
30	0.540	0.570	0.573	0.542
60	0.585	0.538	0.533	0.552
Mean	0.540	0.565	0.560	
SEM ±	0.006			
CD (0.05)	0.020			

Table - 131

Effect of nitrogen and potassium interaction on the percentage of phosphorus in fruits after 90 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.508	0.590	0.563	0.553
30	0.538	0.590	0.577	0.569
60	0.585	0.540	0.537	0.554
Mean	0.544	0.573	0.559	
SEM ±	0.003			
CD (0.05)	0.014			

Table - 132

Effect of phosphorus and potassium interaction on the percentage of phosphorus in fruits after 60 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.480	0.563	0.548	0.531
25	0.543	0.577	0.577	0.565
50	0.617	0.557	0.555	0.576
Mean	0.540	0.565	0.560	
SEM ±	0.006			
CD (0.05)	0.020			

Table - 133

Effect of phosphorus and potassium interaction on the percentage of phosphorus in fruits after 90 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	0.473	0.570	0.542	0.528
25	0.547	0.573	0.572	0.564
50	0.612	0.577	0.563	0.584
Mean	0.544	0.573	0.559	
SEM ±	0.003			
CD (0.05)	0.014			

the percentage of phosphorus increased with higher levels but P_2 and P_1 were at par at the first stage. Potassium application increased the phosphorus content. The potassium level, K_1 recorded the highest value and K_0 the lowest. But the levels, K_1 and K_2 were at par at the first stage.

Over the stages, there was very little change in the phosphorus content of fruits. Comparing between treatments, there was increase in some and decrease in some others. But the differences were marginal in all cases.

b) <u>Interaction effects</u>:- The highest phosphorus content of fruit was obtained at the N_0P_1 and N_1P_2 combinations at 60th and 90th day respectively. At both stages N_0P_0 recorded the lowest value (Tables 128 and 129).

In the case of interaction between nitrogen and potassium at both the stages, N_0K_1 and N_0K_0 recorded the highest and the lowest values of phosphorus content of fruit, respectively (Tables 130 and 131).

Among the phosphorus and potassium combinations, P_2K_0 recorded the highest value and P_0K_0 recorded the

lowest content of phosphorus in fruit, at both stages (Tables 132 and 133).

The above results may be summarised as follows.

i) The effect of nitrogen on phosphorus content though was significant, followed no regular conceivable pattern.

ii) Application of phosphorus led to an increase in phosphorus content of fruit upto the highest level of 50 kg P_2O_5/ha.

iii) Application of potassium also tended to increase phosphorus content but this effect was noted only upto the intermediate level of 25 kg K_2O/ha.

iv) Over the stages, there was very little change in the phosphorus content of fruits. Comparing between treatments, there was increase in some and decrease in some others. The differences, however, were marginal in all cases.

v) The interaction effects were highly variable.

3.3.3 Potassium content (per cent)

a) Main effects:- Effect of nitrogen application was significant only at the first stage (Table 131 and

Appendix XII). The N_1 level of nitrogen recorded the highest percentage of potassium in fruits at this stage and the N_2 level recorded the lowest value. Potassium content increased with increasing levels of phosphorus and this increase was non-significant only between P_0 and P_1 at 90th day. In the case of potassium levels also, the value increased with higher levels, but K_1 and K_2 were at par. These were superior to K_0 at the first stage but K_0 was at par with K_1 at the 2nd stage.

Over the stages, there was a decrease in the potassium content of fruits in all the treatments from 60th to 90th day.

b) <u>Interaction effects</u>:- Among the combinations of nitrogen and phosphorus, N_1P_2 recorded the highest potassium content of fruit and N_1P_0 recorded the lowest value at the both stages (Tables 134 and 135).

Among the combinations of nitrogen and potassium N_1K_2 recorded the highest percentage of potassium in fruits and N_2K_1 recorded the lowest value (Table 136). After 90 days, N_1K_1 recorded the highest percentage and N_1K_0 recorded the lowest value (Table 137).

Table - 134

Effect of nitrogen and phosphorus interaction on the percentage of potassium in fruits after 60 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	3.050	3.078	3.087	3.072
30	2.888	3.073	3.445	3.136
60	3.037	2.973	3.095	3.035
Mean	2.992	3.042	3.209	
SEM ±		0.015		
CD (0.05)		0.054		

Table - 135

Effect of nitrogen and phosphorus interaction on the percentage of potassium in fruits after 90 days of sowing.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	3.015	3.007	2.911	2.977
30	2.793	2.990	3.262	3.015
60	2.998	2.933	2.979	2.970
Mean	2.936	2.971	3.051	
SEM ±		0.018		
CD (0.05)		0.068		

Table - 136

Effect of nitrogen and potassium interaction on the percentage of potassium in fruits after 60 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	3.038	3.133	3.043	3.072
30	2.953	3.212	3.242	3.136
60	3.127	2.952	3.027	3.035
Mean	3.039	3.099	3.104	
SEM ±		0.015		
CD (0.05)		0.054		

Table - 137

Effect of nitrogen and potassium interaction on the percentage of potassium in fruits after 90 days of sowing.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	3.000	2.942	2.987	2.977
30	2.880	3.093	3.071	3.015
60	2.998	2.918	2.995	2.970
Mean	2.961	2.984	3.018	
S.E.M ±	0.018			
C.D (0.05)	0.068			

Table - 138

Effect of phosphorus and potassium interaction on the percentage of potassium in fruits after 60 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2.978	2.822	3.175	2.992
25	2.977	3.020	3.128	3.042
50	3.163	3.455	3.008	3.209
Mean	3.039	3.099	3.104	
S.E.M ±	0.015			
C.D (0.05)	0.054			

Table - 139

Effect of phosphorus and potassium interaction on the percentage of potassium in fruits after 90 days of sowing.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	2.948	2.843	3.016	2.936
25	2.950	2.910	3.055	2.971
50	2.987	3.200	2.965	3.051
Mean	2.961	2.984	3.018	
S.E.M ±	0.018			
C.D (0.05)	0.068			

Among the interactions of phosphorus and potassium P_2K_1 and P_0K_1 recorded the highest and lowest potassium contents of fruits respectively at 60th and 90th days (Tables 138 and 139).

The results may be summarised as follows.

i) The direct effect of nitrogen though was significant, did not follow a regular pattern.

ii) With increasing levels of both phosphorus and potassium, the potassium content tended to increase.

iii) Over the stages, there was a decrease in the potassium content of fruits from 60 to 90 days of sowing in all the treatments.

iv) A number of two-factor interactions were statistically significant but these have to be neglected as no distinct pattern of treatment variation was noticeable.

4. Uptake of nutrients

4.1 Nitrogen (kg/ha)

Effect of nitrogen, phosphorus and potassium on the uptake of nitrogen (kg/ha) at monthly intervals.

a) Main effects:- There was significant increase in the total uptake of nitrogen due to the increasing levels of nitrogen at 30th day of plant growth but at 60th and 90th days, N_1 and N_2 levels were at par and significantly superior to N_0 level (Table 140, Fig. 8 and Appendix XIII).

At 30th day, increasing levels of phosphorus significantly increased the nitrogen uptake. The differences between the levels of phosphorus were not significant at 60th day. At the last stage, even though there was significant difference between phosphorus levels, P_0 recorded the highest value and it was followed by P_2 and P_1.

At all stages, K_2 level recorded the highest nitrogen uptake and it was at par with K_0 and K_1 at first and second stages, respectively, but superior to K_0 and K_1 at the third stage. The levels K_1, K_0 and K_1 gave the lowest values at 30th, 60th and 90th days.

There was substantial increase in uptake of nitrogen with advancing age upto the last stage. However, the rate of increase was highest between 30th and 60th days after sowing.

Table - 140

Effect of levels of nitrogen, phosphorus and potassium on the uptake of these nutrients (Kg/ha) at monthly intervals.

Treatments	Uptake of Nitrogen			Uptake of Phosphorus			Uptake of Potassium		
	30th day	60th day	90th day	30th day	60th day	90th day	30th day	60th day	90th day
Levels of N Kg/ha									
0	5.983	37.949	58.292	1.292	10.708	13.444	12.547	61.872	77.372
30	16.706	59.914	86.535	2.687	15.102	19.860	26.531	102.613	110.529
60	18.250	58.810	87.811	2.673	15.926	20.572	27.177	100.029	103.905
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SEM ±	0.161	1.241	0.555	0.038	0.557	0.400	0.704	2.670	1.342
CD (0.05)	0.475	3.639	1.629	0.112	1.633	1.173	2.065	7.830	3.936
Levels of P_2O_5 Kg/ha									
0	12.030	52.609	81.794	1.846	14.057	17.774	18.667	89.767	97.619
25	12.811	50.965	79.669	2.177	13.111	17.815	22.506	83.570	95.965
50	15.828	53.099	71.175	2.629	14.628	18.288	25.082	91.177	98.222
'F' test	Sig.	NS	Sig.	Sig.	NS	NS	Sig.	NS	NS
SEM ±	0.161	1.241	0.555	0.038	0.557	0.400	0.704	2.670	1.342
CD (0.05)	0.475	-	1.629	0.112	-	-	2.065	—	-
Levels of K_2O Kg/ha									
0	13.906	48.817	77.298	2.056	14.123	18.117	22.271	86.305	99.319
25	13.011	53.628	76.206	2.201	13.724	16.910	20.452	89.097	93.879
50	14.022	54.228	79.134	2.395	13.948	18.850	23.531	89.113	98.609
'F' test	Sig.	Sig.	Sig.	Sig.	NS	Sig.	Sig.	NS	Sig.
SEM ±	0.161	1.241	0.555	0.038	0.557	0.400	0.704	2.670	1.342
CD (0.05)	0.475	3.639	1.629	0.112	-	1.173	2.065	-	3.936

b) Interaction effects:- In the case of nitrogen and phosphorus interactions at 30th day, the combination, N_2P_2 recorded the highest uptake of nitrogen and N_0P_1 recorded the lowest value (Table 141). After 60 days also, N_2P_2 and N_0P_1 combinations recorded highest and lowest nitrogen uptake respectively (Table 142). At the 90the day, unlike the former two stages, N_1P_2 recorded the highest uptake, but the lowest value was recorded by N_0P_1(Table 143).

Among the nitrogen and potassium interactions N_2K_0 recorded the highest value of nitrogen uptake and N_0K_1 recorded the lowest uptake at 30th day (Table 144). At 60th day, N_2K_2 combination recorded the highest value and N_2K_0 recorded the lowest (Table 145). At 90th day, the highest value was recorded by N_2K_0 and the lowest by N_0K_0 (Table 146).

Of the combinations of phosphorus and potassium, P_0K_2 and P_1K_0 recorded the highest and the lowest values of nitrogen uptake at the last two stages, whereas at the first stage P_2K_0 and P_0K_1 recorded respectively the highest and the lowest values (Tables 147, 148 and 149).

The variation in nitrogen uptake by the plant may

Table - 141

Effect of nitrogen and phosphorus interaction on the uptake of nitrogen (Kg/ha) at 30th day.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	6.367	4.600	6.983	5.983
30	14.683	17.483	17.950	16.706
60	15.850	16.350	22.550	18.250
Mean	12.030	12.811	15.828	
SEM ±	0.229			
CD (0.05)	0.823			

Table - 142

Effect of nitrogen and phosphorus interaction on the uptake of nitrogen (Kg/ha) at 60th day.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	41.278	34.975	38.438	37.949
30	60.611	63.340	55.790	59.914
60	55.937	55.426	65.068	58.810
Mean	52.609	50.965	53.099	
SEM ±	1.241			
CD (0.05)	6.303			

Table - 143

Effect of nitrogen and phosphorus interaction on the uptake of nitrogen (Kg/ha) at 90th day.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	71.883	47.087	55.907	58.292
30	84.401	80.969	94.235	86.535
60	89.099	85.469	88.864	87.811
Mean	81.794	79.669	71.175	
SEM ±	0.786			
CD (0.05)	2.822			

Table - 144

Effect of nitrogen and potassium interaction on the uptake of nitrogen (Kg/ha) at 30th day.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	6.750	5.083	6.117	5.983
30	15.600	16.417	18.100	16.706
60	19.367	17.533	17.850	18.250
Mean	13.906	13.011	14.022	
SEM ±	0.229			
CD (0.05)	0.823			

Table - 145

Effect of nitrogen and potassium interaction on the uptake of nitrogen (Kg/ha) at 60th day.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	37.031	40.599	36.726	37.949
30	58.525	67.309	53.907	59.914
60	50.895	52.975	72.561	58.810
Mean	48.817	53.628	54.228	
SEM ±	1.241			
CD (0.05)	6.303			

Table - 146

Effect of nitrogen and potassium interaction on the uptake of nitrogen (Kg/ha) at 90th day.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	54.309	63.864	56.704	58.292
30	82.704	86.870	90.031	86.535
60	94.883	77.883	90.667	87.811
Mean	77.298	76.206	79.134	
SEM ±	0.786			
CD (0.05)	2.822			

Table - 147

Effect of phosphorus and potassium interaction on the uptake of nitrogen (Kg/ha) at 30th day.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	11.900	11.483	13.517	12.030
25	13.217	12.907	12.250	12.811
50	16.600	14.583	16.300	15.828
Mean	13.906	13.011	14.022	
SEM ±	0.229			
CD (0.05)	0.823			

Table - 148

Effect of phosphorus and potassium interaction on the uptake of nitrogen (Kg/ha) at 60th day.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	47.444	43.000	67.382	52.609
25	40.235	65.852	46.809	50.965
50	58.772	52.031	48.494	53.099
Mean	48.817	53.628	54.228	
SEM ±	1.241			
CD (0.05)	6.303			

be summarised as follows.

i) With application of nitrogen, there was a marked and statistically significant increase in nitrogen uptake at all the stages upto the intermediate level of 30 kg N/ha. When the nitrogen application was increased to the next higher level of 60 kg/ha, there was practically little change in nitrogen uptake by the plants.

ii) Application of increasing doses of phosphorus and potassium also, in general, resulted in increasing uptake of nitrogen but the treatment differences were less conspicuous and less consistent.

iii) Over the stages, there was a substantial increase in uptake of nitrogen with advancing age, it being most conspicuous between 30 and 60 days.

iv) All the two-way interactions (nitrogen x phosphorus, nitrogen x potassium and phosphorus x potassium) were significant at all the three stages of observation. However, the results were variable and it is not possible to arrive at concrete conclusions. The only trend noticed is that when the nutrients are

applied in combination, the uptake was generally high. Yet, the highest uptake figures are not always at the highest levels of nutrients.

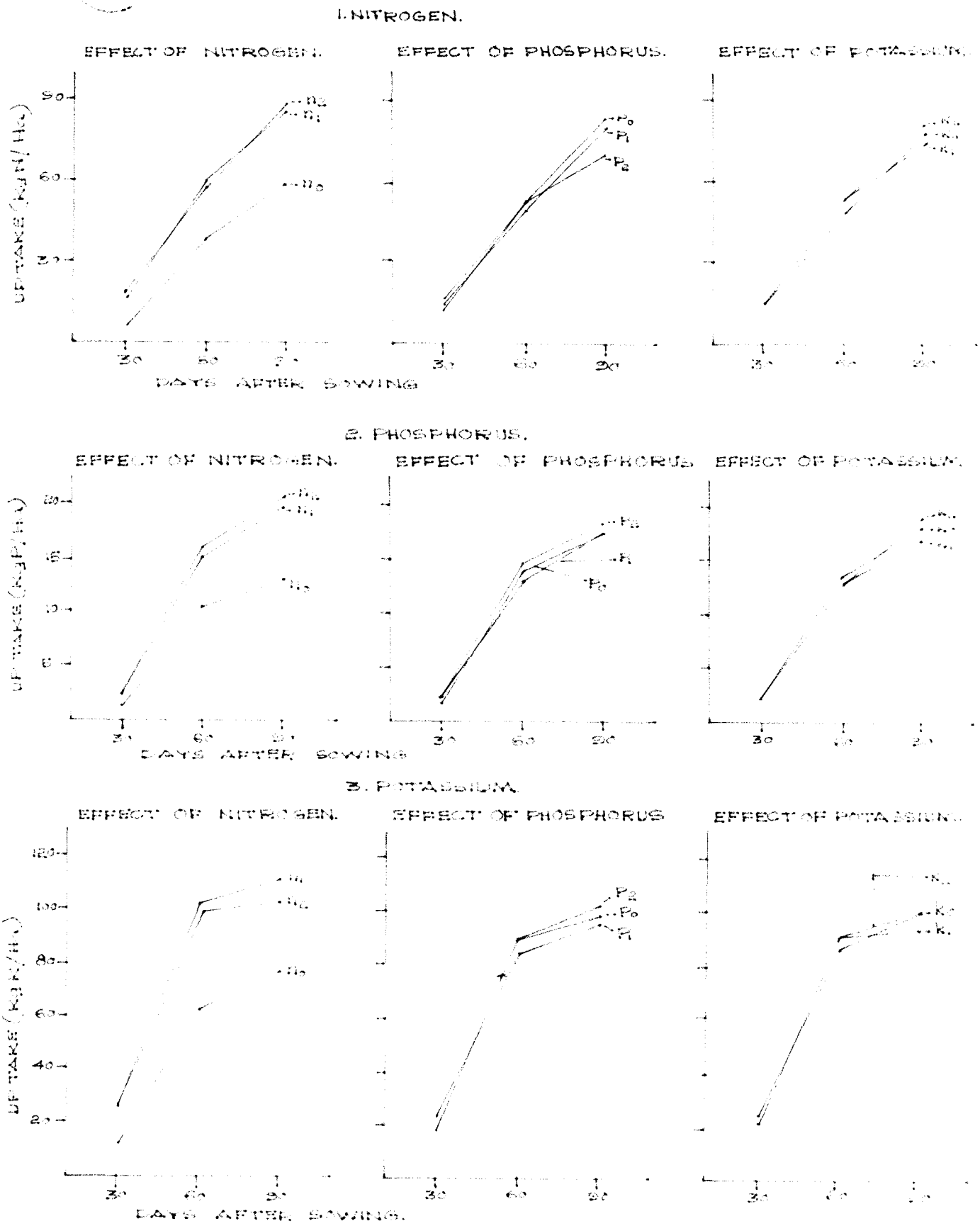
4.2 Phosphorus (kg/ha)

a) Main effects:- The data on the phosphorus uptake are presented in the Table 140, Fig. 8 and analysis of variance in the Appendix XIII. After 30 days, N_1 level recorded the highest value and it was at par with N_2. At 60th and 90th days, there was increase in the uptake with increasing levels of nitrogen, but N_2 and N_1 were at par with each other. The effects of phosphorus levels were significant only at the first stage and at this stage, increasing levels showed significantly higher uptake. In the case of potassium, there was significant difference at 30th and 90th days only. At these two stages, K_2 recorded the highest value and K_0 and K_1 recorded lowest values at the first and the last stages, respectively.

Over the stages, there was increase in the uptake of phosphorus with time upto 90th day. The maximum rate of uptake was observed between the first two stages.

b) Interaction effects:- Among the combinations

FIG-8 EFFECT OF NITROGEN PHOSPHORUS AND POTASSIUM ON THE UPTAKE OF NUTRIENTS.



of nitrogen and phosphorus, N_2P_2 recorded the highest uptake of phosphorus at 30th and 60th days, whereas at 90th day, the highest value was recorded by N_2P_1. At 30th and 90th days, the lowest value was recorded by N_0P_1 and at the 60th day, N_0P_2 recorded the lowest value (Tables 150, 151 and 152).

The interaction between nitrogen and potassium was significant only at 30th and 90th days. At the first stage, the highest phosphorus uptake was given by N_1K_2 whereas at 90th day, it was noticed at N_2K_0 combination. The lowest value was recorded by N_0K_2 and N_0K_0 at 30th and 90th days respectively (Tables 153 and 154).

In the case of interaction between phosphorus and potassium at 30th day, highest uptake of phosphorus was observed in the combination, P_2K_2 whereas at the 60th and the 90th days, P_2K_0 recorded the highest values. The lowest uptake figures were recorded by P_0K_0, P_1K_0 and P_2K_2 at first, second and third stages respectively (Tables 155, 156 and 157).

A summarised account of the result is given below.

i) Increasing doses of applied nutrients generally

Table - 149

Effect of phosphorus and potassium interaction on the uptake of nitrogen (Kg/ha) at 90th day.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	75.802	74.501	95.049	81.794
25	63.988	74.636	74.901	79.669
50	92.105	79.451	67.451	71.175
Mean	77.298	76.206	79.134	
SEM ±	0.786			
CD (0.05)	2.822			

Table - 150

Effect of nitrogen and phosphorus interaction on the uptake of phosphorus (Kg/ha) at 30th day.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	1.358	1.148	1.370	1.292
30	2.099	2.944	3.019	2.687
60	2.080	2.439	3.500	2.673
Mean	1.846	2.177	2.629	
SEM ±	0.054			
CD (0.05)	0.194			

Table - 151

Effect of nitrogen and phosphorus interaction on the uptake of phosphorus (Kg/ha) at 60th day.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	10.778	11.278	10.068	10.708
30	15.130	15.039	15.253	15.102
60	16.265	12.957	18.557	15.926
Mean	14.057	13.111	14.628	
SEM ±	0.787			
CD (0.05)	2.828			

Table - 152

Effect of nitrogen and phosphorus interaction on the uptake of phosphorus (Kg/ha) at 90th day.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	15.685	10.667	13.982	13.444
30	18.846	19.698	21.037	19.860
60	18.790	23.080	19.846	20.572
Mean	17.774	17.815	18.288	
SEM ±	0.566			
CD (0.05)	2.032			

Table - 153

Effect of nitrogen and potassium interaction on the uptake of phosphorus (Kg/ha) at 30th day.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	1.370	1.265	1.241	1.092
30	2.130	2.858	3.074	2.687
60	2.667	2.481	2.870	2.673
Mean	2.056	2.201	2.395	
SEM ±	0.054			
CD (0.55)	0.194			

Table - 154

Effect of nitrogen and potassium interaction on the uptake of phosphorus (Kg/ha) at 90th day.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	13.130	13.827	13.376	13.444
30	18.161	19.185	22.234	19.860
60	23.062	17.716	20.938	20.572
Mean	14.123	13.724	13.948	
SEM ±	0.566			
CD (0.55)	2.032			

Table - 155

Effect of phosphorus and potassium interaction on the uptake of phosphorus (Kg/ha) at 30th day

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	1.685	1.870	1.982	1.846
25	2.039	2.233	2.259	2.177
50	2.444	2.500	2.944	2.629
Mean	2.056	2.201	2.395	
SEM ±	0.054			
CD (0.55)	0.194			

Table - 156

Effect of phosphorus and potassium interaction on the uptake of phosphorus (Kg/ha) at 60th day.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	13.420	12.556	16.197	14.057
25	12.235	13.747	13.352	13.111
50	16.716	14.870	12.296	14.628
Mean	14.123	13.724	13.948	
SEM ±	0.787			
CD (0.55)	2.828			

resulted in an increase in uptake of phosphorus. It was most conspicuous in the case of nitrogen, especially between 0 and 30 kg N/ha. The differences in uptake of phosphorus consequent to application of graded levels of phosphorus and potassium were not so marked.

ii) As in the case of nitrogen uptake, there was increase in uptake of phosphorus also with time. However, the extent of increase was much higher between 30 and 60 days after sowing than between the 60th and 90th days. The rate of increase in uptake with advancing age appeared to be unaffected by the different treatments.

iii) Again, as in the case of nitrogen uptake, the interaction effects showed no consistent pattern and the only indication noted is that often, the uptake of phosphorus was higher when the nutrients were applied in combination. However the combination giving the highest phosphorus uptake was not always the one with highest levels of nutrients.

4.3 Potassium (kg/ha)

a) Main effects:- The data on the main effects are presented in Table 140, Fig. 8 and the analysis of variance in the Appendix XIV.

After 30 days of sowing, N_2 recorded the highest uptake of potassium, whereas at 60th and 90th days, N_1 recorded the highest value. At all stages, N_1 and N_2 were at par and significantly superior to N_0. Effects of phosphorus levels were significant only at the 30th day and at that stage, there was significant increase in the uptake of potassium due to the increasing levels of phosphorus. Effects of potassium levels were significant at 30th and 60th days. At 30th day, K_2 recorded the highest value but the highest uptake was noted at K_0 at 60th day. At both the stages, K_1 recorded the lowest value and it was at par with K_0 at 30th day. At both the stages, K_0 and K_2 were at par.

Over the stages, a marked increase in the uptake of potassium was noticed only upto the 60th day at all levels of all the three nutrients. After that stage, increase in potassium uptake was marginal.

b) <u>Interaction effects</u>:- The interaction effects between nitrogen and phosphorus were significant only at 30th and 90th days. The highest potassium uptake was recorded by the combination N_2P_2 at 30th day, whereas at 90th day, N_1P_2 recorded the highest value. At both

the stages, N_0P_1 recorded the lowest uptake of potassium (Tables 158 and 159).

The interaction between nitrogen and potassium was also significant at 30th and 90th days. The highest uptake of potassium was recorded by N_2K_2 and N_1K_2 and the lowest values were recorded by N_0K_1 and N_0K_0 respectively at 30th and 90th days of planting (Tables 160 and 161).

The interaction between phosphorus and potassium was significant only at 60th and 90th days. The highest values were recorded by P_0K_2 and P_2K_0 combinations at 60th and 90th days, respectively and the lowest values were recorded by P_1K_0 and P_2K_2 combinations at these stages respectively (Tables 162 and 163).

The summary of the results on potassium uptake is given below.

i) With increasing doses of the nutrients, there was increase in uptake of potassium especially upto the intermediate levels. This increase was most conspicuous in the case of nitrogen. The effect on the uptake of potassium was not very high even by application of increasing doses of potassium.

ii) Over the stages, there was an impressive increase in uptake especially between 30 and 60 days after sowing. Between 60 and 90 days also, the uptake of potassium further increased but the magnitude of increase was less.

iii) As in the case of phosphorus uptake, quite a few two-way interactions were statistically significant. However, from the highly variable results, the only general trend indicated is that the uptake was generally higher when the nutrients were applied in combination. Again, the combination giving the highest uptake was not the same in all cases.

Table - 157

Effect of phosphorus and potassium interaction on the uptake of phosphorus (Kg/ha) at 90th day.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	17.389	16.000	19.932	17.774
25	15.889	16.587	20.969	17.815
50	21.074	18.142	15.648	18.288
Mean	18.117	16.910	18.850	
SEM ±	0.566			
CD (0.05)	2.032			

Table - 158

Effect of nitrogen and phosphorus interaction on the uptake of potassium (Kg/ha) at 30th day.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	13.302	9.475	14.364	12.547
30	21.136	30.314	27.543	26.531
60	21.062	27.130	33.339	27.177
Mean	18.667	22.506	25.082	
SEM ±	0.995			
CD (0.05)	3.576			

Table - 159

Effect of nitrogen and phosphorus interaction on the uptake of potassium (Kg/ha) at 90th day.

Levels of N Kg/ha	Levels of P_2O_5 Kg/ha 0	25	50	Mean
0	87.790	64.364	79.963	77.372
30	103.210	109.469	118.908	110.529
60	101.858	114.062	95.796	103.905
Mean	97.619	95.965	98.222	
SEM ±	1.898			
CD (0.05)	6.818			

Table - 160

Effect of nitrogen and potassium interaction on the uptake of potassium (Kg/ha) at 30th day.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	13.938	10.599	13.105	12.547
30	24.216	27.716	27.661	26.531
60	28.060	23.043	29.827	27.177
Mean	22.271	20.452	23.531	
SEM ±	0.995			
CD (0.05)	3.576			

Table - 161

Effect of nitrogen and potassium interaction on the uptake of potassium (Kg/ha) at 90th day.

Levels of N Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	71.117	84.821	76.179	77.372
30	106.389	104.260	120.938	110.529
60	120.451	92.556	98.710	103.905
Mean	99.319	93.879	98.609	
S.E.M ±	1.898			
C.D (0.05)	6.818			

Table - 162

Effect of phosphorus and potassium interaction on the uptake of potassium (Kg/ha) at 90th day.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	83.599	79.247	106.457	89.767
25	75.531	91.543	83.636	83.570
50	99.784	96.450	77.247	91.177
Mean	86.305	89.097	89.113	
S.E.M ±	3.775			
C.D (0.05)	13.562			

Table - 163

Effect of phosphorus and potassium interaction on the uptake of potassium (Kg/ha) at 90th day.

Levels of P_2O_5 Kg/ha	Levels of K_2O Kg/ha 0	25	50	Mean
0	95.426	89.235	108.197	97.619
25	91.592	88.593	107.710	95.965
50	110.938	103.809	79.920	98.222
Mean	99.319	93.879	98.609	
S.E.M ±	1.898			
C.D (0.05)	6.818			

DISCUSSION

D I S C U S S I O N

Application of nitrogen showed significant increase in plant height upto the highest level tried except on the 15th day of sowing where it was only upto the intermediate level. Increase in plant height in bhindi due to nitrogen application was also reported by (Arnon 1943; Wadleigh, 1957; Burris, 1959; Sutton, 1963; Widham, 1966; Singh et al. 1966; Kamalanathan et al. 1970 and Bid et al. 1971).

In the case of phosphorus also there was significant increase in plant height upto the highest level of 50 kg P_2O_5/ha, except during the peak stages of bearing, from 30th to 60th day, where it was only upto the intermediate level of 25 kg P_2O_5/ha. Singh et al. (1966 and 1967) also observed similar response upto a level of 50 kg P_2O_5/ha. But Sharma and Shukla (1973) reported significant effect on height only upto 34.8 kg P_2O_5/ha.

Regarding the response to potassium, it had been noted that, the potassium application recorded significant effect on plant height only upto the bearing stage ie. at 15th and 30th day. At these stages the significance was noticed only upto the intermediate level

of 25 kg K_2O/ha and further increase upto 50 kg K_2O/ha considerably reduced the plant height. Sutton (1963) also observed that application of potassium had no significant effect on the vegetative growth of bhindi. Contradictory result had also been reported by Singh (1979) who found that the height of bhindi increased upto a level of 60 kg K_2O/ha.

All the two-factor interactions were significant. The general trend of nitrogen and phosphorus interaction was positive. A positive response in the case of plant height, to nitrogen and phosphorus combinations was also reported by Saimbhi et al. (1970, 1975) and Singh (1979).

Eventhough the interactions between nitrogen x potassium and phosphorus x potassium were significant, the result was not consistent enough to draw any general conclusion. Plant height in bhindi is a character that is altered appreciably by availability of the three fertilizer nutrients. In the case of nitrogen and phosphorus, the general indication is that of an increase in height with increasing levels of these nutrients. On the contrary, potassium application produced significant increase in a few cases and non-significant increase in

a few other cases. These differences most probably arise from the differences in the original rate of availability of potassium in the soil in which these experiments were conducted. In the present study, there was increase in height with increasing levels of the three nutrients indicating the presence of sub-optimal level of nutrients in soil before cropping. In the case of potassium, the results were not as consistent as in the other two nutrients, there being significant increase in height only at the first two stages. At these stages also, there was increase in height upto 25 kg K_2O/ha, a further increase in application resulting in a decrease. At later stages, differences disappeared. The only justification appears to be that the highest dose of potassium applied basally had some initial inhabitory effect on plant growth and that this was well compensated at later stages. However, evidences for such inhibitory effect of potassium on height of bhindi are not available in literature. Perhaps a certain degree of salt injury might have occured in the early stages. Such significant inhibutory effects were however, not observed in other growth characters.

Eventhough the variety tried is reported to be a

non-branching type, observations on this character were also recorded. There was statistically significant increase in this character with increasing levels of nitrogen and the maximum number of branches produced was 1.67 per plant. The interaction effect were not significant.

The number of functional leaves was affected by application of all the three nutrients though the effect was consistent upto the intermediate levels only. There are two factors that influence the number of functional leaves viz. the rate of leaf production and the retentivity of the leaves. As the results on leaf production would indicate, nitrogen application resulted in higher leaf production, whereas the effects of phosphorus and potassium were not significant. It would thus mean that in the case of nitrogen, higher functional leaf number might have resulted from higher leaf production either alone or in combination with higher leaf retentivity. In the case of phosphorus and potassium increased leaf retentivity appears to be the only factor responsible for the higher number of functional leaves.

Total number of leaves produced per plant was affected significantly by nitrogen application upto the

highest level tried. The same trend was also observed by Randhawa (1962) upto a level of 68 kg N/ha. A comparison of the results with plant height and number of functional leaves would indicate that there is slight deviation of the trend in this case. The justification for this appears to be either that leaf production is a character not as much responsive to phosphorus and potassium or that the level of deficiency of these nutrients for appreciable inhibition in leaf production is lower than that of the other two characters.

Increasing levels of nitrogen significantly increased the leaf area index both at 30th and 60th days. The same effect was noticed in the case of phosphorus application also. Application of potassium decreased the leaf area index at the 30th day, whereas considerable increase in this character was noticed at the 60th day due to its application upto the highest level. There was a steady increase in L.A.I. over the stages and the extent of increase was more or less same in all the treatments. Leaf area index is a function of both the number of functional leaves at a time and the average area of the leaf. The similarity in the trend of results may be taken to indicate that an increase in leaf number

was one of the factors responsible for the increased L.A.I. at higher levels of the nutrients. Yet, the point remains that even when there was no significant increase in leaf number beyond the intermediate levels of the nutrients, leaf area index continued to increase. In all probability, increase in mean area per leaf was an equally important factor responsible for the increase in L.A.I. at the highest level of nutrients.

Application of nitrogen increased net assimilation rate upto the intermediate level and this was followed by decrease at a still higher level. Phosphorus application tended to decrease the N.A.R. value. Added potassium had no effect. N.A.R., being a measure of carbohydrate accumulation per unit leaf area, is expected to follow an inverse relation with L.A.I., because of mutual shading of leaves (Watson, 1958). As application of nitrogen and phosphorus resulted in significant increase in L.A.I., it was to be expected that N.A.R. would decrease with increasing levels of these nutrients. The results obtained, however, do not follow this pattern. A comparison of L.A.I. values will substantiate this lack of decrease in N.A.R. The highest mean L.A.I. obtained was only 1.84 which is generally considered inadequate for inducing any marked mutual shading.

Another factor that affects N.A.R. could be the efficiency of individual leaf to photosynthesise which is often related to the chlorophyll content. If this was the dominant effect, application of nitrogen and phosphorus would have resulted in increasing N.A.R. In this study, no such consistent effects were noticed. It may be concluded, therefore, that the significant effects of nitrogen and phosphorus noticed in this study may be either due to random errors or because of other factors effecting the efficiency of the leaf to photosynthesise. Though all the two-factor interactions were significant the results did not follow any consistent pattern.

Applied nitrogen increased the dry matter yield. Statistical significance was noticed only upto the intermediate level receiving 30 kg N/ha. Application of phosphorus also tended to increase the dry matter yield, but it was significant only at 30th day after sowing. In the case of potassium, the result was not consistent, though the maximum value was recorded at the highest level of 50 kg K_2O/ha.

The increase in dry matter production with increasing levels of nutrients follows an expected

pattern because similar increase was noticed in other vegetative characters like height, number of leaves and L.A.I. It may be recalled that the trend in pod yield was also similar. As had been mentioned elsewhere, this is attributable to the sub-optimal levels of these three nutrients originally in the soil. It may, however, be noted that though there was a general trend of increasing dry matter accumulation with increasing levels of nutrients, the treatment effects were not consistent. Steady increase upto the highest level was not noticed. As would be evident from the comparison of yield data, there was increase in the final yield of fruit upto the higher level of all the nutrients tried. The calculated optimum level based on yield was higher than that tried in the case of nitrogen and response was linear in the case of phosphorus and potassium. From the yield data it is, therefore, concluded that the requirement of the fertilizer nutrients was even higher than the levels tried. Though a similar increase in dry matter accumulation was also to be expected, such a consistent trend was not noticed. The only justification appears to be that the sample size was small (2 plants/plot) and that the random variation must have resulted in a higher error component.

The interactions were generally significant and the over all trend was that of an advantage due to the combined application of nutrients. Similar was the trend in the case of final yield also.

There was significant increase in yield due to the increasing levels of all the three nutrients. In the case of nitrogen, the yield was found to increase upto the level of 60 kg N/ha, and the optimum and the economic doses were worked out to be 61.23 kg and 61 kg N/ha respectively. The results thus indicate that nitrogen supplying power of the soil was inadequate to meet the requirement of the crop. A study of the nitrogen content of the soil will also indicate that the content of this nutrient is comparatively low. There are two factors that affect the response of crops to fertilizers. These are the quantity of the concerned nutrient in the soil in the available form and the requirement of the crop. The significant increase in yield noticed upto 60 kg N/ha indicates that the inherent rate of supply of nitrogen from the soil was not enough to meet the requirement of bhindi. A similar increase in the yield of this crop upto 61 kg N/ha was also reported by Chowdhury (1967).

A comparison of the data on yield components will

indicate that there was a similar increase upto 60 kg N/ha in the case of most of the characters. The components which showed significant increase are, flower production, fruits per plant and weight of fruits. In the case of fruit set, on the contrary, there was a significant decrease with increasing levels of nitrogen. The fact that even with a decrease in the percentage of fruit set there was increase in the final yield, indicating that the depressing effect of this yield component was more than compensated by increase in yield components which showed positive response. The reason for the difference in the response of yield components with increasing levels of nitrogen would be discussed later.

In the case of most of growth characters, there was significant positive response to nitrogen upto 60 kg N/ha. These characters are height of plants, functional leaves at various stages, total leaf production and the L.A.I. at the 30th day. This will further substantiate the conclusion that the original nitrogen supply from the soil was inadequate for meeting the crop requirement.

The only growth component which did not show significant increase upto the highest level of nitrogen

was N.A.E. The reason for this decrease has been discussed already. A study of the content and uptake of nitrogen also showed an increasing trend with increasing levels of nitrogen.

As in the case of nitrogen, there was significant positive response to the phosphorus application upto the highest level of 60 kg P_2O_5/ha. Unlike in the case of nitrogen which showed a quadratic response, the response to phosphorus was linear and the optimum level could not therefore be worked out. The general conclusion would again be that the quantity of phosphorus available in the soil originally was lower than the quantity required by the crop. The extractable phosphorus content of the soil was 4 ppm which is rated as low.

Similar results of increasing response to applied phosphorus even upto 60 kg P_2O_5/ha were also reported by Chonkar and Singh (1963) and Singh (1979). Unlike in the case of nitrogen which showed increasing response in most of the yield components, response to phosphorus was positive and significant in only a few of the yield components. The characters that showed such positive trends were fruits per plant and setting percentage.

The number of flowers and fruit length were unaffected and fruit weight and dry matter percentage increased upto the intermediate level (25 kg P_2O_5/ha). The two yield components that have direct bearing on yield are the number of fruits and the weight of fruits. Among these, the former significantly increased with increasing phosphorus levels, upto the highest level and the later, upto the intermediate level. The two components that affect the number of fruits harvested are the number of flowers and setting percentage. Among these, phosphorus application did not affect the number of flowers but enhanced the setting percentage. It may then be concluded that the increase in yield due to phosphorus application was mainly because of the improvement in the number of fruits per plant, the contributing factor for this being the increased setting percentage. The fruit weight also was affected by phosphorus, but the contribution by this component was of less importance.

Phosphorus application also enhanced the growth of plants, as indicated by increase in plant height, leaf production and L.A.I. As in the case of nitrogen, phosphorus application also resulted in a decrease in N.A.R.

Response to potassium application was significant upto the highest level of 50 kg K_2O/ha. The nature of response was linear indicating thereby that the yield would increase still further at higher rates of potassium. Comparison of the extracted available potassium content of the soil will also indicate that the content of this nutrient in soil was originally low. Similar results of increasing response to applied potassium were also reported by Chandrasekharan and George (1971) upto a high level of 56 kg K_2O/ha and by Singh (1979) who observed significant response upto 60 kg K_2O/ha.

A study of the data on yield components will show that the characters that were improved by the application of this nutrient were the number of flowers, fruits and the length and weight of fruit. The only character that was not affected by applied potassium was the percentage of fruit set.

The growth components also were in general improved by the application of potassium. The only factor which was not affected by its application was N.A.R.

The two-factor interactions, nitrogen x phosphorus and nitrogen x potassium were significant in the case of yield. There was a general trend of increase in yield

when the above factors are in combination. However, such a positive trend was not consistantly noticed upto the highest level. Such a lack of increase in yield in combination of nutrients at higher levels, even when the main effects are significant upto these levels is not usual in the case of fertilizer nutrients. In the case of most of the yield and growth components also, the interactions were significant but the results were not consistent. Not much emphasis is therefore given on the combination that gave the highest yield. The only consistent effect is an advantage due to the combined application of the three nutrients.

To conclude, the increase in yield of bhindi with increasing levels of nitrogen, phosphorus and potassium may be considered to be because of the low contents of the nutrients in soil. The yield components that were effected by the different nutrients were different. Nitrogen and potassium application increased yield through an improvement in number and weight of fruits. Phosphorus had its effects mainly on the number of fruits. Fruit number was increased through both higher flower production and setting in the case of nitrogen and potassium whereas it was only through higher

setting in the case of phosphorus. There was a general improvement in growth by application of all the three nutrients, the only exception being N.A.K. Combined application of nutrients was generally beneficial.

Application of nitrogen and phosphorus resulted in early flowering, whereas potassium application delayed it. However, there was earliness in flowering only due to the intermediate level of nitrogen and further addition slightly delayed the flowering. Induction of early flowering due to the application of phosphorus and delay due to excess application of nitrogen is a common observation in most of the crops (Tisdale and Nelson, 1971). Though the above difference in the time taken for flowering was statistically significant, too much emphasis on the above observation is not to be given because the absolute difference in the number of days taken for 50% flowering was only upto a maximum of 3 days. As in the case of other observations, the two- factor interactions were significant. Though the results were inconsistent to an extent, there was an indication towards earliness in flowering when nitrogen and phosphorus applications were combined.

Application of nitrogen and potassium resulted in

significantly higher number of flowers upto the highest level tried. In the case of phosphorus, on the contrary, there was no advantage in terms of this character. Increased flower production due to nitrogen application upto 68 kg N/ha was reported by Randhawa (1962). As had been discussed earlier, due to the application of nitrogen and potassium there was significant improvement is most of the yield components, the number of flowers being one of them. However, in the case of phosphorus there was significant increase in the number and weight of fruits, whereas the number of flowers was not significantly increased. It is a general observation that depending upon the inherent fertility of the soil, the effect of different nutrients on various yield components vary. This is considered to be because the critical levels of the nutrients in terms of different yield attributes are different. In the case of bhindi, thus, the level of phosphorus availability for optimum number and weight of fruits should be considered more than that of number of flowers. All the three two-factor interactions are significant. But the results were not consistent and no meaningful conclusions could be drawn from these results.

The percentage of fruit set was significantly

affected by nitrogen and phosphorus. Application of nitrogen lowered the setting percentage, whereas phosphorus enhanced it. The effect of potassium was not significant. It may be recalled that the trend was reverse in the number of flowers where application of nitrogen was found to produce larger number of flowers. It may also be noted that the disadvantage due to decrease in flower production due to the application of phosphorus was more than compensated by increase in setting percentage. As had been discussed elsewhere, the overall trend was that of an increase in yield because of the application of phosphorus. The interactions were significant. The combination of highest phosphorus, without nitrogen application resulted in higher percentage of fruit set.

Application of nitrogen and potassium brought about significant increase in the number of fruits upto the highest level. In the case of phosphorus, eventhough there was increase in yield upto the highest level tried, differences were significant only upto the intermediate level of 25 kg P_2O_5/ha. As had been indicated earlier, there are two factors that decide the number of fruits. These are the number of flowers and the setting percentage. As had also been mentioned earlier, in the case of nitrogen

flower production increased with increasing levels of application and the setting percentage decreased with increasing rates. As indicated by the higher number of fruits, the effect of increased flower production dominated. In the case of phosphorus, the reverse was the trend ie; the setting percentage dominated. The final effect in both nitrogen and phosphorus was that of an increased fruit production. Increase in number of pods/plant consequent to nitrogen application of 68 kg N/ha was also reported by Randhawa (1962). The overall effect of applied potassium was also towards an increase upto the highest level. However, the components viz. flower production and setting percentage were affected in different patterns in this case. Flower production was significantly enhanced by application of this nutrient, whereas there was no effect on setting percentage.

To summarise, there was increase in the number of fruits due to the application of all the three nutrients, but there was difference in the response on the components contributing to the number of fruits. Nitrogen application increased flowering, but decreased the setting percentage, the effect of the former being dominant. Phosphorus application decreased flower

production and increased setting percentage, the effect of the latter being dominant. Application of potassium increased flowering but showed no apparent effect on the setting percentage. Among the two-factor interactions the effect of nitrogen x phosphorus and nitrogen x potassium were significant. The results were inconsistent and hence are neglected as due to chance errors.

Application of nitrogen and potassium upto the highest levels resulted in longer fruits. Phosphorus had no significant effect. The observation on length of fruit was included as a measure of fruit size. Assuming that the length is a valid index of fruit size, it may be concluded that nitrogen and potassium application produced bigger fruits. As will be discussed afterwards almost the same trend was noticed in the fruit weight also. Although all the two-factor interactions were significant, the results would not be discussed in detail as the results were not consistent.

There was increase in the weight of fruit due to increasing levels of all the three nutrients. However, in the case of phosphorus significant increase was noticed only upto 25 kg P_2O_5/ha. It was pointed out earlier that application of nitrogen resulted in the production of bigger fruits. As will be discussed

afterwards this nutrient had no significant effect on the dry matter percentage of fruit. Taking for granted that the length is a true measure of size of fruit it may be concluded that increase in fruit weight was mainly through the increase in size of fruit. In the case of phosphorus, fruit length was not affected but dry weight was increased upto the intermediate level. Probably as a result of this increase in dry matter percentage, the fruit weight also increased upto the intermediate level. In the case of potassium the increase in fruit weight upto the highest level must be attributed to both increase in size and dry weight. However, in the case of dry matter percentage there was significant increase upto the intermediate level only. The interaction effects are neglected as the high variability makes it difficult to explain the results.

Application of phosphorus and potassium produced fruits with high percentage of dry matter. However, statistically significant increase was noticed upto the intermediate level only. Nitrogen application had no significant effect on this character. As had been discussed already, dry matter percentage was one of the major contributing factors towards the increase in fruit weight in the case of phosphorus and was contributing to

a lesser extent in the case of potassium. The interaction effects are neglected because of the reasons mentioned already.

None of the three nutrients had any significant effect on the harvest index. Harvest index is a measure of the proportion of the total accumulated dry matter that gets concentrated in the economic part, in this case, the fruits. It is known that application of nitrogen in excessive amounts leads to excessive vegetative growth at the expense of reproductive growth (Fisdale and Nelson, 1971), thus leading to a decrease in harvest index. The above ill-effect of excessive nitrogen supply is also known to be counter acted to an extent by balanced application of the remaining two fertilizer nutrients, phosphorus and potassium. The lack of significant effect of applied nitrogen thus indicates that the level of applied nitrogen tried in this experiment was not excessive. The main effects of the nutrients give only the overall effect as the values are averaged over different levels of applied phosphorus and potassium (ranging from 0 to 50 kg/ha). The evaluation of the interaction effect will further indicate the levels of nitrogen that tended to be excessive at varying levels of applied phosphorus and

potassium. Lack of significant effects of phosphorus and potassium is to be normally expected as these nutrients generally are not reported to effect the relative vegetative and reproductive growth differentially when nitrogen supply is not excessive.

Among the two-factor interactions, that between nitrogen and potassium only was significant. Without potassium, application of nitrogen at the highest level resulted in a marked decrease in harvest index. At the intermediate level of potassium, there was no such decrease and in fact there was increase in harvest index values with increasing levels of nitrogen. These results may be taken to indicate that nitrogen at 60 kg/ha was excessive without applied potassium and that this effect was nullified when potassium was applied at the intermediate level of 25 kg K_2O/ha. At the highest level of potassium (50 kg K_2O/ha), on the contrary, there was decrease in the harvest index with increasing levels of nitrogen. This decrease even when potassium was applied in adequate amounts is difficult to explain. It may however be pointed out that the results were not consistent.

Application of nitrogen increased the nitrogen

content of leaf and stem and applied phosphorus had a depressing effect. Potassium application had no appreciable effect on the nitrogen content. Increase in content of nitrogen with increasing levels of these nutrients is to be normally expected. The decrease in nitrogen content with increasing levels of phosphorus may be attributed to the increase in dry matter accumulation with applied phosphorus and the consequent dilution of nitrogen in the plant in a larger dry weight. It may be noted that there was no such a decrease in nitrogen uptake with increased phosphorus application indicating thereby that this dilution effect was probably responsible for the decreasing content of this nutrient. A similar dilution effect was not observed with increasing levels of potassium, presumably because the extent of increase in dry matter accumulation was not as conspicuous as in the case of potassium application. Over the stages, there was a decrease in nitrogen content of leaf and stem showing thereby that the rates of accumulation of nitrogen in these parts were lower than the rate of increase in dry matter with advancing age. This is in agreement with the usual trend of nitrogen content in almost all plants excepting probably legumes. In the case of fruits, on the contrary, applied nutrients had

no significant effect on the nitrogen content. Over the stages also, there was no appreciable change in the nitrogen content. The fact that the nitrogen content of fruit did not decrease with advancing age even when the content of this nutrient in leaf and stem decreased indicates that there was a preferential translocation of nitrogen to the developing fruits. It is also to be concluded that the rate of absorption of nitrogen did not commensurate with the overall increase in dry matter accumulation. All the two-factor interactions were generally significant, but not consistent.

Applied nitrogen had a depressing effect on the phosphorus content of leaf. It did not have consistent effect on the content of this nutrient in fruit. Application of phosphorus and potassium led to increase in phosphorus content of leaf and fruit. The content of this nutrient in stem was not affected by the application of any fertiliser nutrient. Increase in phosphorus content through increased availability of this nutrient consequent to fertilizer application is an expected observation. The decrease in phosphorus content by the application of nitrogen is attributable to the dilution effect. However, in the case of potassium,

there was no such dilution effect noticed and in fact the trend was that of an increase in phosphorus content with application of potassium. The only justification appears to be an increased vigour of the plant resulting from the application of potassium which more than compensated the probable dilution effect. The interaction effects were not consistent. Unlike in the case of nitrogen, there was no consistent and conspicuous decrease in phosphorus content of any of the component, over the stages. Evidently the continued absorption of phosphorus was adequate enough to commensurate with the increase in the dry weight of the plant parts. The two-factor interactions, though showed statistical significance, were not consistent enough to draw any general conclusion.

The effect of application of fertiliser nutrients on potassium content of plant parts was highly variable. The only consistent effects noticed were the decrease in potassium content of stem consequent to nitrogen application and increase in content of this nutrient in fruits with application of phosphorus and potassium. Even in these cases, though the results were statistically significant, the difference were only to the extent of a maximum of 0.2%. Neglecting these marginal changes in the content of potassium, it may be concluded that, in

general, potassium content of plant parts were not appreciably affected. Even application of potassium at a rate as high as 50 kg K_2O/ha did not alter the potassium content in tissues. This is quite contrary to the expectation because potassium is a nutrient that is known to show a high degree of luxury consumption (Tisdale and Nelson, 1971). The only justification for this appears to be that even at the highest level of applied potassium tried in the experiment, the rate of availability from the soil was not excessive. It may be noted that the trend in yield with increasing levels of potassium was linear. It again supports the point that potassium levels tried were suboptimal. Over the stages, there was a marked decrease in potassium content of all the plant components. This agrees with the general uptake pattern of the nutrient in plants. Many of the two-factor interactions were significant but being inconsistent these are neglected.

There was a marked and statistically significant increase in nitrogen uptake at all stages upto the intermediate level of 30 kg N/ha. Further increase in nitrogen level upto 60 kg N/ha also showed increase but the extent of increase was less. Application of phosphorus and potassium also increased the uptake of

nitrogen but the treatment differences were less conspicuous than those due to nitrogen levels. The increase in uptake of nitrogen at higher levels of nitrogen is an expected observation because dry matter accumulation and nitrogen content of plant parts increased due to the application of this nutrient. The increase in uptake of nitrogen due to the application of phosphorus and potassium is attributable only to the increase in dry weight. This effect of increased dry matter accumulation could more than compensate the decreased nitrogen content consequent to the application of these nutrients. Over the stages, there was a substantial increase in the uptake of nitrogen with advancing age, it being most conspicuous between 30 and 60 days after sowing. It may be noted in this context that the nitrogen content of plant parts showed a trend of decrease with advancing age. Another point of importance is that the extent of increase in uptake was low after the 60th day. This indicates the necessity of application of nitrogen before this period. Though the uptake was not substantial after the 60th day, accumulation by fruits was increasing substantially (as evidenced by marked increase in dry weight and lack of decrease in nitrogen content). At the same time, nitrogen

content in the vegetative parts declined substantially showing thereby that the significant part of nitrogen in the fruits was derived by translocation from the vegetative parts. The interactions are significant but inconsistent. The only trend that could be noticed is a higher uptake of nitrogen when the nutrients are applied in combination.

Increasing doses of applied nutrients generally resulted in an increase in the uptake of phosphorus. It was most conspicuous in the case of nitrogen and especially between control and 30 kg N/ha. But in the case of phosphorus and potassium the differences were not so marked. A comparison of the data on phosphorus content will reveal that the application of nitrogen resulted in a decrease in phosphorus content. On the contrary, phosphorus uptake showed a more conspicuous increase due to nitrogen application than due to applications of phosphorus and potassium. While discussing the nitrogen content, it was pointed out that the decrease in content of phosphorus was probably because of the dilution of absorbed phosphorus in a larger bulk of dry matter. This point will be further substantiated by the results of phosphorus uptake which increased

substantially due to the application of nitrogen. The increase in phosphorus uptake due to the application of phosphorus and potassium at graded levels is understandable because both phosphorus content and dry matter accumulation increased due to these treatments. As in the case of nitrogen, uptake of phosphorus also increased with time. This increase was more conspicuous between 30 and 60 days after sowing. Data on the phosphorus content of tissues, over the stages showed that unlike nitrogen, there was no appreciable change in the content of this nutrient with advancing age. In the case of phosphorus thus there was practically little translocation to the developing new tissues including the fruits. In otherwords, all the increase in uptake over the stages was also accompanied by continued absorption of this nutrient. The trend of interaction effects was similar to that of nitrogen uptake.

There was increase in the uptake of potassium with increasing doses of nutrients, especially upto the intermediate levels. As in the case of nitrogen and phosphorus uptake, this was also more conspicuous with nitrogen application. Even the added potassium

could not bring about a corresponding increase in its uptake.

While discussing potassium content, it was concluded that there was no appreciable change in the content of this nutrient consequent to the application of the three fertilizer nutrients. The marked increase in uptake of this nutrient is thus attributable almost exclusively to the increased dry weight.

As in the case of nitrogen and phosphorus, uptake of potassium also increased with advancing age, the extent of increase being most conspicuous between 30th and 60th days. For the same period content of potassium in all the tissues registered a decrease thus indicating that the continued absorption of the nutrient was mainly responsible for the increased accumulation in developing organs. The interaction effects showed the same pattern of response as in the case of nitrogen and phosphorus uptake.

SUMMARY

S U M M A R Y

The bhindi variety Co.I was grown in a 3^3 confounded factorial design with two replications during May - August 1978 at the Instructional Farm, College of Horticulture, Vellanikkara.

2. The experiment was conducted to find out the optimum/economic doses of nitrogen, phosphorus and potassium for higher yield, its components and pod quality and its components with special emphasis on crude protein content. Nitrogen, phosphorus and potassium at three levels and their combinations formed the 27 treatments in the experiment. Attempts were also made to find out the amount of nitrogen required to produce an economic level of pod productivity. Response curve was also fitted to find out the linear/ quadratic relation among levels of nitrogen and pod productivity.

3. There was increase in plant height with increasing levels of the three nutrients. The increase was significant in the case of nitrogen and phosphorus application only. The number of functional leaves was affected by application of all the three nutrients though the effect was consistent upto the intermediate

level only. In the case of phosphorus and potassium application, the increased leaf retentivity appears to be the factor responsible for the higher number of functional leaf.

4. Higher level of the three nutrients resulted in high leaf area index. Increased mean area/leaf was observed as an important factor responsible for the increase in leaf area index at the highest level of nutrients.

5. Application of nitrogen increased NAR upto the intermediate level (30 kg/ha) and this was followed by decrease at a still higher level. Phosphorus application tended to decrease the NAR. Added potassium had no effect.

6. Applied nitrogen increased the dry matter yield. Application of phosphorus also tended to increase the dry matter yield. In the case of potassium the result was not consistent though the highest value was recorded at the highest level of 50 kg K_2O/ha.

7. There was significant increase in yield due to increasing levels of all the three nutrients. In the case of nitrogen the yield was found to increase

upto 60 kg N/ha and the economic and optimum levels were worked out to be 61 and 61.23 kg respectively. Response to phosphorus and potassium application was observed linear. The optimum dose and the economic dose of phosphorus and potassium could not be hence worked out.

8. Application of nitrogen and potassium resulted in significantly higher number of flowers upto the highest level tried. The per cent of fruit set was significantly affected by nitrogen and phosphorus interaction. The combination of the highest phosphorus (50 kg P_2O_5/ha) without nitrogen resulted in higher per cent of fruit set. Application of nitrogen and potassium brought out significant increase in the number of fruit upto the highest level. Nitrogen and potassium application upto the highest level resulted in longer fruits. There was increase in fruit weight with increasing levels of all the three nutrients. However in the case of phosphorus significant increase was noticed only upto 25 kg P_2O_5/ha. Phosphorus and potassium produced fruits with higher per cent of dry matter. Nitrogen application had no significant effect on this character.

9. Harvest index was not significantly affected by different levels of three nutrients. Nitrogen content in leaf and stem increased with increasing levels of nitrogen applied. The varying levels of phosphorus had a depressing effect on the nitrogen content. Potassium application had no appreciable effect on nitrogen content. Similarly phosphorus content of leaf decreased with increasing levels of nitrogen application. The effect of applied fertilizer nutrients on potassium content of plant parts was observed highly variable.

10. Patterns in uptake of nutrients were studied under different levels of nutrients applied to soil. This has revealed that a bhindi crop yielding 116.39 quintals of pods/ha removes 87.81 kg nitrogen, 20.572 kg P_2O_5 and 103.905 kg K_2O/ha.

REFERENCES

R E F E R E N C E S

Anonymous.(1972-74). Progress report, A.I.C.V.I.P., I.C.A.R., New Delhi. pp. 182 - 184.

Anonymous.(1974-76). Progress report. A.I.C.V.I.P., I.C.A.R., New Delhi. pp. 426 - 428.

Anonymous.(1977-78). Progress report. A.I.C.V.I.P., I.C.A.R., New Delhi. pp. 157 - 164.

Anonymous.(1978). Package of Practices Recommendation, Kerala Agricultural University, Vellanikkara. pp. 136 - 137.

Arnon, D.I. (1943). Mineral nutrition of plant. Ann. Rev. Biochem. 12 : 493 - 528.

Arumugam, R. and Muthukrishnan, C.R. (1977). Oc.i Bhindi – A new variety for Tamil Nadu. Madras Agric. J. 64(12):

Asif, M.I. and Greig, J.K. (1972). Effect of N.P.K. fertilization on fruit yield and macro and micronutrient levels and nitrate accumulation in Okra (Abelmoschus esculentus (L.) Moench). J. American Soc. Hort. Sci. 97(4): 440 - 442.

*Bid, N.N., Das, P.K. and Dhua, S.P. (1971). Efficacy of nitrogen and phosphatic fertilizers on growth and yield of bhindi (Abelmoschus esculentus (L.) Moench). Technology, India. 8(2): 145 - 148. (En, 6 ref.) Fertilizer Corporation of India Ltd., Sindri, Bihar, HA 43(2): 665.

Burris, R.H. (1959). Nitrogen nutrition, Ann. Rev.Pl. Physiology. 10: 301 - 308.

Chandrasekharan, P. and George, C.M. (1971). Studies on the effect of NPK in combination with trace elements on yield of bhindi. Agric. Res. J. of Kerala. 8(2): 93 - 97.

Chonkar, V.S. and Singh, S.N. (1963). Studies on inorganic nutrition of bhindi (Abelmoschus esculentus (L.) Moench) in sand culture. Indian J. Hort. 20: 51 - 8.

Choudhury, B. (1967). Vegetables. National Book Trust, India. 1st Edn. pp. 171 - 173.

Jackson, M.L. (1973). Soil Chemical Analysis. Prentice Hall of India, New Delhi, 2nd Edn. pp. 498.

Kamalanathan, S., Sundararajan, S. and Thumburaj, S. (1970). Studies on the optimum spacing and manuring for Okra (Abelmoschus esculentus (L.) Moench). Madras Agric. J. 57: 10 - 17

Panse, V.G. and Sukhatme, P.V. (1967). Statistical methods for Agricultural Workers, Indian Council of Agric. Research, New Delhi.

Randhawa, G.S. (1962). A study of certain agronomic factor, viz. date of sowing, spacing and levels of nitrogen on early production of lady's finger. M.Sc. Thesis, Punjab Agric. Univ., Ludhiana.

Randhawa, K.S., Bhandari, M.R. and Singh, Diljit (1977). Influence of phosphorus, zinc application on Okra (Abelmoschus esculentus (L.) Moench). Progressive Hort. 9(2): 31 - 38.

Saimbhi, M.S. and Padda, D.S. (1967-68). Fertilizer trial on rainy season crop of Okra. Ann. Prog. Rep. Dept. Hort. P.A.U., Ludhiana, pp. 189 - 90.

Saimbhi, M.S. and Padda, D.S. (1970). Effect of nitrogen and phosphorus fertilization on the growth and yield of Okra (Abelmoschus esculentus (L.) Moench) J. Res. Ludhiana, India. 7(4): 460 - 63.

Saimbhi, M.S., Jaiswal, S.P., Wandpuri, K.S. and Kaur, G. (1975). Effect of K fertilization on plant growth, seed yield and chemical composition of Okra. Indian J. Agric. Sci. 45(4): 152 - 156.

Saimbhi, M.S., Randhawa, K.S. and Wandpuri, K.S. (1977). Effect of N fertilization and phorate on the production of Okra seed. J. Res. India 14(2): 178 - 181.

Choudhury, B. (1967). Vegetables. National Book Trust, India. 1st Ed. pp. 171 - 173.

Jackson, M.L. (1973). Soil Chemical Analysis. Prentice Hall of India, New Delhi, 2nd Ed. pp. 498.

Kamalanathan, S., Sundararajan, S. and Thumburaj, S. (1970). Studies on the optimum spacing and manuring for Okra (Abelmoschus esculentus (L.) Moench). Madras Agric. J. 57: 10 - 17

Panse, V.G. and Sukhatme, P.V. (1967). Statistical methods for Agricultural Workers, Indian Council of Agric. Research, New Delhi.

Randhawa, G.S. (1962). A study of certain agronomic factor, viz. date of sowing, spacing and levels of nitrogen on early production of lady's finger. M.Sc. Thesis, Punjab Agric. Univ., Ludhiana.

Randhawa, K.S., Bhandari, N.R. and Singh, Diljit (1977). Influence of phosphorus, zinc application on Okra (Abelmoschus esculentus (L.) Moench). Progressive Hort. 9(2): 31 - 38.

Saimbhi, M.S. and Padda, D.S. (1967-68). Fertilizer trial on rainy season crop of Okra. Ann. Prog. Rep. Dept. Hort. P.A.U., Ludhiana, pp. 189 - 90.

Saimbhi, M.S. and Padda, D.S. (1970). Effect of nitrogen and phosphorus fertilization on the growth and yield of Okra (Abelmoschus esculentus (L.) Moench) J. Res. Ludhiana, India. 7(4): 460 - 63.

Saimbhi, M.S., Jaiswal, S.P., Nandpuri, K.S. and Kaur, G. (1975). Effect of K fertilization on plant growth, seed yield and chemical composition of Okra. Indian J. Agric. Sci. 45(4): 152 - 156.

Saimbhi, M.S., Randhawa, K.S. and Nandpuri, K.S. (1977). Effect of N fertilization and phorate on the production of Okra seed. J. Res. India 14(2): 178 - 181.

APPENDICES

Appendix - I. Weather data (weekly averages) from June to August 1978

Date	Weeks after sowing	Temp. °C		Relative humidity per cent			Total R.F. mm	No. of hours of bright sunshine
		Max.	Mim.	FN	AN	AV		
June 4 - June 10	1	28.3	22.7	94	82	88	140.5	0.2
June 11 - June 17	2	28.0	21.9	95	85	90	256.6	0.9
June 18 - June 24	3	29.7	23.0	93	79	86	87.5	1.0
June 25 - July 1	4	28.0	22.5	94	84	89	219.9	0.3
July 2 - July 8	5	29.0	22.9	95	81	88	141.8	1.2
July 9 - July 15	6	27.4	22.4	96	81	88.5	296.8	0.6
July 16 - July 22	7	29.5	23.0	93	74	83.5	46.0	2.9
July 23 - July 29	8	27.9	23.2	95	85	90	252.7	0.3
July 30 - August 5	9	29.3	23.3	94	79	86.5	12.5	1.4
August 6 - August 12	10	28.2	23.1	96	86	91	241.5	0.5
August 13 - August 19	11	28.7	22.7	95	80	87.5	127.5	0.4
August 20 - August 26	12	28.1	23.1	95	79	87	93.9	0.6
August 27 - September 2	13	28.1	22.5	94	65	87.5	215.5	1.7

Appendix - II. Analysis of variance for growth components

Source	D.F.	Mean squares					
		Height of plants (cm) at 15 days intervals					
		15	30	45	60	75	90
Block	5	7.37**	45.59**	192.97	423.73*	324.32*	292.20*
N	2	22.47**	174.87**	2962.07**	15121.05**	16425.60**	19879.67**
P	2	6.84**	35.42*	626.34**	584.45*	1080.56**	1102.44**
NP	4	3.44**	30.92*	349.85**	406.35*	402.85*	589.87**
K	2	2.73**	34.71*	7.40	71.51	68.64	82.99
NK	4	2.63**	7.85	31.02	184.52	717.07**	828.23**
PK	4	5.76**	14.15	103.29	389.51	146.67	124.79
NPK	2	1.05	8.62	40.28	8.26	150.60	113.95
NPK^2	2	22.42**	1.37	30.80	247.15	56.52	134.07
NP^2K	2	10.34**	2.32	14.66	23.30	43.05	56.47
NP^2K^2	2	10.98**	3.59	65.32	34.39	239.81	149.26
Error	22	0.462	8.87	76.07	139.95	114.75	82.21

* Significant at 5 per cent level
** Significant at 1 per cent level

Appendix - III. Analysis of variance for growth components (continued)

Source	D.F.	Mean squares					
		Number of functioning leaves at 15 days intervals					
		No. of branches	15	30	45	60	75
Block	5	0.517*	0.456	1.260**	4.050**	2.254*	3.891**
N	2	3.607**	0.045	1.910**	89.020**	13.323**	7.563**
P	2	0.138	0.176	0.850*	8.611**	8.741**	0.093
NP	4	0.135	0.149	0.081	3.593*	19.803**	15.091**
K	2	0.015	0.598	0.417	9.313**	4.381**	6.364**
NK	4	0.367	0.150	0.310	1.411	50.064**	28.962**
PK	4	0.131	0.107	0.260	5.952**	28.081**	1.631
NPK	2	0.023	0.101	0.280	2.091	1.603	6.804**
NPK^2	2	0.186	0.103	0.260	3.541*	1.611	1.803
NP^2K	2	0.075	0.089	0.211	3.452	5.260**	3.902*
NP^2K^2	2	0.059	0.057	0.016	0.293	1.294	5.652**
Error	22	0.220	0.180	0.160	0.784	0.563	0.962

* Significant at 5 per cent level
** Significant at 1 per cent level

Appendix - IV. Analysis of variance for growth components (continued)

Source	D.F.	Mean squares			
		Total leaf production	Leaf area index		NAR ($g/m^2/day$)
			30th day	60th day	
Block	5	11.264**	0.013**	0.039**	1.104
N	2	220.391**	0.871**	2.971**	15.731**
P	2	2.341	0.069**	0.275**	50.923**
NP	4	41.923**	0.033**	0.317**	17.772**
K	2	6.071**	0.031**	0.227**	1.318
NK	4	41.972**	0.057**	0.816**	7.275**
PK	4	14.610**	0.006**	0.287**	33.724**
NPK	2	1.853	0.017**	0.081**	2.032
NPK^2	2	14.313**	0.014**	0.060**	0.373
NP^2K	2	3.751*	0.012**	0.540**	16.055**
NP^2K^2	2	8.711**	0.019**	0.042**	3.578*
Error	22	0.864	0.001	0.007	0.635

* Significant at 5 per cent level
** Significant at 1 per cent level

Appendix - V. Analysis of variance for yield components

Source	D.F.	Mean squares				
		Days taken for 50 % flowering	Number of flowers per plant	Number of fruits per plant	Percentage of fruit set (After angular transformation)	Average length of fruit (cm)
Block	5	56.907**	8.562**	4.345**	105.480**	1.058
N	2	56.909**	226.504**	131.387**	44.241*	10.542**
P	2	12.519*	3.501	6.774**	61.020**	0.436
NP	4	7.102**	43.699**	13.067**	110.418**	2.152**
K	2	23.574**	6.125*	13.958**	22.565	5.556**
NK	4	7.824**	40.197**	29.059**	24.474	1.289**
PK	4	25.514**	9.218**	0.584	71.206**	0.441*
NPK	2	16.259**	1.099	4.741**	5.218	0.580*
NPK^2	2	9.148**	27.090**	5.758**	196.089**	0.708*
NP^2K	2	12.574**	2.333	6.514**	49.644*	1.934**
NP^2K^2	2	8.685	5.290*	4.087**	4.556	0.002
Error	22	1.556	1.151	0.305	10.424	0.135

* Significant at 5 per cent level
** Significant at 1 per cent level

Appendix - VI. Analysis of variance for yield components (continued)

Source	D.F.	Mean squares		
		Mean weight of fruit (g)	Dry matter percentage of fruits	Yield of fruits (kg/ha)
Block	5	10.454**	105.480**	1842.6**
N	2	11.370**	44.241*	25555.6**
P	2	3.526*	61.020**	2530.9**
NP	4	0.601**	110.418**	1672.8**
K	2	9.187**	22.565	4012.3**
NK	4	3.209**	24.474	5237.7**
PK	4	8.476**	71.206	40.1
NPK	2	12.048**	5.218	141.9
NPK^2	2	12.065**	196.089	3074.1**
NP^2K	2	15.487**	49.644	1543.2**
NP^2K^2	2	6.687**	4.556	3030.9**
Error	22	0.157	10.424	153.7

* Significant at 5 per cent level
** Significant at 1 per cent level

Appendix - VII. Analysis of variance for linear and quadratic effects of the different nutrients (Yield kg/ha)

Source	D.F.	Mean squares
Nitrogen		
Leniar	1	47469.14**
Quadratic	1	3641.98**
Phosphorus		
Leniar	1	4969.14**
Quadratic	1	92.59
Potassium		
Leniar	1	7376.54**
Quadratic	1	648.15
Error	22	153.70

* Significant at 5 per cent level
** Significant at 1 per cent level

Appendix - VIII. Analysis of variance of total dry matter production at monthly intervals, harvest index and crude protein

Source	D.F.	Mean squares				
		Total dry matter production (kg/ha)			Harvest index	Crude Protein (g.w.b.)
		30th day	60th day	90th day		
Block	5	22688.6**	215809.3	308740.8	0.0133	0.0117**
N	2	889622.9**	21951895.5**	17965160.7**	0.0014	0.0091**
P	2	137417.6**	49391.7	37097.1	0.0103	0.0438**
NP	4	17916.5*	150592.7	971369.2**	0.0063	0.0922**
K	2	16466.5**	770560.1	1532520.8 **	0.0043	0.0265**
NK	4	18578.9**	1427658.6**	2432177.1**	0.0407*	0.0925**
PK	4	18988.6**	2846195.8**	2370284.1**	0.0081	0.0961**
NPK	2	49266.6**	255581.03	620400.001	0.0088	0.0109**
NPK^2	2	23864.2**	44607.1	2115932.8**	0.0010	0.00401
NP^2K	2	29010.4**	1039022.5*	1083738.4*	0.0190	0.1985**
NP^2K^2	2	24636.9**	220018.4	526460.9	0.0254	0.0258**
Error	22	776.6	279937.8	198431.6	0.0096	0.00152

* Significant at 5 per cent level
** Significant at 1 per cent level

Appendix - IX. Analysis of variance for the nutrient content of plant parts

Source	D.F.	Mean squares					
		Nitrogen content of leaf (per cent)			Phosphorus content of leaf(per cent)		
		30th day	60th day	90th day	30th day	60th day	90th day
Block	5	0.129**	0.182**	0.229**	0.008**	0.002**	0.003
N	2	2.833**	0.051**	0.406**	0.023**	0.012**	0.007*
P	2	0.448**	0.195**	0.084**	0.004**	0.013**	0.010**
NP	4	0.106**	0.185**	0.436**	0.008**	0.012**	0.006**
K	2	0.017**	0.059**	0.151**	0.022**	0.019**	0.022**
NK	4	0.074**	0.083**	0.249**	0.017**	0.029**	0.016**
PK	4	0.264**	0.063**	0.167**	0.016**	0.007**	0.003
NPK	2	0.0045	0.118**	0.268**	0.001*	0.006**	0.001
NPK^2	2	0.257**	0.272**	0.274**	0.014**	0.001	0.001
NP^2K	2	0.560**	0.044**	0.016**	0.011**	0.004**	0.011**
NP^2K^2	2	1.107**	0.051**	0.031**	0.001*	0.018**	0.033**
Error	22	0.003	0.002	0.001	0.0003	0.0004	0.0013

* Significant at 5 per cent level
** Significant at 1 per cent level

Appendix - X. Analysis of variance for the nutrient content of plant parts(continued)

Source	D.F.	Mean squares					
		Potassium content of leaf (per cent)			Nitrogen content of stem(per cent)		
		30th day	60th day	90th day	30th day	60th day	90th day
Block	5	0.857	0.169**	0.024**	0.015	0.022**	0.010**
N	2	0.668	0.802**	0.139**	1.252**	0.034*	0.292**
P	2	1.237	0.035**	0.049**	0.326**	0.025**	0.242**
NP	4	0.910	0.205**	0.134**	0.050**	0.045**	0.127**
K	2	0.630	0.142**	0.444**	0.229**	0.001	0.109**
NK	4	0.319	0.133**	0.112**	0.162**	0.059**	0.009**
PK	4	0.359	0.394**	0.136**	0.304**	0.060**	0.069**
NPK	2	0.0122	0.379**	0.086**	0.055**	0.040**	0.002*
NPK^2	2	1.123	0.040**	0.010	0.050**	0.004**	0.022**
NP^2K	2	1.453	0.078**	0.069**	0.139**	0.070**	0.063
NP^2K^2	2	0.407	0.388**	0.266**	0.008	0.024**	0.034
Error	22	0.0896	0.0024	0.004	0.009	0.0004	0.0004

* Significant at 5 per cent level
** Significant at 1 per cent level

Appendix - XI . Analysis of variance for the nutrient content of plant parts(continued)

Source	D.F.	Mean squares					
		Phosphorus content of stem(per cent)			Potassium content of stem(per cent)		
		30th day	60th day	90th day	30th day	60th day	90th day
Block	5	0.011**	0.003**	0.003**	0.454**	0.236**	0.142**
N	2	0.023**	0.017**	0.029**	3.297**	1.569**	1.043**
P	2	0.018**	0.027**	0.0008	0.261**	0.338**	0.044
NP	4	0.015**	0.003**	0.004**	0.905**	0.395**	0.118**
K	2	0.022**	0.019**	0.006**	0.380**	0.203**	0.088*
NK	4	0.014**	0.015**	0.001	1.549**	0.531**	0.202**
PK	4	0.009**	0.012**	0.006**	1.459**	0.252**	0.438**
NPK	2	0.0003	0.007**	0.0015*	0.550**	0.538**	0.009
NPK^2	2	0.038**	0.002**	0.0016*	0.635**	0.108**	0.656**
NP^2K	2	0.037**	0.006**	0.008**	2.968**	0.064**	0.050
NP^2K^2	2	0.006**	0.007**	0.009**	0.767**	0.170**	0.061
Error	22	0.001	0.0002	0.0004	0.0011	0.0005	0.025

* Significant at 5 per cent level
** Significant at 1 per cent level

Appendix - XII. Analysis of variance for the nutrient content of plant parts (continued)

Source	D.F.	Mean squares					
		Nitrogen content of fruit (per cent)		Phosphorus content of fruit (per cent)		Potassium content of fruit (per cent)	
		60th day	90th day	60th day	90th day	60th day	90th day
Block	5	0.014	0.032**	0.0007*	0.0007**	0.084**	0.112**
N	2	0.040	0.065**	0.0004	0.0014**	0.047**	0.010
P	2	0.041	0.014**	0.0102**	0.0143**	0.233**	0.061**
NP	4	0.058**	0.027**	0.0024**	0.0024**	0.137**	0.149**
K	2	0.104**	0.031**	0.0016**	0.0039**	0.002**	0.015*
NK	4	0.304**	0.068**	0.0070**	0.0076**	0.096**	0.043**
PK	4	0.070**	0.100**	0.0099**	0.0080**	0.255**	0.087**
NPK	2	0.018	0.049**	0.0010*	0.0005	0.114**	0.048**
NPK^2	2	0.050*	0.028**	0.0024**	0.0020**	0.104**	0.225**
NP^2K	2	0.032	0.025**	0.0075**	0.0031**	0.333**	0.176**
NP^2K^2	2	0.076**	0.135**	0.0035**	0.0045**	0.097**	0.145**
Error	22	0.0131	0.0007	0.00027	0.00015	0.0020	0.0033

* Significant at 5 per cent level
** Significant at 1 per cent level

Appendix-XIII. Analysis of variance for the total uptake of nitrogen and phosphorus (kg/ha)

Source	D.F.	Mean squares					
		Uptake of nitrogen (kg/ha)			Uptake of phosphorus (kg/ha)		
		30th day	60th day	90th day	30th day	60th day	90th day
Block	5	7.766**	158.135**	113.243**	0.183**	6.613	14.931**
N	2	803.467**	2756.669**	5011.852**	11.560**	142.970**	277.407**
P	2	56.420**	22.967	568.291**	2.787**	10.560	1.471
NP	4	23.035**	154.757**	344.389**	1.070**	19.619*	37.458**
K	2	5.508**	158.353*	39.407**	0.522**	0.721	17.278**
NK	4	7.125**	504.831**	330.069**	0.602**	13.110	26.941**
PK	4	5.014**	1039.522**	949.091**	6.076*	27.132**	48.170**
NPK	2	8.214**	222.467**	54.191**	0.298**	8.702	6.945
NPK^2	2	7.646**	13.762	121.638**	0.253**	21.281*	13.440*
NP^2K	2	4.139**	96.027*	242.221**	0.650**	45.041**	8.864
NP^2K^2	2	17.204**	72.248	418.728**	0.298**	23.195*	65.441**
Error	22	0.472	27.711	5.553	0.026	5.580	2.880

* Significant at 5 per cent level
** Significant at 1 per cent level

Appendix - XIV. Analysis of variance for the total uptake of potassium

Source	D.F.	Mean squares		
		Uptake of potassium (kg/ha)		
		30th day	60th day	90th day
Block	5	31.197*	218.942	218.781**
N	2	1229.925**	9367.188**	5541.686**
P	2	187.606**	294.777	24.585
NP	4	114.733**	197.295	861.386**
K	2	43.114*	47.049	157.424*
NK	4	39.036**	175.574	956.880**
PK	4	19.506	1254.375**	1310.769**
NPK	2	21.740	802.767**	177.444*
NPK^2	2	9.817	167.966	536.778**
NP^2K	2	52.913**	1044.119**	399.203**
NP^2K^2	2	97.467**	418.282	1961.312**
Error	22	8.918	128.269	32.422

* Significant at 5 per cent level

** Significant at 1 per cent level

STUDIES ON THE EFFECTS OF GRADED DOSES OF NITROGEN, PHOSPHORUS AND POTASSIUM ON GROWTH, YIELD AND QUALITY OF BHINDI (*Abelmoschus esculentus* (L.) Moench.) VARIETY Co. 1

BY

SUBRAMANIAN, K. V.

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the

requirement for the degree

Master of Science in Horticulture

Facultyof Agriculture

Kerala Agricultural University

Department of Olericulture

COLLEGE OF HORTICULTURE

Vellanikkara - Trichur.

1980

A B S T R A C T

The yield of bhindi per unit of land and per unit of time has been observed to be very low in our country. A galaxy of reasons - poor genetic potential of the existing genotypes, incidence of parasitic and non-parasitic diseases and above all lack of an appropriate agronomic practices - have been attributed to the poor performance of Indian bhindi. There remains an urgent need to chalk out a fertilizer schedule for the high yielding varieties like Co.I which is popular in Kerala.

The present study "Studies on the effect of graded doses of nitrogen, phosphorus and potassium on growth, yield and quality of bhindi (Abelmoschus esculentus (L.) Moench.)", was designed to find out the optimum and economic levels of the three major nutrients (nitrogen, phosphorus and potassium) which would give a yield level above 100 q/ha.

A significant increase in yield was observed due to increasing levels of all the three nutrients. In the case of nitrogen the yield was found to increase upto 60 kg/ha and the economic and optimum levels were worked

out to be 61 and 61.23 kg/ha respectively. Response to phosphorus and potassium application was observed to be linear. Patterns in uptake of nutrients indicated that a bhindi crop yielding 116.39 quintals of pods per hectare removes 87.81 kg nitrogen, 20.872 kg P_2O_5 and 103.905 kg K_2O/ha.

The effects of graded doses of nitrogen, phosphorus and potassium on plant height, leaf production, leaf area index, net assimilation rates, per cent of fruit set and other yield components were also studied.