EFFECT OF DIFFERENT LEVELS OF NITROGEN, PHOSPHORUS AND POTASSIUM ON THE GROWTH AND YIELD OF VEGETABLE COWPEA Var. KURUTHOLAPAYAR [*VIGNA UNGUICULATA*-(L) Walp] GROWN AS AN INTERCROP IN THE COCONUT GARDENS AND IN THE OPEN

BY
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THESIS
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requirement for the degree of
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Dedicated to my parents

DECLARATION

I hereby declare that this thesis entitled "Effect of different levels of Nitrogen, Phosphorus and Potassium on the Growth and Yield of Vegetable Cowpea Var. Kurutholapayar (Vigna unguiculata (L.) Walp.) grown as an inter crop in the coconut gardens and in the open" 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, at any other University or Society.

Vellayani,
11-5-1987.

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CERTIFICATE

Certified that this thesis entitled "Effect of different levels of Nitrogen, Phosphorus and Potassium on the growth and yield of Vegetable Cowpea Var. Kurutholapayar (Vigna unguiculata (L.) Walp.) grown as an inter crop in the coconut gardens and in the open" is a record of research work done independently by Sri. Rajesh Chandran under my guidance and supervision and it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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RAJESH CHANDRAN

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LIST OF ABBREVATIONS

1.	C.D.	- Critical Difference
2.	cm	- centimetre
3.	DAS	- Days After Sowing
4.	DMP	- Dry Matter Production
5.	E.C.	- Electrical Conductivity
6.	Fig.	- Figure
7.	ha	- hectare
8.	K	- Potassium
9.	Kg	- Kilogram
10.	mm	- millimetre
11.	N	- Nitrogen
12.	NS	- Not Significant
13.	P	- Phosphorus
14.	S	- Significant
15.	SE	- Standard Error
16.	t	- tonnes

INTRODUCTION

INTRODUCTION

Importance of vegetables for the maintenance of normal health is being realized in all parts of the world and a consciousness for quality has also been developed. Hence the need for the improvement of different vegetable crops and development of new technology to increase their production have been the major considerations of agricultural scientists.

In Kerala, vegetables occupy an area of 3.16 lakh hectares with an annual production of 22 thousand tonnes (Anon, 1983). Among the various vegetable crops grown, vegetable cowpea occupies an important place.

Vegetable cowpea (Vigna unguiculata (L.) Walp) is a highly nutritious leguminous vegetable crop. Its pods are almost as good as peas. Infact, it is a rich and cheap source of vegetable protein. Hence it deserves a place in every vegetable farm and kitchen garden along with other vegetables. Vegetable cowpea, being a warm season crop, can stand a considerable degree of drought and therefore fits every farm every season. It can tolerate moderate shade and hence can be grown as an intercrop in coconut gardens.

A number of varieties of vegetable cowpea are grown throughout India. In the present study, one of the most popular and high yielding local varieties of Kerala viz., "Kurutholapayar" was grown. This variety is extensively cultivated as an intercrop in the coconut gardens in Kerala. But, no specific manurial schedule has been evolved so far for this variety. It is also necessary to standardise its nutritional requirements when grown under partially shaded and open conditions. Hence the present study was undertaken with the following objectives.

1. To study the effect of nitrogen, phosphorus, potassium and their combinations on the growth, yield and quality of vegetable cowpea var. Kurutholapayar in the open and under the partially shaded conditions.

2. To find out the optimum doses of N, P and K for the variety Kurutholapayar in the open and under the partially shaded conditions.

3. To work out the economics of fertilization (N,P and K) of vegetable cowpea in the open and under the partially shaded conditions.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Scientific literature on the agronomic requirements of vegetable cowpea is relatively scanty. However, the available information on the effect of fertilizer nutrients and shade on the growth, yield, quality and nutrient uptake of vegetable cowpea and other similar legumes are briefly reviewed and presented in this chapter.

I. Effect of nitrogen on

1. Vegetable cowpea

Chauhan (1972) recommended 10 to 20 kg N/ha for vegetable cowpea to obtain higher yields.

2. Grain cowpea

George (1981) reported that application of 30 kg N/ha increased the plant height in grain cowpea. Sheela (1985) also observed similar response of grain cowpea due to N application.

Horner and Mojtchedi (1970) and Malik et al. (1972) found no influence of nitrogen on the yield of grain cowpea. However, Kurdikeri et al. (1973) reported increased seed yield with increase in the levels of nitrogen. This

increased yield was due to increased flower production, retention of pods, more seeds per plant and higher thousand seed weight. Sharma (1977) obtained higher yield of cowpea by the application of 20 kg N/ha compared to no N application. Rhodes (1978) observed that seed yield increased with increase in the levels of nitrogen from zero to 60 kg/ha. Viswanathan et al. (1979) from trials carried out for three years found that the crop showed better response to applied nitrogen. The yield recorded at 0, 20 and 40 kg N/ha were 664, 755 and 762 kg/ha. The difference in yield between nitrogen at 20 and 40 kg/ha was less.

Haque et al. (1980) obtained higher grain yield of cowpea by the application of 60 kg N/ha. Huxley (1980) observed that 10.5 kg N/ha supplied as a starter dose increased the pod number. The highest grain yield of cowpea was obtained when 20 kg N/ha was given as basal dose and 10 kg N/ha as foliar spray at mid pod-fill stage (Sheela, 1985). She also found that application of 30 kg N/ha as basal dose resulted in higher bhusa yields.

Dart and Mercer (1965) reported that nitrogen uptake increased with increase in the levels of nitrogen. N uptake was more by nitrogen application and the N uptake at 20 and 30 kg N/ha were on par but superior to the lower level of 10 kg N/ha (Kumar et al., 1979).

George (1981) found that N uptake increased with increase in the amounts of nitrogen applied (10, 20 and 30 kg/ha). Sheela (1985) also noted a similar trend with reference to the nutrient uptake.

Malik et al. (1972) and Kurdikeri et al. (1973) found that application of higher doses of nitrogen did not influence the protein content of grain cowpea. However, George (1981) and Sheela (1985) reported that the protein content of grain cowpea was enhanced by increase in the levels of applied nitrogen.

3. French beans

Bains (1969) observed that the protein content of French beans increased with the rate of N fertilizer applied.

4. Winged beans

Higher rates of N application results in greater growth of all plant parts of winged bean except root (Hilder brand et al., 1981). Nitrogen application upto 30 kg/ha increased the plant height, number of leaves per plant and total dry matter production (Brillin, 1984).

Brillin (1984) reported that the yield of winged beans increased with increase in the levels of nitrogen. He further observed earliness in flowering, increase in the number of flowers, number of pods, yield of green pods and yield of bhusa at higher rates of N application.

The uptake of nitrogen increased with nitrogen application upto 30 kg/ha (Brillin, 1984).

Hilderbrand et al. (1981) obtained increased protein content of winged beans by nitrogen application. Increase in the protein content of pods by increasing the nitrogen dose from zero to 15 kg/ha was reported by Brillin (1984) in winged beans.

The literature on the effect of nitrogen on the growth, yield, quality and nutrient uptake of pulses presented above clearly reveal that pulses respond very well to applied nitrogen. But, in general, the response of pulses to applied nitrogen is restricted to a level of 30 to 60 kg/ha.

II. Effect of phosphorus on

1. Grain cowpea

Sen and Bains (1955) observed an increase in the growth of grain cowpea with increase in the levels of

phosphorus from 16 to 64 kg P_2O_5/ha. Stewart and Reed (1969) found that plant growth increased with increase in the levels of phosphorus upto 90 kg P_2O_5/ha.

Positive influence of phosphorus on dry matter production of grain cowpea was reported by Rama Rao and Patel (1975) and Sharma and Yadav (1976). But, Subramanian et al. (1977) reported that phosphorus had no influence on plant height in grain cowpea.

Application of phosphorus resulted in higher fresh and dry matter yield (Tripathi et al., 1977). Geethakumari (1981) found that plant height and leaf number of grain cowpea increased with increase in phosphorus application upto 50 kg P_2O_5/ha.

Application of 60 kg P_2O_5/ha markedly increased the seed yield, while application of 90 kg P_2O_5/ha decreased it (Malik et al., 1972). But, Addy (1975) and Johnson and Evans (1975) reported non significant effect of phosphorus on the grain yield of cowpea.

Sharma (1977) found that application of 30 kg P_2O_5/ha gave the highest grain yield, but it did not differ significantly when compared with the yield obtained with 60 kg P_2O_5/ha. The yields at these two levels were higher

compared to control. Tarila et al., (1977) observed that increase in the levels of applied phosphorus increased the flower and fruit number.

Ahlawat et al. (1978) reported that application of P had marked effect in increasing the number of pods per plant, length of pod and grain yield. Sharma and Arora (1982) obtained higher grain yield by P application compared to control, but the difference in yield between 40 and 80 kg P_2O_5/ha was not considerable.

Increasing the rates of P_2O_5 from zero to 20 and 40 kg/ha in the rainy season of 1980-81 increased the average seed yields from 0.61 to 0.72 and 1.12 t/ha respectively (Jain et al., 1984). Patel et al. (1985), in an experiment to study the response of cowpea to different levels of phosphorus, found that application of 40 kg P_2O_5/ha gave higher green pod yield than zero and 20 kg P_2O_5/ha. But, the yield obtained at this level was on par with that of 60 kg P_2O_5/ha.

P content of cowpea increased with increase in the rate of applied P_2O_5 upto 67 kg/ha (Singh and Jain, 1968). Omueti and Oyenuga (1970) reported that applied P increased the P content of seed. Sharma et al. (1974) found that application of 50 kg P_2O_5/ha increased the uptake of phosphorus.

However, Johnson and Evans (1975) noted that phosphorus had no effect on the uptake of nitrogen, phosphorus and potassium.

Uptake of nitrogen, phosphorus and potassium by grain cowpea increases with increase in the rate of phosphorus fertilization and application of 50 kg P_2O_5/ha results in the higher uptake of these nutrients (Geethakumari, 1981).

Malik et al. (1972) reported that application of P had no effect on seed protein content. But, Geethakumari (1981) noted increase in the protein content of grain by phosphorus application.

2. French beans

Application of P @ 30 and 60 kg P_2O_5/ha enhances the vegetative growth of French beans (Mahatanya, 1976).

Pande et al. (1974) reported that the yield of French beans increased with phosphorus application upto the level of 75 kg P_2O_5/ha.

3. Winged beans

Application of P @ 60 kg P_2O_5/ha increasesthe dry matter production of winged beans (Dagaduan, 1980).

Reports by Dagaduan (1980) indicated that application of 50 kg P_2O_5/ha increased the pod yield. A similar result was reported by Brillin (1984)

Dagaduan (1980) reported that protein content of winged bean pods was not affected by phosphorus application.

The review on the effect of phosphorus on pulse crops presented above clearly reveals that phosphorus application has got a significant positive effect on the growth, yield and nutrient uptake of pulse crops. In general, the response of pulses to applied phosphorus is restricted to a level of 50 to 75 kg P_2O_5/ha.

III. Effect of potassium on

1. Grain cowpea

Sundaram et al. (1974) reported that application of potassium upto 30 kg K_2O/ha did not affect the green matter and dry matter yield in cowpea.

Chesney (1974) reported that seed yields of cowpea increased by potassium application. Johnson and Evans (1975) observed that potassium application increased cowpea yields when soil potassium content was low.

Viswanathan et al. (1979) reported that response of cowpea to applied potassium was not significant. Similar results were reported by Jain et al. (1984) and Sarnaik et al. (1984).

Stewart and Reed (1969) in pot experiments found that plant content of potassium increased with the addition of potassium. Johnson and Evans (1975) noted higher potassium content in leaf when it was applied to cowpea.

2. French beans

In a fertilizer trial conducted by Barrios et al. (1970) it was found that potassium application gave a negative response in seed yield of French beans. Sutton et al. (1973) reported that increasing the rate of potassium beyond 93 kg K_2O/ha failed to increase the yield consistently. Eira et al. (1974) in a dry season field trial found that yield of French beans tended to decrease as levels of potassium increased.

An increase in the rate of applied potassium increases the potassium content of French beans (Bains, 1969).

3. Winged beans

Higher rates of potassium application decreased dry matter yield in winged beans (Musevics, 1981).

Potassium application did not increase the nitrogen or phosphorus uptake, but it increased the potassium uptake (Brillin, 1984).

The literature on the effect of potassium on grain cowpea, French beans and Winged beans presented above indicates that the effect of potassium on these crops can be positive or negative. In some cases, no effect of potassium could be noticed.

IV. Interaction effects

N x P interaction

Malik et al. (1972) observed a positive interaction of nitrogen and phosphorus on the yield of grain cowpea. Application of 11 kg N along with 44 kg P_2O_5/ha gave the highest yield in grain cowpea (Kurdikeri et al., 1973). This increased yield was related to increase in flower production and retention of pods.

Maharana and Das (1973) reported that in grain cowpea, application of 50 kg N along with 50 kg P_2O_5/ha. produced more number of pods per plant. Application of 37.67 kg N along with 37.37 kg P_2O_5/ha resulted in the highest grain yield in cowpea (Viswanathan et al., 1979).

V. Soil fertility status

From field and glass house experiments with French beans, Bains (1967) observed that there was a build up of available phosphorus and potassium in the soil with the application of P_2O_5 and K_2O.

Khare and Rai (1968) while studying the symbiotic nitrogen fixation by a few leguminous crops including cowpea found that the crops when treated with P, the N content of soil was high.

Garg et al. (1970) from trials conducted with grain cowpea reported that phosphorus application @ 37, 74 and 111 kg P_2O_5/ha increased the residual nitrogen and phosphorus in the soil. Inoculation of cowpea seeds and application of phosphorus (22.4 kg/ha) increased the soil N by 58% over control (Sahu and Behera, 1972).

Brillin (1984) reported that in winged bean grown plots, the total nitrogen and available phosphorus contents in the soil after the experiments was not influenced by the individual effects of nitrogen, phosphorus and potassium or by their combinations. But, the available potassium content in the soil was influenced by the main effect of potassium.

The review presented above generally indicates that application of fertilizer nutrients to leguminous crops results in the build up of these nutrients in the soil.

VI. Shade effect on

1. Growth characters

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

Plant height decreased due to shading in red gram (Sansamma George, 1982). She could not observe any marked effect of shading on cowpea or black gram. But, Krishnankutty (1983) reported significant effect of shading on the height of vegetable cowpea, at 60 days after sowing. He further noticed that the total dry weight at all stages of crop growth was much higher for vegetable cowpea grown without shade and there was a steady decline in dry matter production with increase in shade intensities.

2. Yield components and yield

Sansamma George (1982) observed a drastic decline in the yield of grain cowpea due to shading. Krishnankutty (1983) found considerable reduction in the yield of vegetable cowpea due to shading. On percentage basis, the yields under 25, 50

and 75 per cent shade levels were 39.9, 19.45 and 13.48 per cent respectively compared to those grown in the open. He also noted a delay in flowering in vegetable cowpea with increased shade intensities. The yield components viz., number of pods per plant and weight of pod per plant decreased with increasing shade levels.

3. Uptake of nutrients

Sansamma George (1982) observed increased potassium content under shade compared to open in grain cowpea and groundnut. But, in blackgram the nutrient content remained unaffected by shading.

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

It is evident from the review presented in the foregoing section that the crops raised in the open show a much better performance than those raised under the partial shade.

MATERIALS AND METHODS

MATERIALS AND METHODS

Two field experiments were conducted, one in coconut garden (partially shaded condition with 33 per cent shade) and the other in the open gardenlands, of the Instructional Farm, College of Agriculture, Vellayani, to standardise the requirements of nitrogen, phosphorus and potassium for vegetable cowpea variety Kurutholapayar.

The experimental site is located at an altitude of 29 metres above mean sea level and at a latitude of 8.5°N and 76.9°E longitude.

SOIL

The soil of the experimental area was red sandy loam, moderately acidic, low in nitrogen, medium in available phosphorus and available potassium. The mechanical composition and the chemical properties of the soil before the experiment are presented in Table 1 and 2 respectively.

Table 1. Mechanical composition of soil.

Constituent	Content in soil (%)	Method used
Coarse sand	40.7	Bouyoucos Hydrometer method (Bouyoucos, 1962)
Fine sand	25.3	
Silt	18.0	
Clay	12.4	
Textural class	Sandy loam	

Table 2. Chemical properties of soil before the experiment.

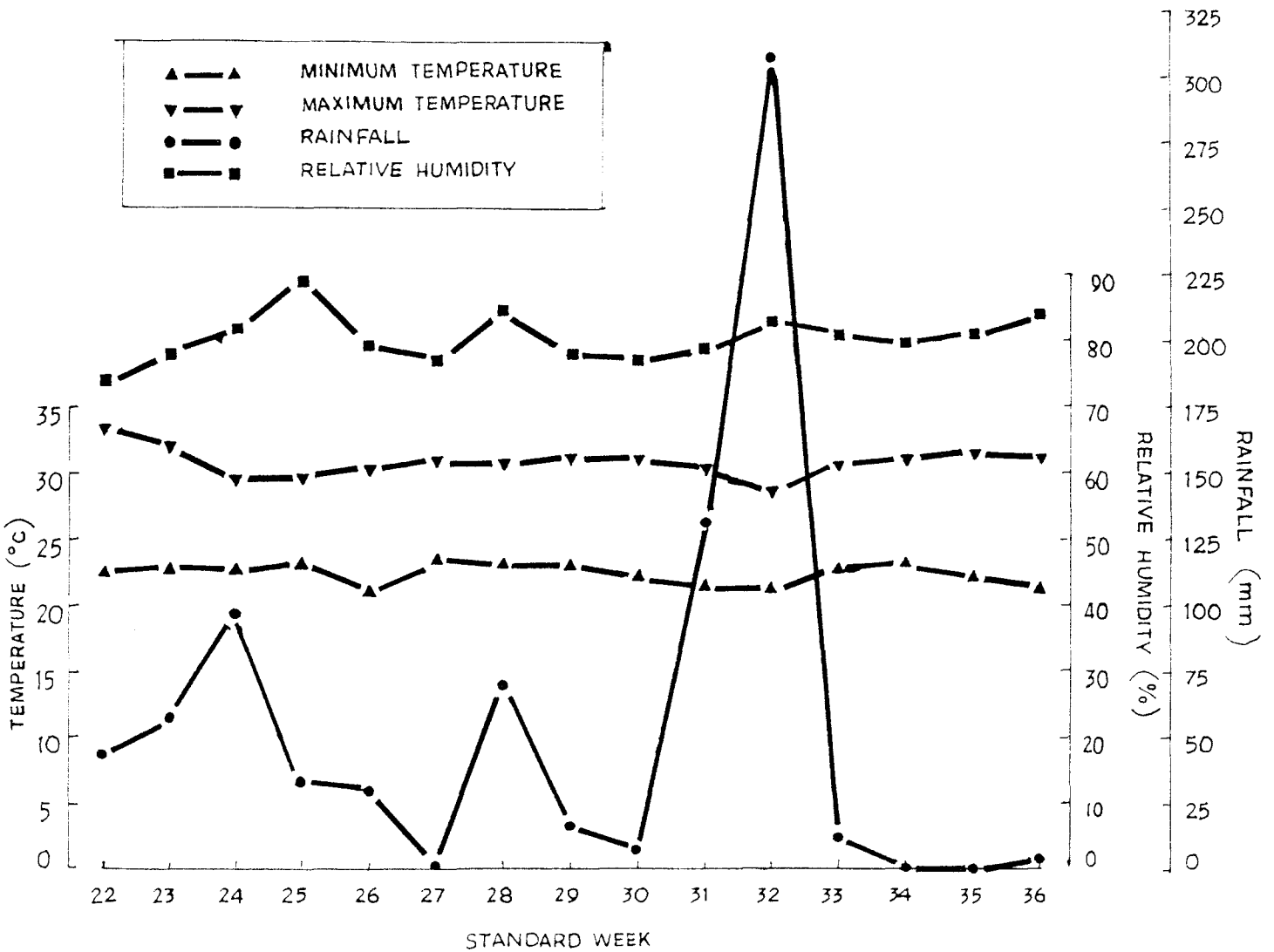
Constituent	Content in soil	Method used (Jackson, 1967)
Total nitrogen (kg/ha)	2400	Modified microkjeldahl method
Available nitrogen (kg/ha)	200 (low)	Alkaline permanganate method
Available phosphoric acid (kg/ha)	33 (medium)	Bray's method
Available potash (kg/ha)	138 (medium)	Neutral normal ammonium acetate extract-Flame photometric method
pH	5.2 (moderately acidic)	1:2.5 soil solution ratio using pH meter
E.C. (m. mhos/cm)	0.1 (safe)	1:2 soil water extract using solubridge

CLIMATE

The experimental site enjoys a humid tropical climate. The data on various weather parameters (monthly rain fall, mean maximum and minimum temperatures and relative humidity) during the cropping period are presented in Fig.1 and Appendix I.

The mean maximum and minimum temperatures during the cropping period ranged from 28.4°C to 39.6°C and 20.5°C to 23.6°C respectively. The mean relative humidity ranged

FIG. 1 WEATHER CONDITIONS DURING THE CROPPING PERIOD



from 69.9% to 89.4%. The monthly rainfall of the cropping period ranged from 0 mm to 308.5 mm with a total receipt of 805.6 mm.

MATERIALS

Variety

Kurutholapayar is a local twining cowpea variety of 100 to 120 days duration with pale green leaves and lilac coloured flowers. Pods are very long (45 to 56 cms), straight and smooth and the fibre content in the fruits is low.

Seed

Seeds with 90 per cent germination were obtained from a local farmer of Kalliyoor village near the College of Agriculture, Vellayani. The seed colour is red.

Fertilizer

The nitrogen, phosphorus and potassium were supplied through ammonium sulphate (20.5% N), super phosphate (16% P_2O_5) and muriate of potash (60% K_2O).

METHODS

Experiment-1. In the coconut gardens

The coconut palms were of 50 years age casting 33% shade on an average.

The treatments consisted of all possible combinations of three levels of nitrogen, three levels of phosphorus and three levels of potassium.

(i) Levels of nitrogen

n_1	-	10 kg N/ha
n_2	-	20 kg N/ha
n_3	-	30 kg N/ha

(ii) Levels of phosphorus

p_1	-	20 kg P_2O_5/ha
p_2	-	40 kg P_2O_5/ha
p_3	-	60 kg P_2O_5/ha

(iii) Levels of potassium

k_1	-	10 kg K_2O/ha
k_2	-	20 kg K_2O/ha
k_3	-	30 kg K_2O/ha

Design and lay-out of the experiment

The experiment was laid out as a 3^3 factorial experiment in 2 replications, confounding NPK in replication 1 and NP^2K^2 in replication 2.

The lay-out plan is presented in Fig.2.

Number of treatment combinations	:	27
Replications	:	2
Number of blocks per replication	:	3
Number of plots per block	:	9
Gross plot size	:	3 x 3 m
Border	:	1 row of plants all around each plot.
Net plot size	:	1.5 x 2.5 m
Spacing	:	75 x 25 cm

Experiment-2. In the open condition

The technical programme of experiment 1 was repeated as such in the open field simultaneously to compare the treatment effects in the coconut garden and in the open conditions.

FIG. 2. LAY-OUT PLAN (3^3 PARTIALLY CONFOUNDED FACTORIAL EXPERIMENT)

OPEN CONDITION

	B 1.1			B 1.2			B 1.3		
REPLICATION 1	N2 P2 K2	N3 P3 K3	N1 P2 K3	N3 P1 K3	N2 P1 K1	N1 P2 K1	N2 P2 K1	N2 P1 K2	N3 P3 K2
	N3 P2 K1	N1 P1 K1	N1 P3 K2	N2 P3 K2	N3 P2 K2	N3 P3 K1	N3 P2 K3	N1 P1 K3	N1 P2 K2
	N2 P3 K1	N3 P1 K2	N2 P1 K3	N1 P3 K3	N2 P2 K3	N1 P1 K2	N3 P1 K1	N2 P3 K3	N1 P3 K1
REPLICATION 2	N2 P3 K3	N1 P2 K3	N3 P1 K3	N2 P3 K1	N2 P1 K3	N1 P1 K2	N1 P2 K2	N1 P3 K1	N2 P2 K3
	N2 P1 K2	N1 P1 K1	N3 P2 K2	N3 P1 K1	N2 P2 K2	N3 P2 K3	N3 P1 K2	N3 P3 K3	N2 P1 K1
	N1 P3 K2	N2 P2 K1	N3 P3 K1	N1 P3 K3	N1 P2 K1	N3 P3 K2	N1 P1 K3	N2 P3 K2	N3 P2 K1
	B 2.1			B 2.2			B 2.3		

PARTIALLY SHADED CONDITION

	B 1.1			B 1.2			B 1.3		
REPLICATION 1	N3 P3 K3	N2 P1 K3	N1 P1 K1	N2 P1 K1	N2 P3 K2	N3 P1 K3	N2 P1 K1	N2 P2 K3	N2 P1 K2
	N3 P1 K2	N2 P3 K1	N2 P2 K2	N3 P2 K2	N3 P3 K1	N1 P2 K1	N3 P1 K1	N1 P1 K3	N3 P3 K2
	N1 P3 K2	N1 P2 K3	N3 P2 K1	N2 P2 K3	N1 P3 K3	N1 P1 K2	N1 P3 K1	N1 P2 K2	N3 P2 K3
REPLICATION 2	N3 P2 K2	N3 P3 K1	N2 P3 K3	N1 P1 K2	N3 P2 K3	N2 P2 K2	N2 P1 K1	N1 P1 K3	N2 P2 K3
	N1 P3 K2	N1 P1 K1	N3 P1 K3	N3 P3 K2	N2 P1 K3	N3 P1 K1	N3 P2 K1	N2 P3 K2	N1 P2 K2
	N2 P2 K1	N1 P2 K3	N2 P1 K2	N1 P2 K1	N1 P3 K3	N2 P3 K1	N3 P1 K2	N1 P3 K1	N3 P3 K2
	B 2.1			B 2.2			B 2.3		

N

TREATMENTS

LEVELS OF NITROGEN (N1, N2, N3) 10, 20, 30 kg N/ha

LEVELS OF PHOSPHORUS (P1, P2, P3) 20, 40, 60 kg P_2O_5/ha

LEVELS OF POTASH (K1, K2, K3) 10, 20, 30 kg K_2O/ha

Preparation of the field

The experimental area was dug twice, stubbles and weeds removed, clods broken and the field was levelled. Blocks and plots were laid out as per the experimental design.

Fertilizer application.

Lime was incorporated in the soil at the rate of 250 kg/ha (Anon, 1986) 10 days prior to sowing.

The required quantities of ammonium sulphate, super phosphate and muriate of potash for each plot were mixed thoroughly and applied uniformly by broadcasting in the respective plots. Half dose of N and full dose of P_2O_5 and K_2O were applied at the time of final digging. The remaining quantity of N was applied in 2 equal split doses, one at 20th and the other at 40th day after sowing.

Seeds and Sowing

Sowing was done on 28th May 1986. Seeds were treated with rhizobium culture and dibbled at the rate of 2 seeds per hole and covered with a thin layer of soil. One light irrigation was given immediately after sowing. Thinning was done 7 days after sowing.

After care

The crop was staked with Glyricidia twigs and coir to facilitate trailing. Hand weeding was done at the end of third, sixth, ninth and twelth week after sowing. Malathion 0.25 per cent (Anon, 1986) was sprayed 65 days after sowing against aphid attack. The general stand of the crop was satisfactory.

Harvest

Harvesting was done from 50th day after sowing by picking mature pods from individual plots. The border rows and the observation plants were harvested separately. The fresh pods collected from the net plots at each harvest were weighed separately. The weight of dried pods was also recorded. The bhusa from the net plots was pulled out, fresh weight recorded, sun dried for three days and the dry weight was also recorded.

Observations

I. Plant characters

A. Biometric observations

Ten plants were selected at random from the net plot for taking the biometric observations.

1. Length of vine

From the plants marked for taking biometric observations, the length of vine was measured from the base to the growing tip of the tallest branch or the longest vine as the case may be and the average was worked out.

2. Number of leaves per plant

Total number of fully opened green leaves in the sample plants were counted at the 20th and 40th day after sowing and the average worked out.

3. Total dry matter production

The pods and bhusa of the sample plants at harvest were separately oven dried to constant weights at 80 ± 5°C. The total dry weight was recorded and expressed in kg/ha.

4. Days to first flowering

Number of days taken from sowing to the appearance of first flower was recorded from the observation plants and the average worked out.

5. Flowering period.

Number of days taken from the date of appearance of first flower to the date of appearance of last flower was recorded from the observation plants and the average worked out.

6. Days to first picking

Number of days taken from sowing to first picking was recorded from the observation plants and the average worked out.

B. Uptake studies

Samples of pods and bhusa collected for recording dry weight were used for chemical analysis. The samples were ground well separately and total analysis was done. The nitrogen and phosphorus contents of pods and bhusa were determined separately using microkjeldahl method and vanadomolybdo phosphoric yellow colour method (Jackson, 1967). The potassium content was estimated using EEL flame photometer (Jackson, 1967).

The total uptake of nitrogen, phosphorus and potassium was calculated from the nutrient content and dry weight of the plant and expressed in kg/ha.

C. Yield components and yield

1. Number of fruiting points

Total number of fruiting points in the observation plants were counted at each time of harvest and the mean recorded.

2. Number of pods per plant

Total number of pods produced in the observation plants was counted and the average number of pods per plant was recorded.

3. Length of pod

Ten pods from each observation plants were selected randomly at the first and final pickings, their lengths were measured and the average recorded.

4. Number of seeds per pod

Total number of seeds per pod was counted from the ten pods selected for measuring the pod length and the average was noted.

5. Yield of fresh pods

The fresh pods from each net plot was harvested periodically and their total fresh weights were expressed in t/ha.

6. Yield of fresh bhusa

The plants from each net plot were pulled out separately after removing the pods, and their fresh weights were recorded and expressed in t/ha.

7. Harvest index (HI)

HI was worked out from the data on fresh pod yield and fresh bhusa yield obtained from each net plot as follows:

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} = \frac{\text{Fresh pod yield}}{\text{Fresh pod yield + Fresh bhusa yiel}}$$

D. Quality aspects

1. Protein content of pods

Percentage of protein in the pods was calculated by multiplying the percentage of nitrogen in the pods with the factor 6.25 (Simpson et al., 1965).

2. Protein yield of pods

Total protein yield of pods was calculated by multiplying the protein percentage of dry pods with the dry weight of pods and expressed in kg/ha.

II. Soil characters

Composite soil samples were taken replication-wise before the start of the experiment. After the experiment, individual samples were collected from each plot. The total nitrogen and available phosphorus contents in these samples were estimated using modified microkjeldahl method

and chlorostannous reduced molybdophosphoric blue colour method respectively (Jackson, 1967). The potassium content was estimated using ELL flame photometer (Jackson, 1967).

III. Economics of N, P and K fertilization

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

	Rs.	P.
1. Cost of 1 kg N	5	65
2. Cost of 1 kg P_2O_5	6	80
3. Cost of 1 kg K_2O	1	66
4. Cost of cultivation of vegetable cowpea per hectare excluding the cost of fertilizers		
a) In the open	7500	00
b) In the coconut garden (Assuming that the area available in the coconut gardens for intercrop is 70 per cent)	5250	00
5. Price of 1 kg fresh pods	1	50
6. Price of 1 kg fresh bhusa	0	10

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

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

Return per ruppe invested (Rs) = $\frac{\text{Gross income}}{\text{cost of cultivation}}$

Statistical analysis

The experimental data were analysed statistically by applying the technique of analysis of variance for partially confounded 3^3 factorial experiment and significance was tested by 'F' test (Cochran and Cox, 1965).

RESULTS

RESULTS

The experimental data were subjected to statistical scrutiny to bring out the main effects of nitrogen, phosphorus, potassium and their interactions. The results obtained from the study are presented in the following sections.

I. Growth characters

a. Length of vine (Table 3, Appendix II)

Vine length increased with increase in the levels of nitrogen upto 30 kg/ha at the 20th and 40th day after sowing. The same effect of N was noticed in the open as well as under the partially shaded condition.

Phosphorus application increased the vine length upto 60 kg P_2O_5/ha at the 20th and 40th day after sowing.

No significant difference in vine length was observed between the three levels of potassium tried.

The interaction effects were absent with respect to this plant character.

The length of vine was much higher in the open compared to the partially shaded condition.

Table 3. Vine length (cm) and number of leaves per plant stagewise.

Treatment (kg/ha)	Vine length (20 DAS)		Vine length (40 DAS)		No. of leaves per plant (20 DAS)		No. of leaves per plant (40 DAS)	
	Open	Shade	Open	Shade	Open	Shade	Open	Shade
N_{10}	17.3	16.6	202.0	179.2	9.9	9.0	58.8	41.2
N_{20}	24.9	21.2	214.7	207.7	11.5	10.9	72.4	58.6
N_{30}	35.0	28.6	281.0	215.3	12.8	12.6	82.2	73.5
	S	S	S	S	S	S	S	S
P_{20}	24.3	20.0	208.0	195.6	11.2	10.1	65.9	54.0
P_{40}	26.0	22.5	240.3	205.6	11.3	10.9	72.2	57.0
P_{60}	27.0	23.9	249.1	215.9	12.6	11.5	75.3	62.4
	S	S	S	S	S	S	S	S
K_{10}	25.5	22.1	231.3	202.4	11.2	10.7	70.9	57.4
K_{20}	25.9	22.4	231.7	199.1	11.5	10.9	71.0	57.7
K_{30}	26.2	22.5	234.7	200.6	11.4	11.1	72.2	59.1
	NS	NS	NS	NS	NS	NS	NS	NS
SE ±	0.3	0.1	2.2	3.2	0.2	0.1	0.4	0.6
CD(0.05)	0.8	0.4	6.4	9.3	0.5	0.4	1.3	1.8
N_{10} P_{20}	15.9	14.2	189.0	172.1	9.8	7.3	49.2	40.0
N_{10} P_{40}	17.8	17.5	210.1	182.3	9.8	9.3	60.4	40.4
N_{10} P_{60}	18.1	18.1	206.8	183.1	10.1	10.3	66.8	43.3
N_{20} P_{20}	24.0	20.2	211.3	201.1	11.6	10.8	69.5	52.7
N_{20} P_{40}	24.7	21.1	216.0	217.8	11.4	10.8	74.1	58.1
N_{20} P_{60}	26.2	22.2	216.9	204.3	11.4	11.0	73.7	66.1
N_{30} P_{20}	32.9	25.7	224.7	213.8	12.3	12.6	79.1	69.2
N_{30} P_{40}	35.6	28.8	294.8	216.7	12.8	12.7	82.2	73.6
N_{30} P_{60}	36.6	31.2	323.7	215.3	13.5	13.2	85.4	77.8
	NS	NS	NS	NS	NS	NS	S	S
N_{10} K_{10}	16.5	15.5	197.5	175.9	9.4	8.3	57.9	41.2
N_{10} K_{20}	17.9	16.7	201.8	179.5	10.3	10.3	58.8	41.0
N_{10} K_{30}	17.5	17.6	206.6	182.2	10.0	10.0	59.7	41.5
N_{20} K_{10}	24.2	21.1	213.8	217.3	11.5	10.9	71.9	56.1
N_{20} K_{20}	24.7	20.9	215.3	202.3	11.6	10.7	72.7	58.7
N_{20} K_{30}	26.0	21.4	215.1	203.7	11.3	10.0	72.6	61.2
N_{30} K_{10}	34.2	27.9	282.7	214.1	12.8	12.4	80.9	72.5
N_{30} K_{20}	35.1	28.7	278.1	215.6	12.7	12.8	81.5	73.6
N_{30} K_{30}	35.8	29.3	282.3	216.1	13.0	12.7	83.2	74.5
	NS	NS	NS	NS	NS	NS	NS	NS
P_{20} K_{10}	22.8	19.3	204.6	192.7	10.7	9.7	64.7	53.1
P_{20} K_{20}	24.5	19.8	206.2	196.9	11.3	10.1	65.6	54.1
P_{20} K_{30}	25.5	21.1	214.2	197.4	11.6	10.4	67.4	54.4
P_{40} K_{10}	25.5	21.5	240.6	214.4	11.4	10.6	71.1	56.6
P_{40} K_{20}	26.7	22.6	240.4	200.0	11.6	11.2	72.7	56.9
P_{40} K_{30}	25.9	23.3	239.9	202.5	11.0	11.1	72.8	57.6
P_{60} K_{10}	26.5	23.7	248.8	200.2	11.6	11.3	74.8	60.0
P_{60} K_{20}	26.5	23.9	248.6	200.5	11.7	11.4	74.7	61.9
P_{60} K_{30}	27.9	23.9	250.0	202.1	11.7	11.8	76.4	65.2
	NS	NS	NS	NS	NS	NS	NS	NS
SE ±	0.2	0.2	3.8	5.6	0.3	0.2	0.7	1.1
CD (0.05)	NS	NS	NS	NS	NS	NS	2.2	3.1
S_1	25.5		232.6		11.4		71.2	
S_2	22.1		200.7		10.9		57.8	
	S		S		S		S	

N - Nitrogen P - P_2O_5 K - K_2O

S - Significant NS - Not significant

S_1 - Open S_2 - Partial shade

b. Number of leaves per plant (Table 3, Appendix -II)

Nitrogen application increased the number of leaves per plant and this effect was seen in the open as well as under the shaded condition.

Phosphorus application increased the number of leaves per plant upto 60 kg P_2O_5/ha.

Application of potassium had no influence on this plant character.

Interaction between N and P was observed at 40 DAS on the leaf number per plant and the highest number of leaves obtained by the application of 30 kg N along with 60 kg P_2O_5/ha. All other interaction effects were not considerable with respect to this character.

The leaf production was more with the plants grown in the open compared to those raised under the partial shade.

c. Total dry matter production (Table 4, Fig.3, Appendix III)

The total dry matter production (DMP) increased with increase in the levels of nitrogen upto 30 kg/ha.

Phosphorus application increased the total DMP upto 60 kg P_2O_5/ha.

Table 4. Total dry matter production(kg/ha),days to first flowering, flowering period and days to first picking.

Treatment (kg/ha)	Total D M P		Days to 1st flowering		Flowering period		Days to 1st picking	
	Open	Shade	Open	Shade	Open	Shade	Open	Shade
N_{10}	7011	4404	39.8	40.8	44.0	43.0	49.9	51.1
N_{20}	7610	4838	39.9	41.8	44.3	43.0	49.9	51.8
N_{30}	7741	5097	40.3	41.5	44.7	43.5	50.2	52.0
	S	S	NS	NS	NS	NS	NS	NS
P_{20}	7301	4697	40.1	41.4	44.8	44.2	50.2	51.7
P_{40}	7429	4744	39.8	41.1	44.6	44.2	49.8	51.1
P_{60}	7631	4899	40.1	41.5	44.6	43.7	50.1	52.1
	S	S	NS	NS	NS	NS	NS	NS
K_{10}	7511	4781	39.9	41.3	44.9	44.5	50.0	51.4
K_{20}	7490	4776	40.0	41.1	44.6	44.9	50.1	51.4
K_{30}	7360	4783	40.5	41.7	44.6	44.9	50.6	52.0
	NS	NS	NS	NS	NS	NS	NS	NS
SE +	83.1	34.2	0.22	0.26	0.19	0.14	0.23	0.32
CD($\bar{0}$.05)	241.5	99.3	NS	NS	NS	NS	NS	NS
N_{10} P_{20}	6490	4334	40.2	41.1	45.6	44.1	50.5	52.0
N_{10} P_{40}	7172	4348	39.6	40.5	45.4	44.0	49.7	50.5
N_{10} P_{60}	7371	4532	39.7	40.7	44.9	43.7	49.7	50.7
N_{20} P_{20}	7480	4712	39.7	41.8	43.9	43.9	49.7	51.8
N_{20} P_{40}	7562	4777	39.9	41.3	43.8	44.2	49.8	51.2
N_{20} P_{60}	7587	5024	40.8	42.3	44.3	43.5	50.2	52.5
N_{30} P_{20}	7633	5044	40.5	41.4	44.8	44.6	50.5	51.3
N_{30} P_{40}	7554	5107	39.9	41.5	44.7	44.5	49.8	51.5
N_{30} P_{60}	7665	5141	40.4	41.6	44.5	44.1	50.3	53.2
	S	NS	NS	NS	NS	NS	NS	NS
N_{10} K_{10}	7058	4352	39.6	40.3	45.4	43.0	49.7	50.8
N_{10} K_{20}	7060	4493	39.5	40.4	45.4	43.8	49.7	50.7
N_{10} K_{30}	6915	4368	40.3	41.6	45.2	43.0	50.5	51.7
N_{20} K_{10}	7817	4963	39.1	42.1	44.1	43.7	49.2	52.2
N_{20} K_{20}	7695	4765	40.0	41.4	43.8	43.5	50.0	51.3
N_{20} K_{30}	7616	4785	40.7	41.8	44.0	43.3	50.5	52.0
N_{30} K_{10}	7658	5020	39.6	41.4	45.1	43.7	49.5	51.3
N_{30} K_{20}	7714	5024	40.5	41.4	44.5	43.7	50.5	52.3
N_{30} K_{30}	7550	5030	40.6	41.6	44.5	43.8	50.7	52.3
	NS	NS	NS	NS	NS	NS	NS	NS
P_{20} K_{10}	7413	4847	39.8	41.6	45.2	44.2	49.8	52.2
P_{20} K_{20}	7380	4651	40.4	40.9	44.9	44.5	50.5	51.0
P_{20} K_{30}	7110	4591	40.2	41.8	44.2	44.0	50.3	52.0
P_{40} K_{10}	7535	4700	39.1	41.4	44.9	44.2	49.0	51.3
P_{40} K_{20}	7482	4768	39.9	40.5	44.5	44.0	49.8	50.9
P_{40} K_{30}	7271	4764	40.4	41.4	44.5	44.5	50.5	51.5
P_{60} K_{10}	7585	4796	39.5	40.8	44.5	44.1	49.5	50.9
P_{60} K_{20}	7607	4908	39.9	41.9	44.3	43.5	49.8	52.0
P_{60} K_{30}	7700	4993	41.0	41.8	44.9	43.7	50.8	52.5
	NS	NS	NS	NS	NS	NS	NS	NS
SE +	143.9	59.1	0.39	0.44	0.33	0.25	0.40	0.55
CD($\bar{0}$.05)	418.3	NS	NS	NS	NS	NS	NS	NS
S_1	7454		40.0		43.9		50.0	
S_2	4780		41.3		43.2		51.6	
	S		S		S		S	

N - Nitrogen, P - P_2O_5, K - K_2O , D.M.P = dry matter production
S_1 - Open , S_2 - Partial shade S - Significant NS - Not significant

No significant variation in DMP was observed between the three levels of potassium tried.

The first order interaction effects on total DMP were generally absent.

The total DMP was more in the open condition (7454 kg/ha) compared to the partial shade (4780 kg/ha).

d. Days to first flowering, flowering period and days to first picking (Table 4, Appendix III)

The main effects of nitrogen, phosphorus and potassium or their interactions did not influence the number of days required for the appearance of the first flower, flowering period and the number of days required for the first picking.

The number of days required for the first flowering and first picking were more for the plants grown under the partial shade compared to those grown in the open. But, the flowering period was more in the open compared to the partially shaded situation.

II. Uptake studies (Table 5, Fig.4(a),4(b)and 4(c),Appendix IV)

a. Uptake of nitrogen

The uptake of nitrogen increased with increase in the levels of nitrogen upto 30 kg/ha.

Phosphorus application also showed a similar effect and the highest N uptake was noticed at 60 kg P_2O_5/ha.

Application of potassium had no influence on the nitrogen uptake.

Interaction between N and P was marked on the nitrogen uptake under partially shaded condition and the N uptake was highest when "30 kg N along with 60 kg P_2O_5/ha" was applied. All other interactions were absent with respect to this character.

The nitrogen uptake was found to be much higher in the case of plants grown in the open (92.5 kg N/ha) compared to those raised under the partially shaded condition (57.0 kg N/ha).

b. Uptake of phosphorus

The uptake of phosphorus increased with increase in the levels of nitrogen upto 30 kg/ha.

Table 5. Uptake of Nitrogen, Phosphorus and Potassium (kg/ha).

Treatment (kg/ha)	Nitrogen uptake		Phosphorus uptake		Potassium uptake	
	Open	Shade	Open	Shade	Open	Shade
N_{10}	70.2	44.0	19.5	9.1	126.9	60.9
N_{20}	95.1	60.1	20.8	12.9	127.8	62.1
N_{30}	112.1	67.1	36.7	18.4	130.5	63.2
	S	S	S	S	NS	NS
P_{20}	86.0	53.6	24.5	12.1	127.4	57.9
P_{40}	90.9	55.4	27.5	13.0	129.6	64.5
P_{60}	97.5	60.1	33.9	15.2	131.1	68.9
	S	S	S	S	NS	NS
K_{10}	89.6	56.3	27.4	12.8	116.5	58.3
K_{20}	92.6	57.0	29.3	13.2	124.2	66.4
K_{30}	95.1	57.9	29.3	14.0	124.3	68.8
	NS	NS	NS	NS	S	S
SE +	1.93	1.2	1.29	0.35	2.31	0.83
CD (0.05)	5.6	3.5	3.74	1.02	3.88	2.42
$N_{10}P_{20}$	57.2	43.9	15.0	8.3	81.6	42.8
$N_{10}P_{40}$	76.3	43.8	18.6	8.9	97.7	46.5
$N_{10}P_{60}$	77.1	44.3	25.0	9.9	105.0	48.8
$N_{20}P_{20}$	93.1	51.6	25.4	11.1	121.5	55.2
$N_{20}P_{40}$	92.9	63.3	69.0	11.8	126.5	63.4
$N_{20}P_{60}$	99.3	65.6	34.9	16.0	135.4	67.6
$N_{30}P_{20}$	107.8	65.4	33.1	17.0	139.9	75.8
$N_{30}P_{40}$	112.4	65.3	35.0	18.4	140.5	83.5
$N_{30}P_{60}$	116.1	70.3	41.9	19.7	142.9	90.2
	NS	S	NS	NS	NS	NS
$N_{10}K_{10}$	67.5	42.3	18.2	8.3	88.7	43.1
$N_{10}K_{20}$	69.3	47.4	20.0	9.1	96.7	46.6
$N_{10}K_{30}$	73.8	42.3	20.1	80.8	98.9	48.4
$N_{20}K_{10}$	91.2	58.5	28.6	12.6	121.9	57.7
$N_{20}K_{20}$	96.0	59.7	29.7	12.6	129.4	62.2
$N_{20}K_{30}$	98.1	62.2	31.0	13.7	132.0	66.3
$N_{30}K_{10}$	110.2	68.0	35.5	17.5	139.0	74.0
$N_{30}K_{20}$	112.6	63.9	38.1	18.0	146.5	83.8
$N_{30}K_{30}$	113.4	69.2	36.1	19.6	147.9	91.7
	NS	NS	NS	NS	NS	S
$P_{20}K_{10}$	77.7	54.3	24.3	11.7	110.6	54.6
$P_{20}K_{20}$	89.2	53.5	25.4	12.0	117.7	57.5
$P_{20}K_{30}$	91.1	53.1	23.7	12.7	114.7	61.7
$P_{40}K_{10}$	92.6	57.9	25.9	13.0	116.7	58.1
$P_{40}K_{20}$	93.8	58.0	27.8	12.3	124.1	65.8
$P_{40}K_{30}$	95.1	56.5	28.9	13.7	123.9	69.5
$P_{60}K_{10}$	98.5	56.7	32.0	13.6	122.3	62.1
$P_{60}K_{20}$	94.9	59.4	34.5	15.3	130.9	69.4
$P_{60}K_{30}$	99.1	57.9	35.3	16.7	140.1	75.1
	NS	NS	NS	NS	S	NS
SE ±	3.35	2.08	2.23	0.61	2.31	1.44
CD(0.05)	NS	6.03	NS	NS	6.73	4.19
S_1	92.5		28.6		122.3	
S_2	57.0		13.0		63.8	
	S		S		S	

N - Nitrogen P - P_2O_5 K - K_2O

S - Significant NS - Not significant S_1 - Open, S_2 - Partial shade

Phosphorus application also showed a similar effect and application of 60 kg P_2O_5/ha resulted in the highest P uptake.

No significant variation on P uptake was observed between the three levels of potassium tried.

The interaction effects were absent with respect to P uptake.

The phosphorus uptake was about double in the open (28.6 kg P/ha) compared to that under partial shade (13.0 kg P/ha).

c. Uptake of potassium

Increase in the levels of nitrogen or phosphorus did not increase the K uptake.

Application of potassium increased the K uptake upto 20 kg K_2O/ha.

Interaction effect between N and K on K uptake was considerable under the partial shade. The highest K uptake (91.7 kg K/ha) was noticed when "30 kg N along with 30 kg K_2O/ha" was applied. Interaction effect between P and K on K uptake was observable in the open condition and the highest K uptake (140.1 kg K/ha) was noticed by the application of "60 kg P_2O_5 along with 30 kg K_2O/ha".

The K uptake of the crop was much higher with the plants raised in the open (122.3 kg K/ha) compared to those grown under the partial shade (63.8 kg K/ha).

III. Yield components and yield

a. Number of fruiting points (Table 6, Appendix V)

The number of fruiting points increased with increase in the levels of nitrogen upto 30 kg/ha.

Application of phosphorus or potassium had no influence on the number of fruiting points.

The first order interaction effects were absent with respect to this character.

There was not much difference in the number of fruiting points between the plants raised in the open and under the partial shade.

b. Number of pods per plant (Table 6, Appendix V)

The number of pods per plant increased with increase in the levels of nitrogen upto 30 kg/ha.

Phosphorus application also showed a very similar effect as that of nitrogen on this character. The highest number of pods per plant was noticed when phosphorus was applied @ 60 kg P_2O_5/ha.

Table 6. Yield components

Treatment (kg/ha)	Number of fruiting points		Number of pods per plant		Length of pod (cm)		Number of seeds per pod	
	Open	Shade	Open	Shade	Open	Shade	Open	Shade
N_{10}	17.1	9.8	31.0	17.5	39.8	39.4	20.5	20.4
N_{20}	20.0	13.8	33.1	20.0	40.5	39.8	21.4	21.5
N_{30}	22.4	18.9	33.7	20.9	40.1	39.4	22.0	22.4
	S	S	S	S	NS	NS	S	S
P_{20}	18.9	14.0	32.4	19.0	40.6	39.7	21.2	21.0
P_{40}	19.1	14.1	32.5	19.4	41.0	39.6	21.5	22.3
P_{60}	19.3	14.4	33.0	20.6	40.6	39.4	22.4	23.3
	NS	NS	S	S	NS	NS	S	S
K_{10}	19.3	13.9	32.6	19.3	40.3	39.2	21.5	22.2
K_{20}	18.9	14.2	32.6	19.3	41.1	40.2	21.4	21.7
K_{30}	19.0	14.5	32.7	19.4	40.9	39.3	21.2	21.7
	NS	NS	NS	NS	NS	NS	NS	NS
SE ±	0.17	0.27	0.15	0.14	0.24	0.38	0.13	0.17
CD(0.05)	0.50	0.77	0.45	0.42	NS	NS	0.37	0.50
$N_{10}P_{20}$	17.1	9.5	30.4	17.0	39.9	39.6	20.0	23.3
$N_{10}P_{40}$	17.5	9.8	31.0	17.7	40.5	39.0	21.0	23.8
$N_{10}P_{60}$	17.2	10.1	31.7	17.8	39.9	40.7	20.6	23.4
$N_{20}P_{20}$	19.8	14.0	33.4	19.4	41.1	40.8	21.7	23.4
$N_{20}P_{40}$	19.3	13.1	32.9	19.6	41.1	40.2	21.3	23.6
$N_{20}P_{60}$	19.7	14.4	33.2	19.8	41.1	39.6	21.4	24.2
$N_{30}P_{20}$	19.7	18.5	33.3	20.6	41.1	39.6	21.9	23.4
$N_{30}P_{40}$	20.5	19.5	33.8	21.1	40.5	39.6	22.1	23.5
$N_{30}P_{60}$	20.9	18.8	34.1	21.2	41.1	39.9	22.2	23.4
	NS	NS	NS	NS	NS	NS	NS	NS
$N_{10}K_{10}$	17.8	9.3	30.9	17.3	39.5	39.5	20.4	23.2
$N_{10}K_{20}$	17.2	9.7	31.0	14.5	40.2	41.4	20.9	23.5
$N_{10}K_{30}$	16.9	10.0	31.3	17.6	39.6	39.7	20.3	23.4
$N_{20}K_{10}$	20.0	13.1	33.3	19.5	40.8	39.5	21.6	23.6
$N_{20}K_{20}$	19.4	14.3	33.1	19.8	41.6	39.7	21.4	23.0
$N_{20}K_{30}$	19.4	14.1	33.1	19.5	42.0	40.4	21.4	23.3
$N_{30}K_{10}$	20.1	18.8	33.7	21.0	40.7	40.1	22.4	23.7
$N_{30}K_{20}$	20.0	18.6	33.6	20.7	41.5	39.5	21.8	23.7
$N_{30}K_{30}$	20.8	19.4	33.8	21.2	41.1	39.7	22.0	23.5
	NS	NS	NS	NS	NS	NS	NS	NS
$P_{20}K_{10}$	19.2	14.1	32.5	19.0	39.6	39.4	21.6	21.9
$P_{20}K_{20}$	19.1	13.8	32.2	18.9	41.5	39.5	21.0	22.0
$P_{20}K_{30}$	19.3	14.2	32.4	19.0	40.6	40.2	20.9	21.9
$P_{40}K_{10}$	19.3	13.8	32.5	19.4	40.9	39.9	21.4	22.8
$P_{40}K_{20}$	19.9	14.3	32.6	19.6	41.4	40.4	21.6	22.7
$P_{40}K_{30}$	19.1	14.2	32.6	19.4	40.8	38.4	21.4	21.9
$P_{60}K_{10}$	19.3	13.7	32.9	19.5	40.5	38.3	21.3	22.8
$P_{60}K_{20}$	19.1	14.5	32.8	19.4	40.4	40.6	21.5	21.9
$P_{60}K_{30}$	19.5	15.1	33.2	19.9	41.0	39.2	21.4	22.3
	NS	NS	NS	NS	NS	NS	NS	NS
SE ±	0.30	0.46	0.27	0.25	0.42	0.66	0.22	0.30
CD (0.05)	NS	NS	NS	NS	NS	NS	NS	NS

S_1	*	32.6	*	21.8
S_2		19.3		21.9
		S		NS

N - Nitrogen
P - P_2O_5
K - K_2O

* - Interaction absent
S - Significant
NS - Not significant

S_1 - Open
S_2 - Partial shade

Application of potassium had no influence on the number of pods per plant.

The interaction effects were not pronounced on this character.

Plants raised in the open produced more number of pods per plant (32.6) compared to those grown under the partial shade (19.3).

c. Length of pod (Table 6, Appendix V)

The levels of nitrogen, phosphorus, potassium or their interaction did not exert any significant variation in pod length.

Not much difference in pod length was observed between the plants raised in the open and under the partial shade.

d. Number of seeds per pod (Table 6, Appendix V)

The number of seeds per pod increased with increase in the levels of nitrogen upto 30 kg/ha.

Phosphorus application increased the seed number per pod upto 60 kg P_2O_5/ha.

Application of potassium had no effect on the number of seeds per pod.

The interaction effects were not considerable on this character.

There was not much difference in the seed number per pod between the plants grown in the open as well as under the partial shade.

e. Fresh pod yield (Table 7, Fig.5, Appendix VI)

The fresh pod yield increased with increase in the levels of nitrogen upto 30 kg/ha.

Phosphorus application also showed a similar effect and highest yield was obtained by the application of 60 kg P_2O_5/ha.

Application of potassium had no influence on the fresh pod yield.

None of the interaction effects were significant on the fresh pod yield.

The fresh pod yield was significantly higher in the open (6.04 t/ha) compared to the partially shaded condition (3.65 t/ha).

Table-7. Fresh pod yield ($t.ha^{-1}$), fresh bhusa yield($t.ha^{-1}$) and harvest index.

Treatment (kg/ha)	Fresh pod yield		Fresh bhusa yield		Harvest index	
	Open	Shade	Open	Shade	Open	Shade
N_{10}	5.77	3.34	16.59	10.57	0.26	0.24
N_{20}	5.91	3.67	17.34	11.60	0.25	0.24
N_{30}	6.18	3.94	18.13	12.19	0.25	0.24
	S	S	S	S	NS	NS
P_{20}	5.99	3.57	17.28	11.25	0.24	0.24
P_{40}	5.99	3.59	17.64	11.35	0.24	0.24
P_{60}	6.11	3.70	18.4	11.76	0.25	0.24
	S	S	S	S	NS	NS
K_{10}	6.05	3.64	17.84	11.46	0.25	0.24
K_{20}	6.03	3.65	17.79	11.44	0.25	0.24
K_{30}	6.02	3.66	17.44	11.46	0.25	0.24
	NS	NS	NS	NS	NS	NS
SE +	0.032	0.031	0.22	0.09	0.005	0.002
CD($\bar{0}$.05)	0.092	0.091	0.63	0.26	NS	NS
N_{10} P_{20}	5.65	3.30	17.45	10.39	0.24	0.24
N_{10} P_{40}	5.77	3.35	17.43	10.41	0.25	0.24
N_{10} P_{60}	5.88	3.37	17.54	10.91	0.25	0.24
N_{20} P_{20}	6.18	3.59	18.52	11.29	0.25	0.24
N_{20} P_{40}	6.09	3.65	17.96	11.44	0.25	0.24
N_{20} P_{60}	6.19	3.77	18.54	12.07	0.25	0.24
N_{30} P_{20}	6.15	3.88	18.13	12.07	0.25	0.24
N_{30} P_{40}	6.12	3.97	17.92	12.20	0.25	0.25
N_{30} P_{60}	6.27	3.97	18.35	12.30	0.24	0.24
	NS	NS	NS	NS	NS	NS
N_{10} K_{10}	5.77	3.33	16.72	11.62	0.26	0.22
N_{10} K_{20}	5.78	3.37	16.72	11.80	0.26	0.22
N_{10} K_{30}	5.76	3.31	16.33	11.58	0.26	0.22
N_{20} K_{10}	6.21	3.69	18.61	11.94	0.25	0.24
N_{20} K_{20}	6.13	3.66	18.31	11.59	0.25	0.24
N_{20} K_{30}	6.13	3.66	18.09	11.66	0.25	0.24
N_{30} K_{10}	6.18	3.91	18.18	12.02	0.25	0.25
N_{30} K_{20}	6.19	3.90	18.33	12.00	0.25	0.24
N_{30} K_{30}	6.17	4.01	17.89	12.00	0.24	0.24
	NS	NS	NS	NS	NS	NS
P_{20} K_{10}	6.03	3.64	17.58	11.65	0.26	0.24
P_{20} K_{20}	6.00	3.59	17.50	11.55	0.26	0.24
P_{20} K_{30}	5.95	3.55	16.78	11.76	0.26	0.24
P_{40} K_{10}	6.05	3.64	17.91	11.54	0.25	0.24
P_{40} K_{20}	6.02	3.67	17.78	11.54	0.25	0.24
P_{40} K_{30}	5.91	3.65	17.24	11.54	0.24	0.24
P_{60} K_{10}	6.07	3.65	18.04	11.54	0.25	0.24
P_{60} K_{20}	6.08	3.68	18.09	11.80	0.25	0.24
P_{60} K_{30}	6.19	3.78	18.30	11.98	0.23	0.24
	NS	NS	NS	NS	NS	NS
SE +	0.055	0.054	0.380	0.156	0.008	0.003
CD $\bar{(}$0.05)	NS	NS	NS	NS	NS	NS
S_1	6.04					
S_2	3.65					
	S		*		*	

N - Nitrogen, P - P_2O_5 , K - K_2O S - Significant/ NS - Not significant

* - Interaction absent S_1 - Open S_2 - Partial shade

f. Fresh bhusa yield (Table 7, Fig. 6, Appendix VI)

The fresh bhusa yield increased with increase in the levels of nitrogen upto 30 kg/ha.

Phosphorus application also showed a similar effect and the highest bhusa yield was observed by the application of 60 kg P_2O_5/ha.

Application of potassium had no influence on the fresh bhusa yield.

The interactions were absent with respect to bhusa yield.

There was not much difference in the fresh bhusa yield between the plants grown in the open and under the partial shade.

g. Harvest index (Table 7, Appendix VI)

Neither the main effects of nitrogen, phosphorus and potassium nor their interactions did influence the harvest index.

There was not much difference in the harvest index between the plants grown in the open as well as under partial shade.

IV. Quality aspects (Table 8, Appendix VII)

Protein content and protein yield of pods

The protein content and the protein yield of pods increased with increase in the levels of nitrogen upto 30 kg/ha.

Phosphorus application increased the protein content and the protein yield of pods upto 60 kg P_2O_5/ha.

There was no significant variation in the protein content and the protein yield of pods between the three levels of potassium tried.

Interaction effect between N and P on the protein content and protein yield of pods was marked under both conditions. In the open condition, the highest protein content (31.4 %) and highest protein yield (192.9 kg/ha) were obtained by the application of 30 kg N along with 60 kg P_2O_5/ha. Under the partially shaded situation N @ 30 kg/ha along with 60 kg P_2O_5/ha gave the highest protein content (27.9 %) and highest protein yield (107.9 Kg/ha) and the effect of this N P combination was on par with that of N_{30} P_{40} and N_{30} P_{20}. The other interactions were absent with respect to these characters.

Table-8. Protein content (%) and protein yield (kg/ha)of pods on dryweight basis.

Treatment (kg/ha)	Protein content		Protein yield	
	Open	Shade	Open	Shade
N_{10}	24.5	19.1	113.3	39.4
N_{20}	26.1	25.9	137.6	87.6
N_{30}	29.8	27.4	179.0	103.0
	S	S	S	S
P_{20}	26.8	22.9	132.3	67.0
P_{40}	27.0	24.1	140.3	76.7
P_{60}	27.3	25.4	151.2	86.3
	S	S	S	S
K_{10}	26.5	23.9	141.2	74.6
K_{20}	26.4	24.0	139.1	75.4
K_{30}	27.2	24.6	149.5	80.0
	NS	NS	NS	NS
SE +	0.28	0.24	3.02	1.74
CD($\bar{0}$.05)	0.82	0.69	8.78	5.76
N_{10} P_{20}	23.1	19.1	96.6	39.4
N_{10} P_{40}	25.6	18.7	124.6	37.6
N_{10} P_{60}	24.8	19.3	118.5	41.2
N_{20} P_{20}	25.7	22.6	133.8	64.0
N_{20} P_{40}	24.7	26.1	121.6	88.3
N_{20} P_{60}	27.8	26.1	157.4	107.5
N_{30} P_{20}	28.7	26.8	166.3	98.7
N_{30} P_{40}	29.2	27.5	172.7	104.3
N_{30} P_{60}	31.4	27.9	192.9	107.9
	S	S	S	S
N_{10} K_{10}	23.5	19.2	102.7	40.3
N_{10} K_{20}	24.3	18.6	111.4	37.0
N_{10} K_{30}	25.7	19.4	125.6	40.9
N_{20} K_{10}	26.5	25.0	143.3	81.5
N_{20} K_{20}	25.1	25.7	126.4	85.5
N_{20} K_{30}	26.6	27.1	143.1	95.8
N_{30} K_{10}	29.6	27.4	177.7	102.0
N_{30} K_{20}	29.8	27.7	179.5	103.7
N_{30} K_{30}	29.9	27.2	179.8	103.4
	NS	NS	NS	NS
P_{20} K_{10}	25.3	22.1	128.2	62.8
P_{20} K_{20}	25.4	23.3	127.9	69.0
P_{20} K_{30}	26.7	23.1	140.6	68.4
P_{40} K_{10}	27.3	24.2	149.2	77.0
P_{40} K_{20}	26.4	23.9	139.2	75.1
P_{40} K_{30}	27.7	24.4	150.6	78.0
P_{60} K_{10}	27.0	25.3	146.3	83.9
P_{60} K_{20}	27.3	24.7	150.2	81.2
P_{60} K_{30}	27.7	26.3	157.2	93.8
	NS	NS	NS	NS
SE +	0.49	0.41	5.23	3.02
CD($\bar{0}$.05)	1.4	1.2	15.21	8.77

S_1	26.8	143.3
S_2	24.1 S	76.7 S

N - Nitrogen, P - P_2O_5, K - K_2O

S - Signficant NS - Not significant

S_1 - Open , S_2 - Partial shade

The protein content and the protein yield of pods were much higher with the plants raised in the open compared to those grown under the partial shade.

V. Soil nutrient status after the experiment

a. Total nitrogen (Table 9, Appendix VIII)

The total nitrogen content in the soil after the experiment increased with increase in the levels of nitrogen upto 30 kg/na.

Phosphorus application increased the total nitrogen content in the soil upto 60 kg P_2O_5/ha.

Application of potassium increased the total N content in the soil. But this effect of potassium did not persist beyond the level of 20 kg K_2O/ha.

None of the interactions influenced the total N content in the soil.

The total N content of the soil after the experiment was more in the open field (2470 kg/ha) compared to the partially shaded situation (2410 kg/ha).

b. Available phosphorus (Table 9, Appendix VIII)

The available P content of the soil after the experimant increased with increase in the levels of nitrogen upto 30 kg/ha.

Table-9. Total nitrogen, available phosphorus and available potassium contents in the soil after experiment in Kg/ha.

Treatment (kg/ha)	Total N		Available P_2O_5		Available K_2O	
	Open	Shade	Open	Shade	Open	Shade
N_{10}	2450	2390	50	49	151	150
N_{20}	2460	2410	58	56	151	151
N_{30}	2500	2430	63	61	152	151
	S	S	S	S	NS	NS
P_{20}	2460	2390	53	51	151	150
P_{40}	2470	2420	53	55	151	150
P_{60}	2500	2450	56	59	151	151
	S	S	S	S	NS	NS
K_{10}	2490	2410	57	54	151	150
K_{20}	2500	2420	57	55	151	151
K_{30}	2420	2390	57	55	152	151
	S	S	NS	NS	NS	NS
SE +	0.9	0.5	0.4	0.5	0.4	0.4
CD($\bar{0}$.05)	2.5	1.6	1.2	1.4	NS	NS
N_{10} P_{20}	2470	2350	47	47	152	148
N_{10} P_{40}	2420	2400	50	48	150	148
N_{10} P_{60}	2470	2400	52	51	151	151
N_{20} P_{20}	2450	2410	54	52	150	150
N_{20} P_{40}	2450	2410	57	55	150	151
N_{20} P_{60}	2470	2400	64	60	151	151
N_{30} P_{20}	2490	2420	58	56	151	152
N_{30} P_{40}	2490	2430	62	61	152	151
N_{30} P_{60}	2530	2440	69	65	152	154
	NS	NS	S	S	NS	NS
N_{10} K_{10}	2460	2390	50	48	149	149
N_{10} K_{20}	2480	2400	50	49	151	149
N_{10} K_{30}	2420	2370	50	49	153	150
N_{20} K_{10}	2470	2410	57	54	151	151
N_{20} K_{20}	2490	2420	59	57	150	151
N_{20} K_{30}	2420	2400	59	56	151	151
N_{30} K_{10}	2530	2440	63	61	152	151
N_{30} K_{20}	2530	2430	64	60	152	152
N_{30} K_{30}	2440	2410	62	61	153	153
	NS	NS	NS	NS	NS	NS
P_{20} K_{10}	2480	2400	54	50	150	149
P_{20} K_{20}	2490	2400	53	52	150	150
P_{20} K_{30}	2430	2380	53	51	153	151
P_{40} K_{10}	2480	2410	55	55	151	150
P_{40} K_{20}	2490	2440	58	54	151	150
P_{40} K_{30}	2400	2400	57	55	152	150
P_{60} K_{10}	2510	2420	61	54	151	152
P_{60} K_{20}	2520	2420	62	55	152	152
P_{60} K_{30}	2440	2410	62	55	152	152
	NS	NS	NS	NS	NS	NS
SE +	1.5	0.9	0.7	0.8	0.7	0.8
CD($\bar{0}$.05)	NS	NS	2.1	2.3	NS	NS
S_1	2470		57		151.3	
S_2	2410		55		150.6	
	S		S		NS	

N - Nitrogen, P - P_2O_5, K - K_2O S_1 - Open

S - Significant NS - Not significant S_2 - Partial shade

Phosphorus application increased the available P content in the soil upto 60 kg P_2O_5/ha.

Application of potassium had no effect on the available P content in the soil.

The interaction between N and P was marked on the available P content of the soil after the experiment. The plots applied with "30 kg N along with 60 kg P_2O_5/ha" contained the highest amounts of available P.

The soil samples collected from the partially shaded field analysed for low amounts of available P compared to those collected from the open fields.

c. Available potassium (Table 9, Appendix VIII)

Neither the main effect of N, P or K nor their interactions influenced the available potassium content of the soil after the experiment.

The available K content of the soil remained more or less the same in the open as well as under partially shaded fields.

VI. Economics of N, P and K fertilization (Table 10, Appendix IX)

Net income and return per rupee invested

In respect of the crop raised in the open, there was considerable difference in the net income as well as in the

Table-10. Economics of N, P and K fertilization.

Treatment (kg/ha)	Net income (Rs./ha)		Return per rupee invested	
	Open	Shade	Open	Shade
N_{10}	9314.83	4273.17	2.17	1.76
N_{20}	10393.21	5204.93	2.25	1.90
N_{30}	10408.23	5938.23	2.28	2.01
	S	S	S	S
P_{20}	10107.47	5152.47	2.28	1.92
P_{40}	9918.21	5156.53	2.23	1.91
P_{60}	10090.60	5107.33	2.22	1.85
	NS	NS	S	S
K_{10}	1010.70	5139.10	2.26	1.91
K_{20}	10038.21	5128.20	2.25	1.88
K_{30}	9967.37	6149.03	2.23	1.88
	NS	NS	NS	NS
SE ±	94.78	93.81	0.012	0.017
CD($\bar{0}$.05)	275.58	272.76	0.035	0.049
N_{10} P_{20}	9149.10	4354.10	2.17	1.78
N_{10} P_{40}	9336.50	4296.50	2.17	1.80
N_{10} P_{60}	9458.90	4168.90	2.16	1.71
N_{20} P_{20}	10670.80	5150.80	2.36	1.92
N_{20} P_{40}	10193.22	5153.20	2.26	1.89
N_{20} P_{60}	10315.60	5310.80	2.25	1.89
N_{30} P_{20}	10502.50	5952.50	2.31	2.05
N_{30} P_{40}	10224.90	6019.90	2.26	2.02
N_{30} P_{60}	10497.30	5842.30	2.26	1.96
	NS	NS	NS	NS
N_{10} K_{10}	9339.00	4274.00	2.17	1.81
N_{10} K_{20}	9351.50	4381.50	2.15	1.77
N_{10} K_{30}	9254.00	4164.00	2.17	1.72
N_{20} K_{10}	10570.70	5275.90	2.32	1.91
N_{20} K_{20}	10313.22	5183.20	2.28	1.90
N_{20} K_{30}	10295.70	5155.70	2.28	1.88
N_{30} K_{10}	10422.40	5867.40	2.288	2.01
N_{30} K_{20}	10449.90	5819.90	2.29	1.99
N_{30} K_{30}	10352.40	6127.40	2.27	2.04
	NS	NS	NS	NS
P_{20} K_{10}	10233.30	5313.30	2.30	1.95
P_{20} K_{20}	10140.80	5140.80	2.29	1.92
P_{20} K_{30}	9948.30	5003.30	2.58	1.89
P_{40} K_{10}	10120.70	5125.70	2.26	1.94
P_{40} K_{20}	9983.22	5213.20	2.24	1.90
P_{40} K_{30}	9650.70	5130.70	2.19	1.88
P_{60} K_{10}	9978.10	4978.30	2.21	1.83
P_{60} K_{20}	9990.60	5030.60	2.21	1.84
P_{60} K_{30}	10303.10	5313.10	2.25	1.88
	NS	NS	NS	NS
SE ±	164.16	162.48	0.021	0.029
CD($\bar{0}$.05)	NS	NS	NS	NS

N_{10} P_{20} K_{10}	9291.60	4551.50	2.20	1.82
N_{10} P_{20} K_{20}	9179.10	4544.10	2.18	1.82
N_{10} P_{20} K_{30}	8976.60	3966.60	2.15	1.71
N_{10} P_{40} K_{10}	9284.00	4124.00	2.17	1.89
N_{10} P_{40} K_{20}	9381.50	4491.50	2.18	1.78
N_{10} P_{40} K_{30}	9344.00	4274.00	2.17	1.74
N_{10} P_{60} K_{10}	9441.40	4146.40	2.16	1.76
N_{10} P_{60} K_{20}	9493.90	4108.90	2.16	1.70
N_{10} P_{60} K_{30}	9441.40	4251.40	2.15	1.71
N_{20} P_{20} K_{10}	10753.30	5308.30	2.37	1.95
N_{20} P_{20} K_{20}	10655.80	5240.80	3.36	1.94
N_{20} P_{20} K_{30}	10603.30	4903.30	2.35	1.87
N_{20} P_{40} K_{10}	10550.70	5225.70	2.31	1.91
N_{20} P_{40} K_{20}	10168.25	5128.20	2.26	1.89
N_{20} P_{40} K_{30}	9860.70	5105.70	2.22	1.88
N_{20} P_{60} K_{10}	10408.10	5293.70	2.27	1.89
N_{20} P_{60} K_{20}	10115.60	5180.60	2.23	1.87
N_{20} P_{60} K_{30}	10423.10	5458.10	2.26	1.93
N_{30} P_{20} K_{10}	10655.00	6080.00	2.32	2.08
N_{30} P_{20} K_{20}	10587.50	5637.50	2.34	1.99
N_{30} P_{20} K_{30}	10265.00	6140.00	2.26	2.08
N_{30} P_{40} K_{10}	10527.40	6027.40	2.30	2.03
N_{30} P_{40} K_{20}	10399.90	6019.90	2.28	2.03
N_{30} P_{40} K_{30}	9747.40	6012.40	2.20	2.02
N_{30} P_{60} K_{10}	10084.80	5494.80	2.21	1.91
N_{30} P_{60} K_{20}	10362.80	5802.30	2.25	1.96
N_{30} P_{60} K_{30}	11044.80	6229.80	2.34	2.08
SE $\pm$	405.62	312.35	0.052	0.035
CD.(0.05)	833.96	NS	0.1068	NS

N - Nitrogen, P - P_2O_5, K - K_2O

S - Significant, NS - Not significant

return per rupee invested due to the interaction between the three fertilizer nutrients. The highest net income of Rs.11044.80 was obtained by the application of "30 kg N along with 60 kg P_2O_5 and 30 kg K_2O/ha". But, the net income obtained at this NPK combination was on par with that obtained at N_{20} P_{20} K_{10}. The highest return per rupee invested (Rs.2.37) was obtained in the open condition by the application of "20 kg N along with 20 kg P_2O_5 and 10 kg K_2O/ha".

Under the partial shade, the effect of nitrogen changed the net income. There was an increase in net income with increase in the levels of nitrogen upto 30 kg/ha. The net income did not change by changing the levels of P or K or due to their interaction, in the shaded condition. There was a linear increase in the return per rupee invested upto a level of 30 kg N/ha under the partial shade. The return per rupee invested did not increase beyond the level of 20 kg P_2O_5/ha. The main effect of potassium or the interaction effects between the fertilizer nutrients did not change the return per rupee invested under the partial shade.

The net income as well as the return per rupee invested obtained from the vegetable cowpea raised in the shaded situation was low compared to those obtained from the crop raised in the open.

DISCUSSION

DISCUSSION

The present investigation is an attempt to study the effects of N, P and K on the growth, yield and quality of vegetable cowpea variety Kurutholapayar grown as an intercrop in coconut gardens and in the open. The results obtained from the study are discussed below:

I. Growth characters

a. Length of vine

The results presented in Table 3 revealed that the vine length increased with increase in the levels of nitrogen upto 30 kg/ha both in the open and under the partially shaded condition. The influence of nitrogen in promoting vegetative growth of plants is a well established fact. Similar effects of N have been reported by George (1981) and Sheela (1985) in grain cowpea and Brillin (1984) in winged bean.

Phosphorus application increased the vine length upto 60 kg P_2O_5/ha. The response of vegetable cowpea to applied phosphorus is high in the early stages of growth and it decreases gradually with the advancement of age.

The result obtained is in conformity with the findings of Sen and Bains (1955) and Stewart and Reed (1969) in grain cowpea and Mahatanya (1976) in French beans.

The effect of potassium on the vine length was not considerable. Non significant effect of K on plant height was reported by Sundaram et al. (1974) in grain cowpea.

The vine length was much higher for the plants raised in the open compared to those raised under partial shade. Shading either partially or completely might have reduced the carbondioxide assimilation by plants. Decrease in plant height due to shading in red gram was reported by Sansamma George (1982).

b. Number of leaves per plant

Nitrogen being an important constituent of chlorophyll has a pivotal role in the production of more number of leaves in plants. Application of nitrogen @ 30 kg/ha along with 60 kg P_2O_5/ha produced the highest number of leaves per plant. The main effect of N and P was considerable in leaf production. This result is in conformity with findings of Geethakumari (1981) in grain cowpea.

Potassium application had no influence on this character.

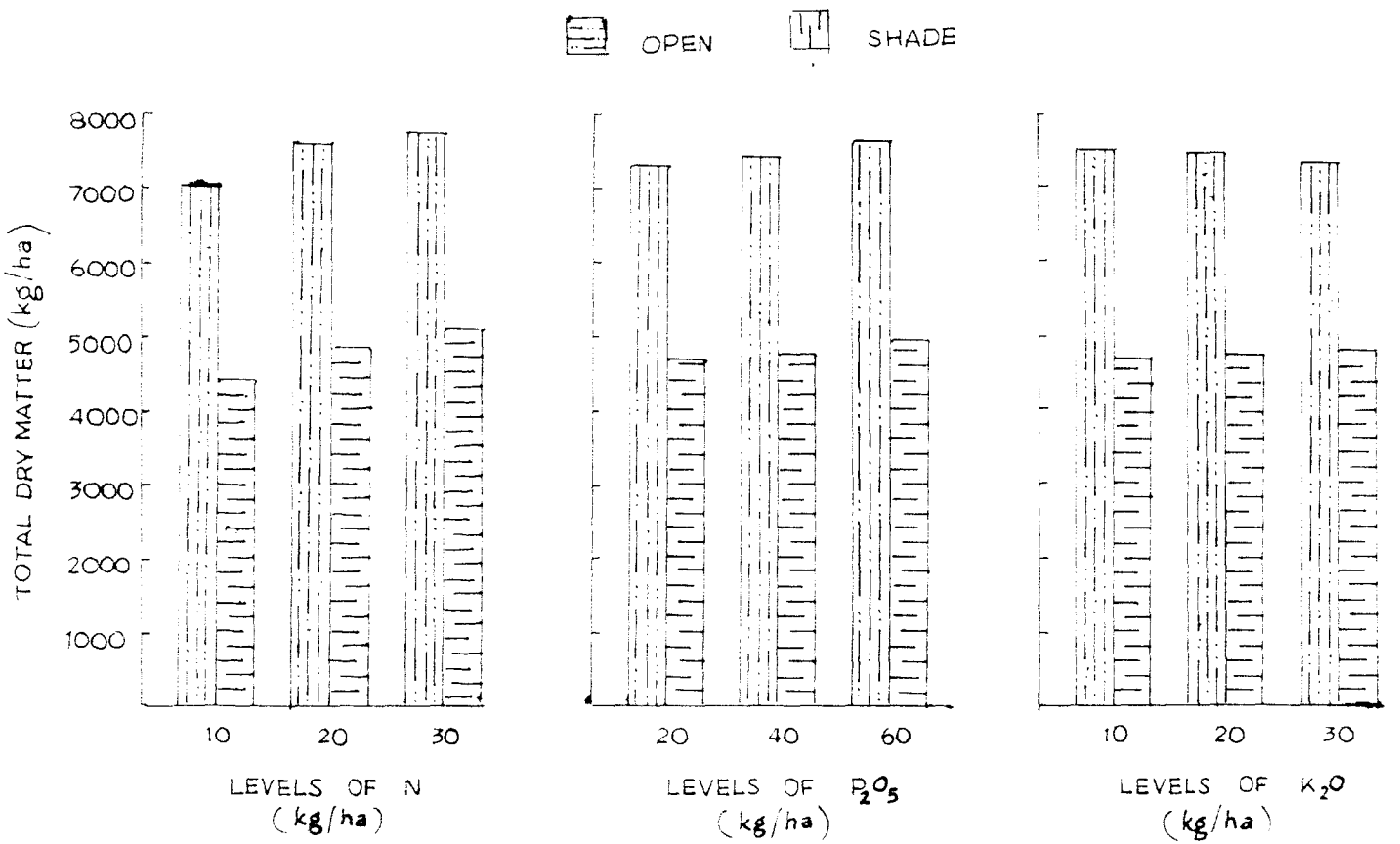
The leaf number per plant was much higher in the open compared to the shaded situation. This may be due to the adverse effect of shade on photosynthesis.

c. Total dry matter production

Nitrogen application had significant influence on the total dry matter production upto the highest level (30 kg N/ha) tried (Table 4, Fig. 3). The influence of nitrogen in promoting vegetative growth is a well established fact. Increased DMP with increase in the rates of nitrogen have been reported by Brillin (1984) in winged beans.

The effect of phosphorus was also marked in increasing the DMP. The highest amount of dry matter was obtained at 60 kg P_2O_5/ha. The increased rates of phosphorus application might have increased the activity of Rhizobia leading to more N fixation and better plant growth. Similar results in DMP due to high rates of phosphorus application have been reported by Malik et al. (1972), Sharma and Yadav (1976), Tripathi et al. (1977) in grain cowpea and Dagaduan (1980) in winged beans.

FIG. 3 EFFECT OF N, P AND K ON THE TOTAL DRYMATTER PRODUCTION



Application of potassium had no influence on DMP. The non significant influence of potassium on DMP was reported by Sundaram et al. (1974) in grain cowpea.

Under the partial shade, the DMP decreased by 35.87 % compared to that in the open. The decrease in dry matter under the shaded situation could be attributed to the decreased rates of photosynthesis under shade. Further, as the light reaching the canopy is less in the shaded condition, the light intensities of a larger proportion of lower leaves may be below compensation point. Thus, the lower leaves might have become parasitic over the upper leaves resulting in a decreased net photosynthesis. The results of the present study is in conformity with the findings of Krishnankutty (1983) in vegetable cowpea.

d. Days to first flowering, flowering period and days to first picking

Neither the main effect of N, P and K nor their interactions did influence the days to first flowering, flowering period and the days to first picking.

The crops grown under the partial shade took more days for the production of first flower. Consequently, the number of days required to commence the first picking was also more.

The plants in the open had an early start of flowering and hence their total flowering period was also more. These results are in conformity with the findings of Krishnankutty (1983) in vegetable cowpea.

II. Uptake studies

a. Uptake of nitrogen

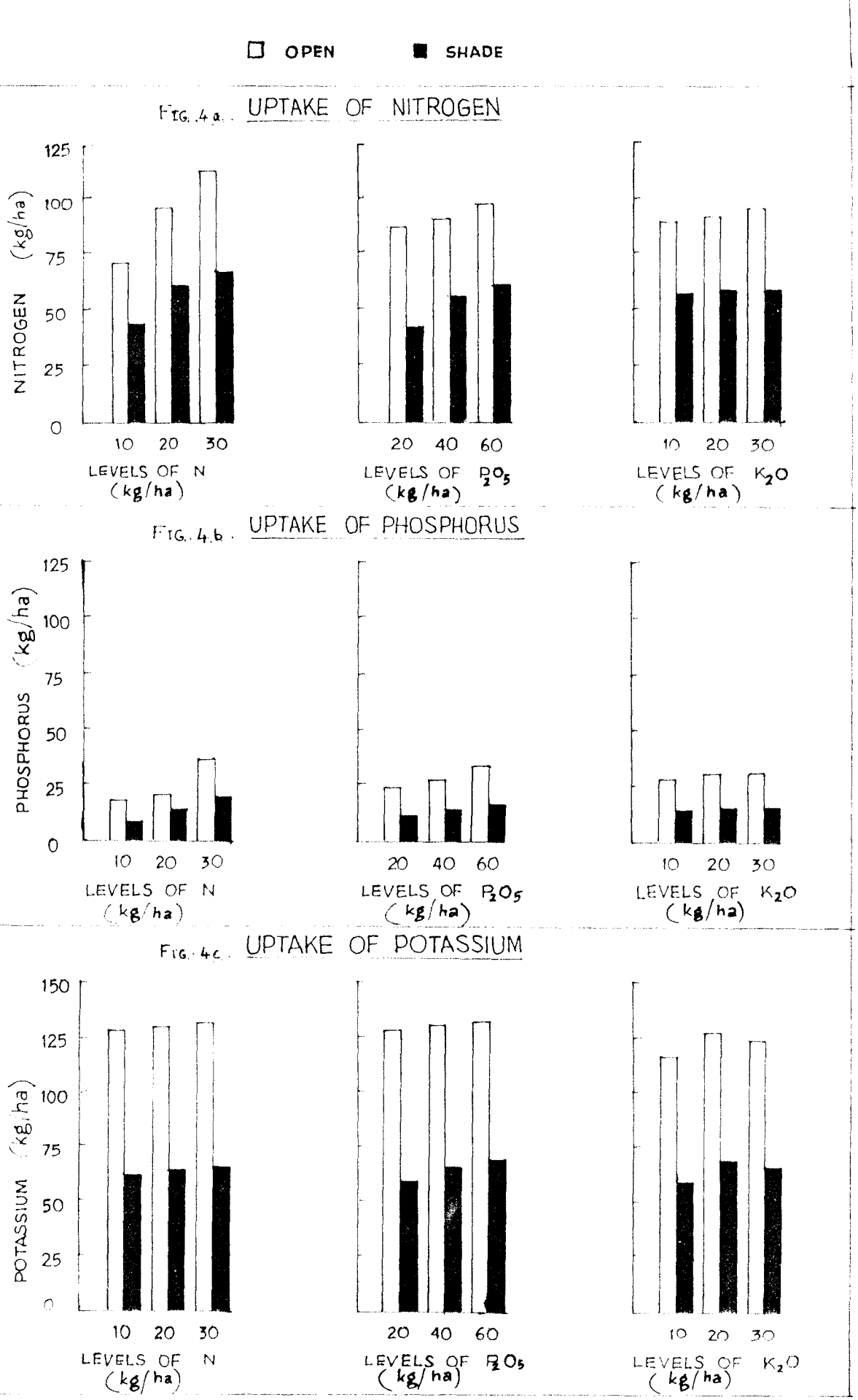
The uptake of nitrogen increased with increase in the levels of nitrogen upto 30 kg/ha (Table 5, Fig. 4(a). It may be noted from Table 4 that the effect of N on biomass production was also similar. This result is in agreement with the findings of Dart and Mercer (1975) in grain cowpea, Bains (1969) in French beans and Brillin (1984) in winged beans.

Phosphorus application increased the N uptake under both conditions. Geethakumari (1981) reported similar result in grain cowpea.

Application of potassium had no influence on N uptake.

Application of N @ 30 kg/ha along with 60 kg P_2O_5/ha resulted in the highest N uptake. The main effects of N and P were also considerable on the N uptake by plants.

FIG.4. EFFECT OF N, P AND K ON THEIR UPTAKE



Vegetable cowpea raised in the open absorbed more amounts of N compared to those raised under the partial shade. Krishnankutty (1983) obtained a similar result in vegetable cowpea. He found that the nitrogen fixing capacity of vegetable cowpea was greater in the open compared to that under the shade and this might have helped the plants to absorb more N when grown in the open.

b. Uptake of phosphorus

Increase in the levels of nitrogen increased the P uptake (Table 5, Fig.4(b). Addition of ammoniacal nitrogen (ammonium sulphate) at planting had beneficial effect on the absorption of P by blackgram (Annamma George, 1980).

The phosphorus uptake increased with increase in phosphorus application upto 60 kg P_2O_5/ha. It may be noted from Table 4 that the DMP increased with increase in P application upto 60 kg P_2O_5/ha. Singh and Jains (1968) could observe similar results in grain cowpea.

Application of potassium did not exert any influence on the P uptake of plants.

Plants raised in the open absorbed more P compared to those grown under the partial shade. The difference in the DMP between the shade and the open conditions (Table 4) explains this.

c. Uptake of potassium

Application of nitrogen or phosphorus did not influence the uptake of potassium (Table 5, Fig. 4(c).

The uptake of potassium by the plants increased with increase in the levels of potassium upto 20 kg K_2O/ha. Johnson and Evans (1975) observed increased K uptake with increase in the levels of K in grain cowpea. Brillin (1984) also observed similar results in winged bean.

The decreased K uptake by the plants noticed under the partial shade compared to those raised in the open can be due to the decreased DMP under the shade.

III. Yield components and yield

a. Number of fruiting points

While the number of fruiting points increased with increase in the levels of nitrogen upto 30 kg/ha (Table 6), the effects of P and K were not considerable on this character.

b. Number of pods per plant

The pod number per plant increased by N application upto a level of 30 kg/ha (Table 6).

Phosphorus application increased the number of pods per plant upto 60 kg P_2O_5/ha. Ahlawat et al. (1978) reported that application of P has marked effect in increasing the number of pods per plant in grain cowpea.

The pod number per plant obtained under the partial shade was 40.8 % less than those obtained in the open. Perhaps, the decreased rates of photosynthesis and translocation of the assimilates to the sink might have resulted in the low production of pods in the shade.

c. Length of pod

Pod length was not influenced by the levels of N, P or K or due to their interactions (Table 6). The length of pod is a varietal character.

d. Number of seeds per pod

The number of seeds per pod increased with increase in the levels of nitrogen upto 30 kg/ha (Table 6). An increase in the seed number per pod has been noted by Kurdikeri et al. (1973) with increased rates of N application in grain cowpea.

Phosphorus application upto 60 kg P_2O_5/ha increased the number of seeds per pod.

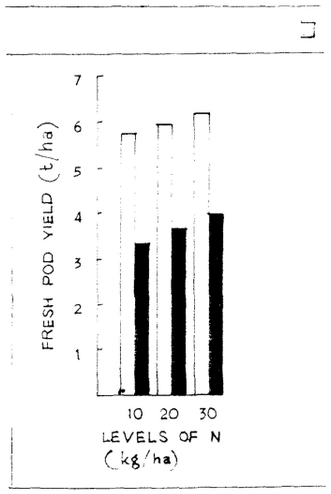
The non significant influence of potassium on this character as seen in this study has been reported by Barrios et al. (1970) in French beans.

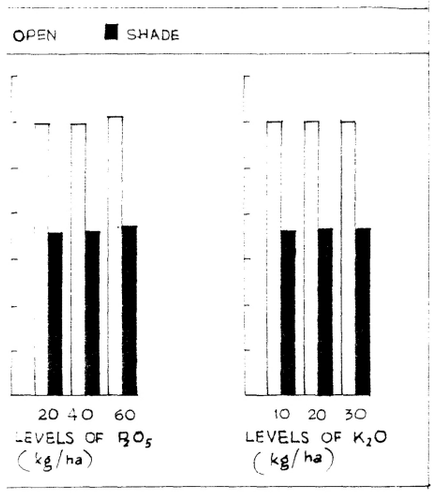
e. Fresh pod yield

The fresh pod yield increased with increase in the levels of nitrogen upto 30 kg/ha (Table 7, Fig.5). The leaf production (Table 3) was also high at this level of N application and this might have contributed for a better photosynthetic efficiency of the plant which in turn might have increased the production of more number of pods per plant and seeds per pod (Table 6) resulting in an enhanced pod yield. Further, it can be seen from Table 5 that the N uptake was higher at this rate of N application. The result obtained in this study is in conformity with the findings of Rhodes (1978) and Haque et al. (1980) in gr in cowpea and Gnetieva (1978) in French beans.

Phosphorus application increased the pod yield upto 60 kg P_2O_5/ha. The beneficial effect of P at this particular dose on the yield components is evident from Table 6.

FIG.5. EFFECT OF N, P AND K ON THE FRESH POD YIELD





Similar results were reported by Malik et al. (1972) in grain cowpea and Dagaduan (1980) in winged beans.

Potassium application did not influence the fresh pod yield. It can be seen from Table 2 that the available potassium content of the experimental soil was medium. Perhaps, the amount of this nutrient present in the soil might have been sufficient to meet the demand of the crop. This result is in agreement with the findings of Viswanathan et al. (1979) in grain cowpea and Bira et al. (1974) in French beans.

The data presented in Table 3 and 6 reveal that the interaction effects were not pronounced on the growth characters such as vine length and leaf number per plant and the yield components such as number of fruiting points, number of pods per plant, length of pod and number of seeds per pod. The same effect was noticed in the fresh pod yield also. The non significant effect of interactions between fertilizer nutrients on vegetable cowpea indicates that the effects of N, P and K are independent of each other on this crop.

The fresh pod yield obtained by the crop under the partial shade was 39.5 % lesser than those obtained in the open.

A decline in the fresh pod yield as well as in the total dry matter production (by 35.87%) noticed in the case of the crop grown under the partial shade could be attributed to mutual shading and leaf parasitism. The negative influence of shade on the photosynthate accumulation and translocation has reflected on the primary yield components viz., number of pods per plant and number of seeds per pod. The plants under shade took more time to reach the flowering stage. The flowering period was also less in the case of plants grown under the shaded condition.

The growth characters viz., vine length and leaf number per plant also showed a decreasing trend under the shaded condition. A decrease in the nodulation and nitrogen fixation due to decreased availability of carbohydrates under the shaded condition has also been reported by Sansamma George (1982) in grain cowpea and Krishnankutty (1983) in vegetable cowpea.

The uptake of N, P and K by the plants grown under the shaded condition (Table 5) was respectively 38.38, 54.55 and 47.83 per cent less than those raised in the open.

The cumulative effect of shade on the growth characters, yield components and the nutrient uptake explained so far has resulted in the production of lesser amount of fresh pods under the shaded situation compared to the crop grown in the open.

From the results and discussion presented in the foregoing sections, the following conclusions can be drawn.

1. There was a linear response of vegetable cowpea var. Kurutholapayar to applied nitrogen upto the highest level tried (30 kg/ha). Hence, further field experiments are to be conducted with higher doses of nitrogen to arrive at the optimum dose.

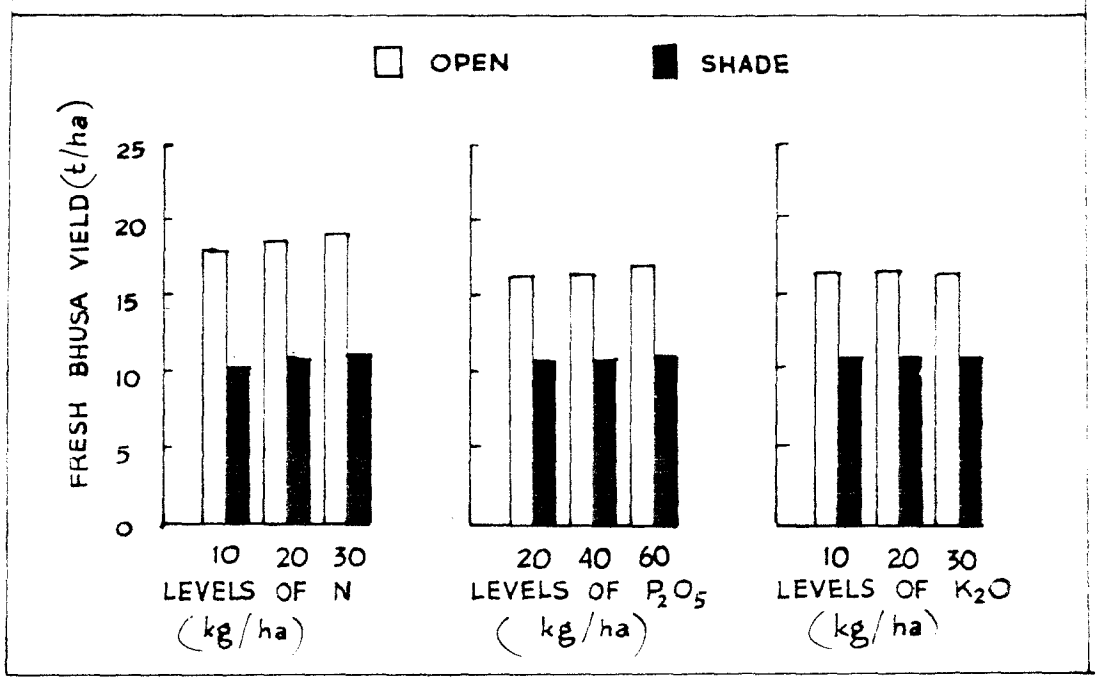
2. As in the case of nitrogen, the response of vegetable cowpea to applied phosphorus was also linear upto the highest level of P_2O_5 tried (60 kg/ha) in this experiment. Here again, to fix the optimum dose of phosphorus, further experiments with higher doses of phosphorus are to be conducted.

3. In Vellayani soils (containing medium to high amounts of available potassium), it appears that there is no need for the application of potassic fertilizers to vegetable cowpea. However, this is to be confirmed by repeated trials.

f. Fresh bhusa yield

The fresh bhusa yield increased with increase in the levels of nitrogen upto 30 kg/ha (Table 7, Fig.6). It can be seen from Table 3 that the growth characters like vine length and leaf number per plant were highest when nitrogen was applie

FIG. 6. EFFECT OF N, P AND K ON THE FRESH BHUSA YIELD



@ 30 kg/ha. Increased bhusa yields upto 30 kg N/ha has been reported by Brillin (1984) in winged bean.

Phosphorus application increased the bhusa yield upto 60 kg P_2O_5/ha. The increased bhusa yield with increase in the levels of phosphorus can be attributed to the influence of this nutrient on growth characters like vine length and leaf number per plant as evidenced by the data presented in Table 3. This result is in conformity with the findings of Malik et al. (1972) and Tripathi et al.(1977) in grain cowpea.

Potassium did not influence the bhusa yield. Sundaram et al. (1974) reported a non significant effect of K on the bhusa yield of grain cowpea.

g. Harvest index

Neither the main effects of N, P or K nor their interactions did influence the harvest index (Table 7).

IV. Quality aspects

Protein content and protein yield of pods

The protein content and the protein yield of pods increased with increase in the levels of nitrogen upto 30 kg/ha (Table 8). Nitrogen application

enhanced the N uptake (Table 5) and hence the protein synthesis. Similar results in protein content of pods with increased rates of nitrogen application have been reported by George (1981) and Sheela (1985) in grain cowpea.

Increase in the levels of phosphorus increased the protein content and the protein yield of pods upto 60 kg P_2O_5/ha. A similar result was reported by Geethakumari (1981) in grain cowpea.

The effect of potassium on the protein content as well as protein yield was not marked.

Interaction effect between N and P on the protein content and the protein yield was considerable and the highest protein content and the highest protein yield were noticed when 30 kg N was applied along with 60 kg P_2O_5/ha. It may be noted that the main effects of N and P on the protein content and the protein yield of pods were also considerable.

The pods of the plants grown under the partial shade contained 10.1% less protein compared to those grown in the open. The protein yield was also less under the shade by 46.5%, compared to the open. The data on the effect of shade on N uptake presented in Table 5 explain this.

V. Soil nutrient status after the experiment

a. Total nitrogen

Increase in the levels of nitrogen increased the total N content in the soil after the experiment. The post harvest N content of the soil was higher compared to the pre-experimental N status. This might be due to the addition of organic matter through the fallen leaves as well as addition of N through biological N fixation by cowpea. The residue of the applied nitrogen also might have contributed to this. The total nitrogen content of the soil after the experiment increased by the application of phosphorus. It is suggested that P application may stimulate nodule production and thus N fixation. Increased soil nitrogen content by P fertilization on grain cowpea has been reported by Khare and Rai (1968), Garg et al. (1970) and Sahu and Behera (1972).

Eventhough potassium application influenced the nitrogen content of the soil after the experiment, no definite trend was observable.

The total N content of the soil after the experiment was more in the open compared to the partially shaded conditions. It can be seen from Table 4 that the DMP was more in the open compared to the shaded condition. Naturally, addition of organic nitrogen through the fallen leaves might also have been more under this situation. Further,

Krishnankutty (1983) reported that the nodule production of vegetable cowpea was more in the open compared to the shade. All these factors together might have contributed for a higher post harvest N content of the soil in the open.

b. Available phosphorus

Interaction effect between N and P was considerable on the available phosphorus content in the soil. The highest available P content was noticed in the plots applied with 30 kg N along with 60 kg P_2O_5/ha.

Potassium application had no influence on the available P content in the soil after the experiment.

The post harvest available P content of the soil was higher in the open compared to the shaded condition. The plant growth was more vigorous in the open compared to the shade. The plants grown in the open might have developed a deep and prolific root system enabling the same to absorb nutrients from a larger rhizosphere even from the deeper layers. This might have enabled the plants to absorb phosphorus and other nutrients from the lower layers of soil and recycle the same to the surface soil through the fallen leaves. Perhaps such a possibility of nutrient recycling might have resulted in a high available P content of the soil after the experiment in the open fields.

Inspite of a larger removal of phosphorus by the crops raised in the open, compared to those grown in the shade, there was a high amount of post harvest available P in the open fields. This indicate that the contribution of phosphorus through nutrient recycling was much more than the removal.

c. Available potassium.

The available potassium content in the soil remained unaffected due to the application of nitrogen, phosphorus or potassium.

VI. Economics of N, P and K fertilization

Net income and return per rupee invested

The data presented in Table 10 reveal that the highest net income was obtained by the application of 30 kg N along with 60 kg P_2O_5 and 30 kg K_2O/ha in the open condition. It can be seen from Table 7 that the highest pod yield was obtained at this particular NPK combination. The net income obtained at this NPK combination was on par with that of $N_{20}P_{20}K_{10}$. However, it is to be noted that the NPK interaction effect on the fresh pod yield was not pronounced.

The effect of interaction between N, P and K on the return per rupee invested was observable in the crop grown in the open and the highest return per rupee invested (Rs.2.37) was obtained by the application of 20 kg N along with 20 kg P_2O_5 and 10 kg K_2O/ha.

In the shaded condition, the effect of interaction between the fertilizer nutrients on the net income as well as the return per rupee invested was not considerable. But, the main effect of nitrogen changed the net income under partial shade. There was increase in the net income with increase in the levels of N upto 30 kg/ha. The return per rupee invested was also found to increase upto a level of 30 kg N/ha under partial shade.

The net income as well as the return per rupee invested from the crop raised in the shaded condition was considerably low compared to that in the open. The yield difference noticed in these two situations (Table 7) explains this.

SUMMARY

SUMMARY

An experiment was conducted at the College of Agriculture, Vellayani during May-September 1986 to find out the effect of graded doses of nitrogen (10, 20 and 30 kg/ha), phosphorus (20, 40 and 60 kg P_2O_5/ha) and potassium (10, 20 and 30 kg K_2O/ha) on the growth, yield and quality of vegetable cowpea var. Kurutholapayar grown as an intercrop in coconut gardens and in the open. The trial was conducted as a 3^3 factorial experiment with two replications confounding NPK in replication 1 and NP^2K^2 in replication 2. The results of the study are summarised below.

1. The vine length, leaf number per plant and dry matter production increased with increase in the levels of nitrogen up to 30 kg/ha or phosphorus upto 60 kg P_2O_5/ha in the open as well as partially shaded conditions. Potassium application did not influence these characters.

2. The days to first flowering, flowering period and the days to first picking remained unaffected due to the application of N, P or K. However, the plants raised under the partial shade took more days for flowering and picking. The total flowering period was more in the case of plants grown in the open.

3. The uptake of nitrogen increased by N application upto 30 kg/ha. Phosphorus application increased the N uptake upto 60 kg P_2O_5/ha. Application of potassium had no influence on N uptake.

4. Phosphorus uptake increased by N application upto 30 kg/ha and by P fertilization upto 60 kg P_2O_5/ha. Potassium application did not influence the P uptake.

5. Increase in the levels of N or P did not increase the potassium uptake by vegetable cowpea. However, application of potassium (upto 20 kg K_2O/ha) increased the K uptake by the crop.

6. The uptake of N, P and K was much higher by the crop raised in the open compared to those raised under the partial shade.

7. The fresh pod yield of vegetable cowpea var. Kuruthola-payar increased with N application upto 30 kg/ha. Phosphorus application increased the fresh pod yield of this variety upto 60 kg P_2O_5/ha. Application of potassium had no influence on the fresh pod yield of vegetable cowpea in the red loam soils of Vellayani containing medium amounts of potassium.

8. The fresh bhusa yield increased with N application upto 30 kg/ha. Phosphorus application also increased the fresh bhusa yield upto 60 kg P_2O_5/ha. Potassium application had no influence on this character.

9. The protein content and the protein yield of pods increased by application of "30 kg N/ha along with 60 kg P_2O_5/ha." Application of potassium had no effect on these parameters.

10. The total nitrogen content of the soil after the experiment increased with increase in the levels of nitrogen upto 30 kg/ha. Application of phosphorus upto 60 kg P_2O_5/ha resulted in a higher total N content of the soil. Potassium application had no effect on the post harvest N content of the soil.

11. The available phosphorus content of the soil after the experiment increased by the combined application of "30 Kg N along with 60 kg P_2O_5/ha". Potassium application had no influence on the post harvest P content of the soil.

12. Neither the individual effects of nitrogen, phosphorus or potassium nor their interactions were significant on the available potash content of the soil after the experiment.

13. The total N and the available P_2O_5 contents of the soil after the experiment was higher in the open fields compared to the partially shaded fields.

14. A maximum net income of Rs.11044.80 was obtained from the plants raised in the open by the application of "30 kg N along with 60 kg P_2O_5 and 30 kg K_2O/ha". The highest

return per rupee invested (Rs.2.37) was obtained from the plants raised in the open by the application of "20 kg N along with 20 kg P_2O_5 and 10 kg K_2O/ha".

15. Vegetable cowpea showed a much better performance when grown in the open compared to partial shade. The vine length, leaf number per plant, dry matter production, pod number per plant, seed number per pod, yield of fresh pods and yield of fresh bhusa were much higher in the case of plants raised in the open.

Future line of work

The present study reveals that there was a linear increase in the fresh pod yield of vegetable cowpea var. Kurutholapayar upto the highest levels of N(30 kg/ha) and P(60 kg P_2O_5/ha) tried in this experiment. Hence, the optimum doses of N and P could not be arrived at. Potassium application had no effect on the fresh pod yield of the crop in the red loam soils of Vellayani containing medium amounts of potassium.

Hence, further field experiments are to be conducted with higher doses of N and P to arrive at the optimum doses of these nutrients. The non significant effect of potassium on the fresh pod yield of vegetable cowpea is to be confirmed by repeating the trial.

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* Originals not seen

APPENDICES

APPENDIX I

Weather conditions (weekly means) during the cropping period (28th May to 4th Septemer, 1986)

Std. week	Period		Temperature (°C)		Rainfall (mm)	Relative humidity (%)
			Maximum	Minimum		
22	May	28 - June 3	33.47	22.47	44.6	74
23	June	4 - June 10	32.26	22.86	56.1	78
24	June	11 - June 17	29.64	22.70	97.6	82
25	June	18 - June 24	29.68	23.33	33.6	89
26	June	25 - July 1	30.41	21.11	30.0	79
27	July	2 - July 8	31.15	23.59	0.4	77
28	July	9 - July 15	30.83	23.21	70.0	85
29	July	16 - July 22	31.17	23.11	16.6	78
30	July	23 - July 29	31.25	22.31	7.4	77
31	July	30 - August 5	30.26	21.79	130.2	79
32	August	6 - August 12	28.35	21.41	308.5	83
33	August	13 - August 19	30.71	22.79	10.6	71
34	August	20 - August 26	31.28	23.20	0	70
35	August	27 - September 2	31.47	22.15	0	71
36	September	3 - September 9	31.25	21.24	3.6	74

APPENDIX II

Abstract of analysis of variance table for vine length and number of leaves per plant stage-wise

Source	df	Mean square							
		Vine length (20 DAS)		Vine length (40 DAS)		No.of leaves/plant (20 DAS)		No. of leaves/plant (40 DAS)	
		Open	Shade	Open	Shade	Open	Shade	Open	Shade
Block	5	0.75	0.02	21.25	49.9	0.01	0.08	0.04	17.28
N	2	1424.19*	661.97*	32417.38*	6521.63*	39.83*	59.96*	2484.32*	4707.52*
P	2	33.89*	67.29*	8294.25*	598.63*	1.92*	9.00*	412.66*	325.39*
NxP	4	2.09	0.69	144.13	133.00	0.74	1.29	38.60*	40.89*
K	2	1.18	0.44	60.00	48.88	0.39	0.50	8.09	7.70
NxK	4	1.12	0.50	53.13	214.56	0.61	0.72	3.70	8.70
PxK	4	3.30	0.45	50.38	177.38	0.74	0.13	1.90	8.99
NPK	2+	1.49	0.74	80.31	375.50	0.19	0.11	4.38	1.57
NP^2K	2	3.54	0.11	125.75	110.63	1.17	0.09	1.42	11.79
NPK^2	2	0.67	0.50	41.38	132.88	0.49	0.33	7.88	3.35
NP^2K^2	2+	0.37	0.25	19.63	4.25	0.45	0.86	5.17	0.55
Error	22	1.22	0.26	87.69	185.69	0.56	0.29	3.38	6.74

+ Confounded effects

* Significant at 0.05 level

DAS : Days after sowing

APPENDIX III

Abstract of analysis of variance table for total dry matter production, days to first flowering, flowering period and days to first picking

Source	df	Mean square							
		Total D M P		Days to first flowering		Flowering Period		Days to first picking	
		Open	Shade	Open	Shade	Open	Shade	Open	Shade
Block	5	335565*	199117*	2.11	0.54	0.51	0.12	2.14	0.95
N	2	2666880*	2205888*	0.92	0.52	1.19	0.60	0.59	4.58
P	2	498048*	201152*	0.57	0.74	0.19	0.34	0.90	5.13
NxP	4	464704*	24512	0.59	0.61	0.57	0.14	0.77	3.88
K	2	119552	256	0.58	1.69	0.58	0.10	1.64	1.85
NxK	4	12352	25744	0.66	1.13	0.20	0.30	0.70	1.52
PxK	4	92800	27392	0.76	1.90	0.92	0.64	0.44	3.32
NPK	2^{+}	131392	4160	0.21	0.79	0.61	0.50	0.12	2.93
NP^2K	2	20864	118208*	2.47	1.63	0.14	0.73	2.22	3.02
NPK^2	2	104576	146688*	0.14	0.95	0.29	0.63	0.09	5.02
NP^2K^2	2^{+}	287936	73824*	0.03	0.17	0.00	0.10	0.15	0.11
Error	22	124183	20989.09	0.89	1.18	0.64	0.36	0.94	1.81

$^{+}$ Confounded effects

* Significant at 0.05 level

D M P : Dry matter production

APPENDIX IV

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

Source	df	Mean square					
		Nitrogen uptake		Phosphorus uptake		Potassium uptake	
		Open	Shade	Open	Shade	Open	Shade
Block	5	32.71	49.75	9.94	0.009	114.99*	24.62
N	2	7979.21*	2521.72*	1337.93*	392.33*	47.78	2.42
P	2	619.05*	187.52*	419.42*	44.67*	70.63	15.04
NxP	4	163.64	100.45*	1.40	2.98	10.41	29.98
K	2	134.94	12.25	21.08	12.10	473.91*	498.85*
NxK	4	10.03	53.89	3.50	0.59	1.02	62.40*
PxK	4	109.61	39.73	8.13	3.49	94.22*	17.31
NPK	2+	60.16	74.96	42.05	1.18	91.14	3.53
NP^2K	2	12.98	2.05	13.09	0.53	47.13	14.49
NPK^2	2	94.98	7.52	0.60	1.11	70.28	18.49
NP^2K^2	2+	0.57	5.35	19.12	0.55	133.67*	2.38
Error	22	67.29	25.83	29.72	2.22	32.10	12.43

+ Confounded effects

* Significant at 0.05 level

APPENDIX V

Abstract of analysis of variance table for number of fruiting points, number of pods per plant, length of pod and number of seeds per pod.

Source	df	Mean square							
		No.of fruiting points		No. of pods/plant		Length of pod		No. of seeds/pod	
		Open	Shade	Open	Shade	Open	Shade	Open	Shade
Block	5	0.008	0.27	0.09	0.04	0.62	7.46*	0.29	0.13
N	2	46.39*	377.46*	35.38*	55.68*	1.34	1.08	10.34*	32.42*
P	2	0.73	1.01	1.94*	1.86*	0.95	0.46	1.43*	9.95*
NxP	4	1.13	1.96	1.04	0.08	2.42	4.22	0.75	0.60
K	2	0.53	1.59	0.15	0.09	2.66	5.21	0.26	1.34
NxK	4	1.00	0.89	0.13	0.32	0.59	4.81	0.44	0.28
PxK	4	0.33	0.97	0.11	0.20	2.03	5.15	0.42	0.83
NPK	2^{+}	1.31	0.21	0.99	0.07	0.16	8.77	0.38	0.88
NP^2K	2	0.07	1.18	0.03	0.18	2.58	3.45	0.54	5.71
NPK^2	2	0.33	0.46	1.06	0.39	2.05	3.05	0.61	3.62
NP^2K^2	2^{+}	0.14	3.11	0.24	0.15	2.81	4.80	0.30	0.44
Error	22	0.53	1.27	0.42	0.37	1.04	2.62	0.28	0.54

+ Confounded effects

* Significant at 0.05 level

APPENDIX VI

Abstract of analysis of variance table for pod yield, bhusa yield and harvest index

Source	df	Mean square					
		Pod yield		Bhusa yield		Harvest index	
		Open	Shade	Open	Shade	Open	Shade
Block	5	0.041	0.007	2.274*	1.436	0.00033	0.00022*
N	2	0.960*	1.630*	16.420*	12.178*	0.00061	0.00011
P	2	0.086*	0.070*	3.337*	1.295*	0.00080	0.00010
NxP	4	0.026	0.008	2.011	0.161	00.00040	0.00002
K	2	0.005	0.001	0.861	0.001	0.00003	0.000003
NxK	4	0.005	0.014	0.077	0.015	0.00031	0.00006
PxK	4	0.032	0.020	0.582	0.076	0.00041	0.00005
NPK	2+	0.030	0.0006	0.843	0.036	0.00043	0.00004
NP^2K	2	0.006	0.007	0.155	0.091	0.00009	0.00003
NPK^2	2	0.020	0.020	0.687	0.092	0.00046	0.00010
NP^2K^2	2+	0.048	0.011	2.107	0.494	0.00035	0.00004
Error	22	0.013	0.018	0.866	0.146	0.00042	0.00007

+ Confounded effects

* Significant at 0.05 level

APPENDIX VII

Abstract of analysis of variance table for protein content and protein yield of pods

Source	df	Mean square			
		Protein content		Protein yield	
		Open	Shade	Open	Shade
Block	5	0.803	0.116	2145690	101581
N	2	132.116*	357.132*	198771200*	198309800*
P	2	12.512*	29.646*	17488900*	16735740*
NxP	4	10.794*	17.840*	12967170*	8697024*
K	2	3.361	2.695	5391872	1548352
NxK	4	3.258	2.015	4153856	1010976
PxK	4	0.950	1.885	947712	1011072
NPK	2+	0.825	1.488	515072	594112
NP^2K	2	4.022	0.416	5077504	381248
NPK^2	2	1.541	0.241	996352	92480
NP^2K^2	2+	1.456	6.370	1775488	3128544*
Error	22	1.418	1.006	1641623	545836

+ Confounded effects

* Significant at 0.05 level

APPENDIX VIII

Abstract of analysis of variance table for total nitrogen, available phosphorus and available potassium contents of soil after experiment

Source	df	Mean square					
		Total nitrogen		Available Phosphorus		Available potassium	
		Open	Shade	Open	Shade	Open	Shade
Block	5	5.65	0.375	2.14	0.07	0.03	0.06
N	2	132.31*	77.06*	830.60*	663.41*	4.69	4.13
P	2	50.75*	26.88*	342.38*	261.28*	0.58	3.35
NxP	4	19.78	13.47	14.45*	11.63*	1.68	6.07
K	2	16.13	5.88	1.28	4.35	3.35	2.58
NxK	4	13.22	2.53	2.80	3.44	4.05	2.71
PxK	4	7.28	4.75	6.16	4.33	1.85	2.02
NPK	2+	4.13	1.69	1.41	0.40	1.59	2.92
NP^2K	2	2.19	1.63	10.34	2.30	0.13	14.30*
NPK^2	2	15.50	8.81	15.22*	1.26	0.69	0.30
NP^2K^2	2+	3.28	3.34	8.68	3.77	1.37	10.33
Error	22	13.03	5.33	3.18	3.89	2.66	3.61

+ Confounded effects

* Significant at 0.05 level

APPENDIX IX

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

Source	df	Mean square			
		Net income		Return per rupee invested	
		Open	Shade	Open	Shade
Block	5				
N	2	7076096*	123535100*	0.0851*	0.2756*
P	2	197632	13504	0.0177*	0.0218*
N×P	4	234496	2048	0.0043	0.0038
K	2	92672	69504	0.0025	0.0039
N×K	4	40960	128576	0.0008	0.0058
P×K	4	294016	175936	0.0043	0.0666
NPK	2+	634624*	4800	0.0093*	0.0020
NP^2K	2	55040	65920	0.0006	0.0037
NPK^2	2	186880	175104	0.0023	0.0008
NP^2K^2	2+	129664	98240	0.0014	0.0016
Error	22	161687.3	158405	0.0027	0.0050

+ Confounded effects

* Significant at 0.05 level.

EFFECT OF DIFFERENT LEVELS OF NITROGEN, PHOSPHORUS AND POTASSIUM ON THE GROWTH AND YIELD OF VEGETABLE COWPEA Var. KURUTHOLAPAYAR [*VIGNA UNGUICULATA*-(L) Walp] GROWN AS AN INTERCROP IN THE COCONUT GARDENS AND IN THE OPEN

BY

RAJESH CHANDRAN B.Sc. (Ag.)

ABSTRACT OF A THESIS

Submitted in partial fulfilment of the
requirement for the degree of
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Faculty of Agriculture
Kerala Agricultural University

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
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ABSTRACT

Field experiments were conducted at the College of Agriculture, Vellayani during 1986 to study the effect of three levels of nitrogen (10, 20 and 30 kg/ha), three levels of phosphorus (20, 40 and 60 kg P_2O_5/ha) and three levels of potassium (10, 20 and 30 kg K_2O/ha) on the growth, yield and quality of vegetable cowpea var. Kurutholapayar grown in the coconut gardens and in the open. The experiment was laid out in a 3^3 factorial experiment with two replications confounding NPK in replication 1 and NP^2K^2 in replication 2. The same experiment was simultaneously laid out, both in the open and in the coconut garden. The abstract of the results is presented below.

Nitrogen application upto 30 kg/ha or phosphorus application upto 60 kg P_2O_5/ha increased the vine length, leaf number per plant, dry matter production, number of pods per plant and number of seeds per pod.

Application of 30 kg N/ha or 60 kg P_2O_5/ha resulted in the highest uptake of nitrogen and phosphorus. The highest potassium uptake was noticed with the application of 20 kg K_2O/ha.

The fresh pod yield and the fresh bhusa yield of vegetable cowpea var. Kurutholapayar increased with N application upto 30 kg/ha or P application upto 60 kg P_2O_5/ha.

Application of potassium had no significant effect on the fresh pod yield of vegetable cowpea in the red loam soils of Vellayani containing medium amounts of potassium.

A maximum net income of Rs.11,044.80 was obtained from the plants raised in the open by the application of "20 kg N along with 60 kg P_2O_5 and 30 kg K_2O/ha".

In general, vegetable cowpea grown in the open showed a much better performance compared to those raised under the partial shade.