# NUTRITIONAL REQUIREMENTS OF WINGED BEAN [*Psophocarpus tetragonolobus* (L.) DC.]



by

**C. BRILLIN**

THESIS

submitted in partial fulfilment of the requirement for the degree

**MASTER OF SCIENCE IN AGRICULTURE**

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF AGRONOMY
COLLEGE OF AGRICULTURE
VELLAYANI, TRIVANDRUM

1984

DECLARATION

I hereby declare that this thesis entitled "Nutritional requirements of winged bean (*Psophocarpus tetragonolobus* (L.)DC.)" 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 of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

Vellayani,
28th February, 1984.

( C. BRILLIN )

## CERTIFICATE

Certified that this thesis entitled "Nutritional requirements of winged bean (Psophocarpus tetragonolobus (L.)DC.)" is a record of research work done independently by Sri.C. Brillia, under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

Vellayani,
Feb. 1984.

(M. PUSHPANGADAN)
Chairman,
Advisory Committee,
Associate Professor of Agronomy.

APPROVED BY :

CHAIRMAN

SRI. K. PUSHPANGADAN.

MEMBERS

1. DR. V.K. SASIDHAR.

2. DR. R.S. AIYER.
9.3.84

3. SRI. N. PURUSHOTHAMAN NAIR.

4. Dr A. Subramanian
9/3
84
Ex. Examiner

## ACKNOWLEDGEMENTS

I wish to place on record my deep sense of gratitude and indebtedness to Sri. K. Pushpangadan, Associate Professor of Agronomy and Chairman of the Advisory Committee, for his sincere guidance, valuable suggestions, constructive criticism and constant encouragement throughout the course of this investigation.

I am highly indebted to Dr. V.K. Sasidhar, Professor of Agronomy, Dr. R.S. Aiyer, Professor of Soil Science and Agricultural Chemistry and Sri. N. Purushothaman Nair, Assistant Professor of Agronomy for their valuable advices and generous help rendered throughout the course of this study.

I owe immence gratitude to Dr. K.C.George, Professor and Head of the Department of Agricultural Statistics and Smt.P. Saraswathy, Associate Professor of Agricultural Statistics for their helpful suggestions in designing the experiment and in analysing the data.

I am also grateful to all the other staff members of the Department of Agronomy for their kind co-operation and help during the course of the study.

My sincere thanks are also due to Dr. N. Sadanandan, Dean, Faculty of Agriculture for providing all the facilities for the conduct of the study at Kerala Agricultural University.

( C. BRILLIN )

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# Introduction

# INTRODUCTION

India has achieved self sufficienty in food production. With the introduction of high yielding, input responsive varieties of rice and wheat since mid sixtees, India could conquer new horizonos in food front. However not much progress could be achieved in the nutritional improvement of food stuff.

Pulses have a key role in the protein nutrition of the people especially in a country like India where the major population is vegetarian. This coupled with other factors make pulses indispensable in the overall economy of the country. Every plant of pulses by itself is a minifertilizer factory which could maintain Indian soil in good health. According to conservative estimates pulses add much more nitrogen than what is being added through chemical fertilizers.

Pulses can utilise the inexhaustible stock of atmospheric nitrogen directly. In India, these crops use some 12 lakh tonnes of atmospheric nitrogen worth Rs.250 crores every year. Pulses have been popular with farmers for centuries because they fit suitably in crop rotations and crop mixtures.

Proteins are the scarcest and the most expensive of food stuffs. Man has to get his proteins in a round about way from animals which depend on plants, which build up proteins from the nitrogen, hydrogen, carbon and oxygen found in soil, air and water. Man mostly gets his proteins from the seeds of plants, particularly legumes and flesh foods. Edible legumes are excellent sources of dietary proteins and oils and they form important constituents of Indian diet. They are responsible for raising the level of per capita consumption of energy as well as enriching the soil with nitrogen. Among legumes, winged bean offers exceptionally good promise and shows a great potential for easing the protein malnutrition problem throughout the humid tropics.

Nutritionally the winged bean is equal to soyabean: its seeds contain 30 to 48 per cent protein and about 15.0 to 18.0 per cent oil. It is considered relatively superior to soyabean in the sense that virtually the entire winged bean plant is rich in food source for man and animals as compared to soyabean whose edible portion is beans only.

The green pods, green and mature seeds, leaves, flowers and tubers all are consumable with ease. The seeds are rich in iron, phosphorus and calcium and do not contain trypsin inhibitor nor urease. The green tender pods contain 20 to 30 per cent protein. Its tuberous roots contain about 20 per cent protein compared to 1 to 2 per cent in cassava, potato, yam and taro. Like all other parts of the plant the foliage has high protein content ranging from 5 to 15 per cent and in flowers about 5 per cent. The protein percentage of drymatter is reported to be as high as 25.6 per cent. Similarly it appears that the leaves of the winged bean would have one of the highest protein contents of all tropical forage legumes.

Currently, winged bean is grown mainly as a garden vegetable. The main consumption areas are South East Asia, Indonesia, New Guinea with limited use in West Africa. Unfortunately the dietary value of the winged bean has not been fully recognised as it deserves. It would be difficult to find another well adapted tropical legume crop with as many desirable characteristics as winged bean.

The potential of winged bean as a vegetable crop capable of supplying the protein requirements should be exploited to the fullest, particularly in those high rainfall areas of the tropics where the commercial production of other pulses is difficult owing to climate, terrain and other Socio ecological factors.

Not much work has been done regarding the adaptability, manurial requirements and quality of winged bean under Kerala conditions and as such the present investigation was taken up with the following objectives.

1. To find out the suitable combination of N, P and K for maximum yield.
2. To find out the economic as well as optimum levels of N, P and K as related to the yield of green pods.
3. To find out the response of N, P and K on the growth and yield attributes.
4. To find out the effect of N, P and K on the quality of green pods.

# Review of literature

## REVIEW OF LITERATURE

Although winged bean (Psophocarpus tetragonolobus (L.) DC.) is grown allover the tropical world, only very little work has been done on this crop with regard to its requirement of nitrogen, phosphorus and potassium and their response on growth and yield attributes. The available literature on the manurial trials in winged bean and allied crops are reviewed here.

Some of the experiments conducted on winged bean showed the necessity of application of all the three essential elements nitrogen, phosphorus and potassium for obtaining higher production and quality of produce. Chandel and Jhoshi (1980) conducted trials at IARI and observed that complete and balanced fertilization gave substantially higher yields. National Academy of Sciences (1975) reported that NPK application was required for the luxurient growth of the winged bean under tropical climates.

### Effect of Nitrogen

(a) On growth.

All most all works carried out on different leguminous crops showed that application of nitrogen was beneficial in increasing the general growth and vigour of the plants.

Okuten (1970) noticed that where soil nitrogen was high the plant size, fresh and dry weights of beans were increased.

Edje et al (1975) reported that Leaf Area Index, plant height and size were closely related to rates of nitrogen in snap beans. Results of experiments conducted by Sader (1979) revealed that in snap bean dry matter content, leaf area and Leaf Area Index were increased with increase in nitrogen rates at all growth stages except at the fully developed trifoliate leaf stage. Similarly Urban et al (1980) found that in rainy season the straw yield increased with the application of nitrogen but in dry season there was no difference between the nitrogen treatments.

Saddati and Samadi (1978) reported that application of nitrogen at the rate of 100 kg per hectare increased the plant height in soyabean.

Hasegawa and Nomura (1978) observed that the efficiency of nitrogen in dwarf kidney bean was low during the early growth, then increased upto the end of pod elongation but was low during pod filling and the rate of pod elongation was increased by nitrogen applied during pod elongation.

Moursi et al (1976) found that application of nitrogen increased the vegetative growth in lupin as reflected in its plant height, number of branches per plant and straw yield.

Mc Lean et al (1974) reported that in field peas application of nitrogen increased the plant weight.

Agboola (1978) observed that top growth in cowpea was increased by nitrogen application.

Hilderbrand *et al* (1981) concluded that higher nitrate application resulted in greater growth of all plant parts except root in winged bean.

Cate and Breteler (1972) observed that the pattern of plant development in bean was unaffected by nitrogen supply and the plants did not differ visually until flowering.

Posypanov and Knyaseva (1974) stated that the different levels of mineral nitrogen supply had practically no effect on plant growth and development of peas.

Zusevics (1981) conducted trials in winged bean and found that dry matter yield was decreased when 400 mg nitrogen per pot was applied in the form of ammonium nitrate in pot trials. Higher nitrogen levels also prevented nodulation and effectiveness of other nutrients.

(b) On flowering and setting percentage.

Almeida *et al* (1973) emphasised the importance of nitrogen at flowering for increasing the grain yield of beans. Edje *et al* (1975) obtained an increase in the number of pods per plant in dry bean by increasing the nitrogen rates; on the other hand Moursi *et al* (1975) reported that in beans ammonium sulphate had no marked effect on the time of flowering, the percentage of fruit set and the total number of fruit abscission but increased the total number of flowers and fruits per plant.

Delayed maturity was noted in field bean by Roberts and Weaver (1971) when nitrogen was applied. Egure *et al* (1977) concluded that when nitrogen was applied number of flowers and flowering nodes were increased in broad beans.

Investigations by Brevedan (1977) revealed that Soyabean plants which received higher nitrogen rates during flowering had significantly increased the number of pods than those which received the lowest nitrogen rate. The number of pods finally retained by the plant was conditioned by the nitrogen supplying capacity of the plant. Another study conducted by him showed that maintaining nitrogen supply at the higher levels until maturity had no further effect on flower and pod abortion and not significantly increased the number of pods in soyabean (Brevedan et al, (1978).

From experimental backing Moursi et al (1976) stated that nitrogen fertilizers did not affect the reproductive characters such as the number of days to flowering, number of flowers per plant, fruit setting percentage, pod absciesion per plant and length and diameter of the pod in lupins.

Trials conducted by Cutcliffe and Munro (1980) revealed that maturity was slightly delayed by increasing the rates of added nitrogen in pea.

(c) On yield and quality.

Sistachs (1970) reported that the plots that received nitrogen yielded considerably but there was a lower nitrogen content in leaves and seeds. Increased pod yield was reported by Asif and Greig (1972) due to nitrogen application in snap beans.

Lopez et al (1977) observed that application of 80 kg nitrogen per hectare produced 96.7 per cent of the estimated maximum yield in snap beans. Results of experiment conducted by Cardoso et al (1978) showed that when nitrogen was applied in the form of urea a postive and linear response was obtained in seed yields of snap bean. At the same time Cunha et al (1980)observed a significant increase in yield of beans by the application of 80 and 120 kg nitrogen per hectare. Longo (1980) in his studies revealed that seed yield of snap beans increased from 1.18 to 2.31 tonnes by increasing the nitrogen level from zero to 100 kg per hectare. Duranti and Caroni (1981) indicated a positive response in dry beans when 100 kg nitrogen applied per hectare.

Hamissa et al (1975) noticed that nitrogen application at the rate of 18 kg per hectare increased the yield of field beans by 9.4 to 10.5 per cent. Gnetieva (1978) found that in field beans application of nitrogen increased the yield by 410 kg per hectare (17% increase).

Aleman and Franco (1976) found that application of 400 kg nitrogen per hectare increased the yield of soyabeans. Greater effect on seed yield was noticed by Huang (1930) when nitrogen was applied to soyabean.

Results of an experiment conducted by Hasegawa and Nomura (1978) showed that the yield of dwarf kidney bean was decreased by the absence of nitrogen during growth period.

Graman et al (1978) noted an increase in the dry matter yield by 3.6 and 4.6 per cent when nitrogen levels of 40 and 80 kg per hectare were applied to horse beans.

The essentiality of nitrogen application was reported by Shekhawat et al (1972) who concluded that 50 kg N per hectare was economic in moth bean.

Mc lean et al (1974) in his growth room tests reported that field beans showed efficient conversion of soil nitrogen to seed protein. Trials by Ahmad and Shafi (1975) revealed that in peas 90 kg nitrogen per hectare increased the number of pods per plant, pod weight, weight of pods per plot and dry matter yield but the number of seeds per pod was not significantly altered.

Rhodes (1978) observed that seed yield and plant nitrogen content of cowpea increased with increasing doses of nitrogen from zero to 60 kg per hectare. Haque et al (1980) obtained maximum yield in cowpea by 60 kg nitrogen per hectare.

Trials by Bhuiya et al (1979) showed that application of 20 kg nitrogen per hectare increased the grain yield and protein content in soyabean.

Singh and Yadav (1971) obtained 12 per cent increase in the yield of bengal gram when 22.5 kg nitrogen per hectare was applied. Chundawat et al (1976) recorded an increase in the yield of bengal gram by the application of 15 kg nitrogen per hectare. A significant increase in 100 seed weight and seed protein content in mung was reported by Kushwaha and Srivastava (1978) by the application of nitrogen.

Hilderbrand et al (1981) obtained an increase in the total protein in winged bean by nitrogen application during the growth period.

However, Richards and Soper (1979) noted that protein content of field bean was unaffected by higher levels of nitrogen.

Bishop et al (1976) obtained only very little effect on yield and seed protein content in soyabean due to application of nitrogen upto 56 kg per hectare.

Hoffer and Jaggi (1978) observed a decrease in seed yield as a result of higher rates of nitrogen in peas varying from zero to 150 kg per hectare.

Panwar et al (1976) reported that there was no response to application of nitrogen in mung. Similarly Mudholkar and Ahlawat (1979) found that application of 25 kg nitrogen per hectare had no effect on the yield of bengal gram.

Zusevics (1981) observed that high levels of nitrogen prevented dry matter accumulation, nodulation and effectiveness of other nutrients in winged bean.

(d) On the uptake of nutrients.

Asif and Greig (1972) found that increased nitrogen application resulted in higher accumulation of potassium, calcium, magnesium, zinc and nitrogen in the pods of snap beans. On the other hand El-Leboudi et al (1976) reported that nitrogen had no effect on the content of phosphorus and potassium in snap bean seeds. But El-Bakry et al (1980) reported that nitrogen application in beans resulted in increased nitrogen content in plant parts. So also Sarkar and Jones (1980) obtained increased trahslocation of phosphorus from root to shoot when nitrogen was applied to snap beans.

Cassman et al (1981) noticed that phosphorus concentration in nitrogen fixing soybean plants were significantly lower than that of nitrogen supplied plants.

Posypanov and knyaseva (1974) found that the peas supplied with mineral nitrogen took up more nitrogen, phosphorus and potassium and synthesized more organic matter and raw protein than those limited to symbiotic nitrogen only.

Enikov and Velchev (1976) observed that nitrogen application increased seed nitrogen content and decreased phosphorus and potassium content in chick pea.

Effect of Phosphorus

(a) On growth.

The beneficial effects of phosphate on nodulation, yield, composition and general behaviour of leguminous crops have been very well established.

Phosphorus plays a very important role in sustaining the soil micorobial population at a higher level. It has a definite stimulatory effect on the multiplication of rhizobia, which in association with leguminous crops fix atmospheric nitrogen.

Results of field experiments conducted at different places in the country have shown that the response of legumes to phosphate has been conspicuous in soils poor in available phosphorus. In phosphate rich soils, the results have not been significant.

Enhanced vegetative growth in bean was reported by Mahatanya (1976) due to phosphate application at 30 and 60 kg per hectare. Mahatanya (1980) also stated that in bean plants plant height, Leaf Area Index, pod number and weight of pods per plant were increased with increasing the phosphorus level from zero to 30 and 30 to 60 kg per hectare.

Shaalan et al (1977) noticed that the number of branches per plant was significantly increased when 108 kg $P_2O_5$ per hectare was applied in broad beans.

Zaroug and Munns (1980) reported that phosphorus deficiency caused stunting and chlorosis in Clitoria ternatea.

Svoboda (1974) obtained a positive effect of phosphorus on growth characteristics of pea. Similarly Singh et al (1980) showed that various growth attributes (plant height, leaf number, branch number, pod number and plant dry weight) were significantly affected when phosphorus application was increased from zero to 100 kg per hectare in field pea.

Tripathi et al (1977) found that application of phosphorus resulted in maximum fresh and dry matter yield in cowpea.

Phosphorus application was found to give maximum top and root dry weight and plant height in redgram, (Bassire et al (1979). The beneficial effect of phosphorus in promoting root and shoot growth, intensity and volume of nodulation in red gram was emphasised by Ahlawat and Saraf (1981).

Increase in drymatter yield of winged bean has been observed by Dagaduan (1980) when 60 kg $P_2O_5$ was applied per hectare.

Parodi et al (1977) reported that addition of phosphorus increased relative and total phosphorus content in beans but it did not contribute to dry matter yield. Shaalan et al (1977) concluded that in broad beans plant height, pod weight, seed weight and number of seeds por plant were not significantly increased by increasing phosphorus application even upto 108 kg per hectare.

In an experiment conducted with bush beans it was observed that application of higher levels of phosphorus decreased the root growth (Wallace et al, 1976).

Application of 10 to 40 kg $P_2O_5$ per hectare to the soil and or as a foliar spray was found to have no significant effect on yield components of green gram (Reddy and Palaniappan, 1979).

(b) On flower production.

Almeida et al (1973) emphasized the importance of phosphorus in beans for flowering.

Kogure et al (1977) concluded that higher levels of phosphorus increased the number of flowers, pods and percentage podding in broad bean.

The importance of phosphorus in the nutrition of peas for better setting of pods was emphasised by Sinha (1970). Investigation by Petkov and Kalaidzhiev (1973) revealed that in pea plants total phosphorus content was highest during flowering, seed development and ripening indicating the profound uptake of this element at the time of flowering.

Agboola and Obigbesan (1977) found that converted bone meal and superphosphate induced earliness in flowering by two weeks in cowpea.

(c) <u>On yield and quality</u>.

Hiroci <u>et al</u> (1970) emphasized the importance of phosphorus in enhancing the yield of snap beans. Almeida <u>et al</u> (1973) concluded that application of phosphorus increased the yield of snap beans. Significant response to phosphorus was obtained by Eira <u>et al</u> (1974) when 79 Kg $P_2O_5$ per hectare was applied to snap beans. Prummel <u>et al</u> (1975) concluded that in snap beans yield was much higher from 30 to 200 kg $P_2O_5$ per hectare, but yield increase curve flattened out above 120 kg per hectare.

Hamissa <u>et al</u> (1975) found that application of phosphorus increased the pod yield by 9.8 to 15.7 per cent in field beans when phosphorus dose was increased from 36 kg to 72 kg per hectare.

Aleman and Franco (1976) reported that in soyabean application of phosphorus resulted in higher yields.

In guar Tomer <u>et al</u> (1972) obtained maximum forage yield when 60 kg $P_2O_5$ per hectare was applied. In cluster bean Chauha and Bajpai (1979) obtained maximum yield when 90 kg $P_2O_5$ per hectare was applied. Reports by Gill (1979) showed that application of 30 kg $P_2O_5$ per hectare gave significant increase in seed yield and protein content in cluster bean.

Reports by Pande et al (1974) showed that application of 75 to 125 kg $P_2O_5$ per hectare to french bean increased the green pod yield per plant and total yield.

Ali et al (1981) reported an increase in crude protein content due to phosphorus application in lentil.

Sharma (1968) noted a significant increase in the yield of peas when phosphorus was applied upto 66 kg per hectare. Trials by Ahmad and Shafi (1975) revealed that in peas 60 or 90 kg $P_2O_5$ per hectare increased the number of pods, weight of pods and dry matter yield.

Significant response in fodder yield of cowpea was obtained when 20 kg $P_2O_5$ was applied per hectare (Faroda, 1973). Dubey et al (1975) obtained higher fresh fodder yield of cowpea by the application of 100 kg $P_2O_5$ per hectare. Kunju et al (1976) reported that application of 60 kg $P_2O_5$ per hectare significantly increased the yield of cowpea. The response of cowpea to phosphorus application was studied by Ahlawat et al (1978) who recorded an increase in yield when 60 kg $P_2O_5$ was applied per hectare.

Venugopal and Morachan (1974) obtained higher yields when 20 kg $P_2O_5$ per hectare was applied to green gram. Higher seed yield in mung, soyabean and urd were obtained by Ravankar and Badhe (1975) when phosphorus was applied to these crops. Panwar and Singh (1975) revealed that the yield of mung was increased by increasing the phosphorus rate upto 40 kg per hectare. Badanur et al (1976) obtained higher yield of black gram by the application of phosphatic fertilisers at the rate of 90 kg per hectare. Kaul and Sekhon (1976) reported that 40 kg $P_2O_5$ per hectare increased the seed yield of mungo. Increase in seed yield was reported by Rathi and Singh (1976) when phosphorus was applied to bengal gram. Trials by Rao (1977) revealed that in red gram 90 kg $P_2O_5$ per hectare gave highest yields. Ramanathan et al (1977) obtained higher red gram yields by increasing the phosphorus application from zero to 76.5 kg per hectare. Shrivastava (1977) reported that highest seed yield of black gram was obtained when 75 kg $P_2O_5$ was applied per hectare.

Significant yield response in mung was obtained by Panwar et al (1978) when phosphorus was applied upto 60 kg per hectare. Rathi and Tripathi (1978) reported that 80 kg $P_2O_5$ per hectare gave the maximum seed yield in red gram. Singh et al (1978) received maximum yield of red gram when 80 kg phosphorus was applied per hectare. Nair and Aiyer (1979) noticed that in green gram application of 15 kg $P_2O_5$ per hectare increased the seed yield.

Increased yield of pulses due to phosphorus was reported by Devarajan et al (1980). Kalyan et al (1980) obtained higher seed yield from red gram by increased phosphorus application. Vasimalai and Subramanian (1980) found that in green gram yields were significantly increased with 50 kg $P_2O_5$ per hectare and decreased with further increase in phosphorus levels. Ahlawat and Saraf (1981) found that phosphorus application in red gram resulted in increased seed yield. Prasad and Sonoria (1981) reported that seed protein content was highest when 150 kg $P_2O_5$ per hectare was applied to bengal gram. Singh et al (1981a) noted that in red gram application of 13 kg $P_2O_5$ per hectare increased growth, yield attributes and seed yields significantly and no additional increase was obtained when 26 kg $P_2O_5$ per hectare was given. Increase in yield was reported was Venkateswarlu et al (1981) when phosphorus was applied at the rate of 15 to 30 kg per hectare to green gram.

Results of experiments conducted in gram, lentil and pea by Panwar et al (1977a) convinced the effect of phosphorus in increasing the yield of pulses.

Reports by Dagaduan (1980) indicated that application of 60 kg $P_2O_5$ per hectare increased the pod yield in winged bean.

While the above mentioned results showed spectacular influence of phosphorus in the growth and performance of different legumes Bishop et al (1976) obtained only very little effect on the pod yield and seed protein content in soyabean due to phosphorus application.

Further, staud (1974) observed that in peas the different phosphate levels had no effect on the yields of vine, pod, seed etc.

Results of experiment conducted by Dagaduan (1980) in winged bean showed that pod crude protein was not affected by phosphorus application.

(d) <u>On the uptake of nutrients</u>.

In addition to better growth in legumes the phosphate application is also found to increase the uptake of phosphorus and other nutrients.

Sasidhar and George (1972a) reported that application of phosphorus increased the nitrogen and phosphorus content of pods and haulms in lablab bean. Kastori et al (1977) concluded that the phosphorus content of beans increased with increasing the phosphorus rates. Higher phosphorus uptake was reported by Amer (1978) by increasing the rate of phosphorus application in snap beans.

Reports by Browning and George (1981) revealed that there was higher concentration of phosphorus in pea seeds due to phosphorus application. Singh et al (1981b) showed that maximum yield and uptake of nitrogen and phosphorus were obtained when 60 kg $P_2O_5$ per hectare was applied.

Ali et al (1981) concluded that phosphorus application increased nitrogen and phosphorus contents in the plant and phosphorus uptake in lentil.

Enikov and Velchev (1976) concluded that phosphorus application increased ash, phosphorus and potassium content and had no effect in the nitrogen content of bengal gram. Singh et al (1981a) found that in red gram increasing the phosphorus rates from zero to 100 kg per hectare increased seed nitrogen and phosphorus uptake in seeds and stem.

However Parodi et al (1977) observed no significant difference between percentage and total phosphorus content of bean plants receiving medium and high phosphorus levels, suggesting that plants reached their maximum phosphorus requirement at 50 kg $P_2O_5$ per hectare.

Sinha (1970) reported that the basal dressing of phosphorus have not affected the drymatter production or phosphorus uptake.

Trials in cowpea by Dalal and Quilt (1977) reported that phosphorus increased the total $P_2O_5$ uptake but decreased the concentration of zinc. Boudreaux (1979) showed that phosphorus application had no effect on the phosphorus content of leaves.

Faroda and Tomer (1975) stated that an increase in the application of $P_2O_5$ from 17 to 35 kg per hectare in cowpea increased the N and $P_2O_5$ content and uptake of N, $P_2O_5$, $K_2O$ and Ca. Johnson and Evans (1975) noted that fertilizer phosphorus had no effect on the nitrogen, phosphorus and potassium content in cowpea.

## Effect of Potassium

(a) On growth.

Tsonev and Parlapanova (1972) reported that application of Potassium increased plant growth in beans. Increase in growth was reported by El-Leboudi et al (1974) when 250 kg of potassium per hectare was applied in beans. Peck and Buren (1975) concluded that snap beans grown with high rates of potassium made excessive vegetative growth.

Investigations by cutcliffe and Munro (1980) revealed that application of potassium tended to increase haulm length in green peas.

(b) On flower production, earliness and setting percentage.

Kogure et al (1977) concluded that when potassium was applied number of flowers and flowering nodes were increased in broad beans.

Investigation by Cutcliffe and Munro (1980) revealed that application of potassium at the rate of 90 kg per hectare tended to advance maturity period in green peas.

(c) On yield and quality.

Trials by stanev and chichev (1972) in beans showed that raising potassium levels increased growth and leaf area of the plants, where as potassium deficiency reduced the photosynthetic intensity. Increase in yield was noted by El-Leboudi _et al_ (1974) when 250 kg of potassium per hectare was applied in beans. A seven percent increase in yield was reported by Kranz _et al_ (1976) when 80 kg potassium was applied per hectare to beans in dry season. Gutierrez _et al_ (1978) reported that potassium deficiency was found to be responsible for reduced growth and weight of snap beans.

A twenty percent increase in protein yield was noticed by Haghparast and Mengel (1975) when potassium was applied to broad beans. Furlan (1977) found that higher doses of potassium increased seed yield in broad beans.

Trials in soyabean by Chevalier (1976) revealed that application of potassium increased seed yield upto 200 kg per hectare. Fauconnier (1976) and Ferrari _et al_ (1976) obtained an increase in the yield of soyabean when potassium was applied at the rate of 100 kg each respectively per hectare. Markus (1976) obtained higher yields in soyabean when 150 kg potassium was applied per hectare. Investigation by Graves _et al_ (1979) revealed that potassium fertilization generally increased the seed yield of soyabean. Higher yield was obtained by Sartain _et al_ (1979) when potassium was applied to soyabeans at the rate of 100 kg per hectare.

Hernandez *et al* (1978) reported that in red gram application of potassium had a linear effect on the yield of dry seed and quadratic effect on fresh seed yield. They further observed that the highest yield of 4.56 tonnes of fresh seed was obtained by applying 50 kg per hectare. Kulkarni and Panwar (1981) obtained higher yield in red gram by the application of 20 kg $K_2O$ per hectare.

On the other hand factorial trials by Braga *et al* (1973) showed that there was no response to applied potassium even upto 80 kg per hectare in beans. A reduction in yield was noted by Eira *et al* (1974) when potassium at the rate of 80 kg per hectare was applied to beans.

Results of experiment conducted by Hamissa *et al* (1975) showed that there was no response to applied potassium in field beans.

Chevalier (1976) revealed that application of potassium decreased the protein content of ripe seed in soyabean. Almedia *et al* (1980) found that potassium application had no significant effect on the yield of soyabean.

Reports by Sasidhar and George (1972b) showed that pod yield was not affected by potassium application in lab-lab bean.

Trials by Ahmad and Shafi (1975) revealed that application of 60 kg potassium had no effect on the yield of peas.

Trials by Viswanithan et al (1978) indicated that response to applied potassium was not significant in cowpea.

Zusevics (1981) found that in winged bean higher rates of potassium application decreased dry matter yield.

(d) On the uptake of nutrients.

Increase in the applied potassium was found to give increased leaf, seed potash and crude protein content in broad beans (Furlan, 1977).

Trials by Singh and Saxena (1978) found that in soyabean about 55 to 60 per cent of the total potassium was removed by stems and husks and the remainder by seeds. Yuan et al (1979) obtained increased potassium content in leaf when soil application of potassium was done in soyabean.

Johnson and Evans (1975) noted higher potassium content in leaf when potassium was applied to southern peas.

## Interaction Effects

(a) N x P Interaction.

Trials by Bolsanello et al (1975) revealed that in beans the interaction between nitrogen and phosphorus was significant.

El-Bakry et al (1980) reported that foliar application of 0.5 to 1 per cent of phosphorus increased growth especially in conjuction with soil nitrogen application in snap beans.

Smith (1977) concluded that in snap beans added potassium increased vine weight but not yield of pods, but this was compensated by NP interaction. Reports by Haag et al (1978) showed that on dry beans higher doses of nitrogen and phosphorus increased average seed yield per plant, pod numbers per plant, seed numbers per pod and single seed weight.

Hamissa (1974) reported that 36 kg nitrogen and 72 kg phosphorus per hectare were found to be the optimum levels for beans.

Axinte (1975) obtained maximum yield of soyabeans by applying 48 kg N and 48 kg $P_2O_5$ per hectare. In soyabean the highest seed yield was obtained when 60 to 90 kg N was applied in combination with 80 kg $P_2O_5$ per hectare (Mate, 1977). Trials conducted by Romosan et al (1979) concluded that 80 Kg N in combination with 40 kg $P_2O_5$ per hectare gave maximum yields in soyabean.

Sharma et al (1976) obtained highest yield in french bean when 40 kg N was applied along with 60 kg $P_2O_5$ per hectare.

Browning and George (1981) reported that np interaction was highly significant in peas with respect to their yields.

Malik et al (1972) observed a significant interaction between nitrogen and Phosphorus on the yield of cowpea. Kumar and Pillai (1979) obtained maximum yield of cowpea when a combination of 20 kg N and 40 kg $P_2O_5$ was applied per hectare. Highest yield was obtained by Kumar et al (1979) when 30 kg N and 40 kg $P_2O_5$ per hectare was applied to cowpea.

Reports by Rajendran et al (1974) showed that seed protein and phosphorus content were increased with increasing the levels of nitrogen and phosphorus in black gram. Subramaniyan et al (1978) concluded that application of 25 kg $P_2O_5$ along with 12.5 kg N per hectare increased the seed yield of red gram. Selvaraj and Subramaniyan (1981) found that application of nitrogen and phosphorus along with IAA gave the highest yield in pigeon peas when it was harvested 130 days after sowing.

On the other hand Asif and Greig (1972) reported that application of nitrogen and phosphorus resulted in lesser yields in snap beans. Result of experiment conducted by Neptune et al (1978) revealed that there was no interaction between nitrogen and phosphorus on the yield of beans. Midan et al (1980) reported that there was no significant interaction between nitrogen and phosphorus in snap beans.

Upadhaya and Saharia (1977) stated that yields were similar even when nitrogen and phosphorus were applied to lentil.

Addy (1975) from glasshouse and field trials in cowpea concluded that application of nitrogen and phosphorus in the early wet season had no significant effect on seed yield; though applied nitrogen tended to increase it slightly, phosphorus tended to decrease it.

Trials by Raikhelkar et al (1977) found that there was no significant difference on seed yield of bengal gram due to the application of nitrogen and phosphorus.

(b) P x K interaction.

Rodriguez (1976) found that in dry beans maximum yield was obtained by applying 225 kg $P_2O_5$ along with 40 kg $K_2O$ per hectare.

Reports by Fordonski et al (1980) showed that increasing the rates of applied phosphorus and potassium had little effect on the emergence but increased the yield of straw, seed and crude protein in field beans.

Porto et al (1979) concluded that application of phosphorus with potassium increased plant height, number of nodes, stem diameter and number of days to maturity in soyabean. Shahidullah et al (1979) reported that combination of 40 kg $P_2O_5$ and 40 kg

$K_2O$ per hectare resulted in maximum height in soyabeans, at the same time number of branches per plant was not affected by the same fertilizer combinations.

Analysis of data from pk trials by Bhattacharya and Dasgupta (1976) showed that in horse gram the economic optimum rate was 31.8 kg of $P_2O_5$ and 10.6 kg to $K_2O$ per hectare.

But Gratieva (1978) reported that phosphorus and potassium had no effect on the yield of broad beans.

Reports by Teixeira et al (1979) showed that application of phosphorus together with potassium had no effect on the crude protein content of soyabeans.

(c) N x P x K interaction.

Increased seed yield from bean was reported due to the application of N, $P_2O_5$ and $K_2O$ by Chagas and Vieira (1975). Similarly Detkov (1975) received maximum yield when a combination of 80 kg N, 80 kg $P_2O_5$ and 60 kg $K_2O$ were applied to beans per hectare. In field trials by Murtika (1979) showed that a combination of 100 kg each of N, $P_2O_5$ and $K_2O$ per hectare gave the maximum yield of snap beans. Dekov et al (1980) recommended 40 kg N, 80 kg $P_2O_5$ and 30 kg $K_2O$ per hectare as the optimum fertilizer combination for snap beans.

Igue (1969) reported that in beans significant interactions were most frequent where the effects of individual nutrients are significant. But at low levels of applied nutrients the interactions were relatively low.

Aleman et al (1976) concluded that in soyabean seed yields were highest with highest rate of NPK fertilizers. Significant increase in seed and crude protein yield was reported by Daminov and Ermatova (1980) in soyabean by the application of 60 kg N, 40 kg $P_2O_5$ and 45 kg $K_2O$ per hectare.

Graman (1978) emphasized the importance of balanced nutrition for maximum yield in horse bean.

Fontes et al. (1979) reported that maximum yield and seed quality were obtained in pea from the plots receiving 15:75:30 kg of N, $P_2O_5$ and $K_2O$ respectively.

Gowda and Gowda (1978) obtained maximum yield of green gram by the application of 30 kg N, 60 kg $P_2O_5$ and 20 kg $K_2O$ per hectare.

However Chipman and Mac Eachern (1977) found no response to applied N, $P_2O_5$ and $K_2O$ in snap beans. Similarly Kozera (1977) observed that application of N, $P_2O_5$ and $K_2O$ had no effect on bean yield even in plants receiving no organic fertilizers. Kolarowa (1978) concluded that application of 40 kg N, 60 kg $P_2O_5$ and 30 kg $K_2O$ per hectare as singlet and in combination had no effect in snap bean Yield.

Aleman and Franco (1976) found that higher doses of N, $P_2O_5$ and $K_2O$ had no interaction effect in the yield and quality of soyabean.

In winged bean Chandel and Jhoshi (1980) conducted experiments at IARI and reported that 40:100: 40 kg NPK per hectare produced economic yields. Ingavale and Rajput (1981) reported that in winged bean application of 40 kg nitrogen, 50 kg phosphorus and 50 kg potassium per hectare gave the maximum yield.

# Materials and methods

# MATERIALS AND METHODS

The present investigation was carried out to study the effect of various levels of nitrogen, phosphorus and potassium on the growth attributes, yield and quality of winged bean (*Psophocarpus tetragonolobus* (L.) DC.) under the soil and climatic conditions of Vellayani. The materials employed and the methods adopted in this investigation are given below.

## Materials

### 1. Experimental Site.

The experiment was laid out in the Instructional Farm attached to the College of Agriculture, Vellayani. The area selected was even and uniform in soil conditions and free from any shade.

### 2. Soil.

The soil of the experimental area belongs to red loam. The nutrient status of the soil prior to the commencement of this experiment is given in Table 1.

Table 1. Chemical Analysis of Soil before the Experiment.

| Constituents | Content in Soil | Methods used |
|---|---|---|
| Total nitrogen | 0.1 per cent | Modified microkjeldahl's method |
| Available $P_2O_5$ | 89.5 kg/ha | Bray's method |
| Available $K_2O$ | 62.4 kg/ha | Ammonium acetate method |
| pH | 5.3 | 1:2.5 soil solution ratio, using pH meter |

3. Season and climate.

The best season for sowing of the crop is during the period between second fortnight of June to early August. Since this is a short day plant. Accordingly this experiment was laid out during July and the crop was sown on 27th July, 1982 and the harvest of the crop was finally completed on

FIG 1 WEATHER CONDITION DURING THIS CROP YEAR AND THE AVERAGE FOR THE LAST 25 YEARS

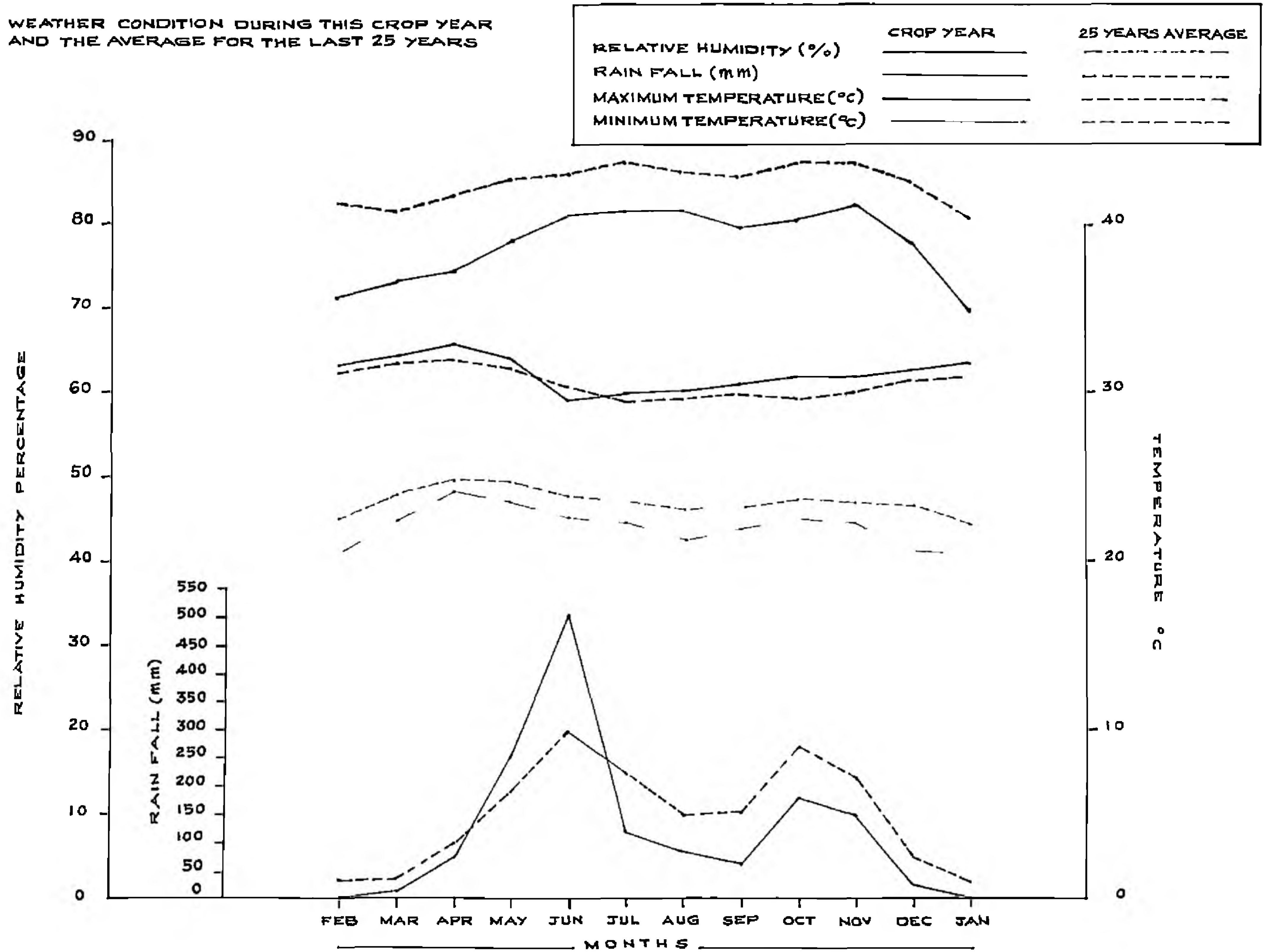
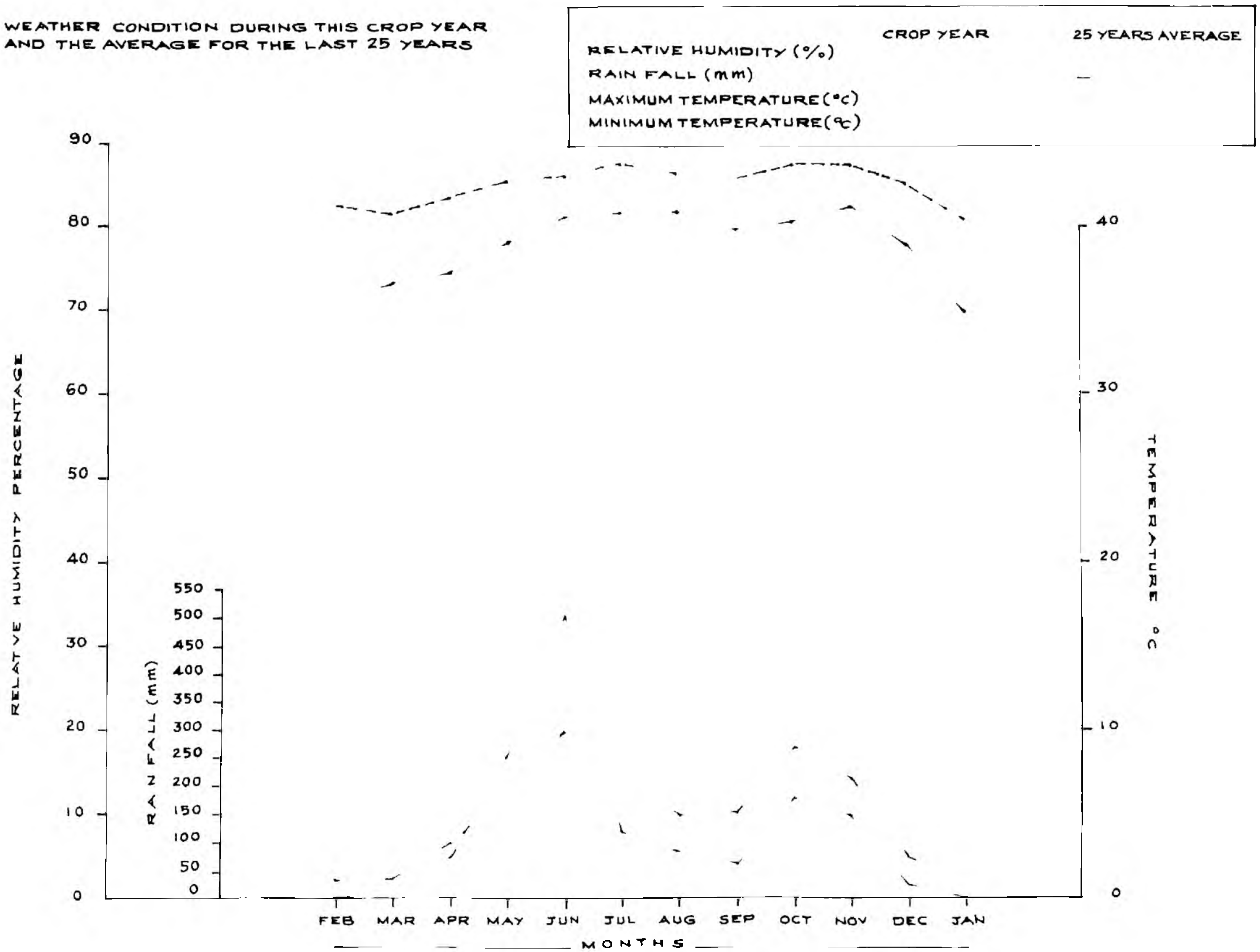


FIG 1 WEATHER CONDITION DURING THIS CROP YEAR AND THE AVERAGE FOR THE LAST 25 YEARS



17th January, 1983. The meteorological parameters such as rainfall, maximum and minimum temperatures and relative humidity prevailed during the growth period of the crop were recorded. The average monthly values from sowing to harvest were worked out and presented in Appendix 1 and Fig.1.

4. Cropping history of the experimental site.

The experimental area selected was under fallow for the past two years.

5. Seeds.

The seeds used in the experiment was type "Pattambi" with 98 percent germination. The seeds were obtained from the College of Horticulture, Vellanikkara, Trichur. The type "Pattambi" possesses the following characters:

It is a season bound type having 5 to 6 months duration and is found to be suitable for growing under irrigated and rainfed conditions. It is a short day plant. The plant is hardy and twiny with plenty of branches. The inflorescence is axillary in nature and are produced in the axils of main, secondary as well as tertiarry branches. The flowers are bluish white in colour. Flowering commences usually from 40th day after sowing and continues for about 100 to 130 days with an average of 5 to 8 flowers in an inflorescence. The setting percentage ranges from 25 to 35. The green pods of 15 to 18 days maturity is most suited as a vegetable. It takes about 45 to 50 days for the full maturity of the pods. On ripening the colour of the pods becomes greyish black. The average length of the pods varies from 16 to 18 cm and girth 6 to 7 cm. The shape of the pod is linear and quadrangular with four cornered wings. The protein content of the pods ranges from 20 to 30 per cent on dry weight basis.

6. Manures and fertilizers.

Lime at the rate of 500 kg per hectare was uniformly spread in the experimental area and was incorporated well with the third digging.

Farmyard manure was applied uniformly at the rate of 10 tonnes per hectare in the planting pits. The analysis of the farmyard manure is given below.

| | |
|---|---|
| Total Nitrogen | 0.48 per cent |
| Available phosphoric acid ($P_2O_5$) | 0.29 per cent |
| Available potassium ($K_2O$) | 0.46 per cent |

In this experiment nitrogen, phosphorus and potassium were given as ammonium sulphate, single superphosphate and muriate of potash with the following composition.

| | |
|---|---|
| Ammonium Sulphate | 20.5 per cent N |
| Single Superphosphate | 16 per cent $P_2O_5$ |
| Muriate of potash | 60 per cent $K_2O$ |

## Methods

### A. Design and Lay Out.

(a) Treatments and Treatment combinations.

A factorial combination of four levels of phosphorus and three levels each of nitrogen and potassium were used as treatments in this experiment. The levels of each nutrient are given hereunder.

i. Nitrogen - 3 levels

| | | |
|---|---|---|
| No | Zero kg nitrogen/ha | |
| N1 | 15 | " |
| N2 | 30 | " |

ii. Phosphorus - 4 levels

| | | |
|---|---|---|
| Po | Zero kg phosphorus/ha | |
| P1 | 30 | " |
| P2 | 60 | " |
| P3 | 90 | " |

iii. Potash - 3 levels kg potash/ha

| | | |
|---|---|---|
| Ko | 0 | " |
| K1 | 30 | " |
| $K_2$ | 60 | " |

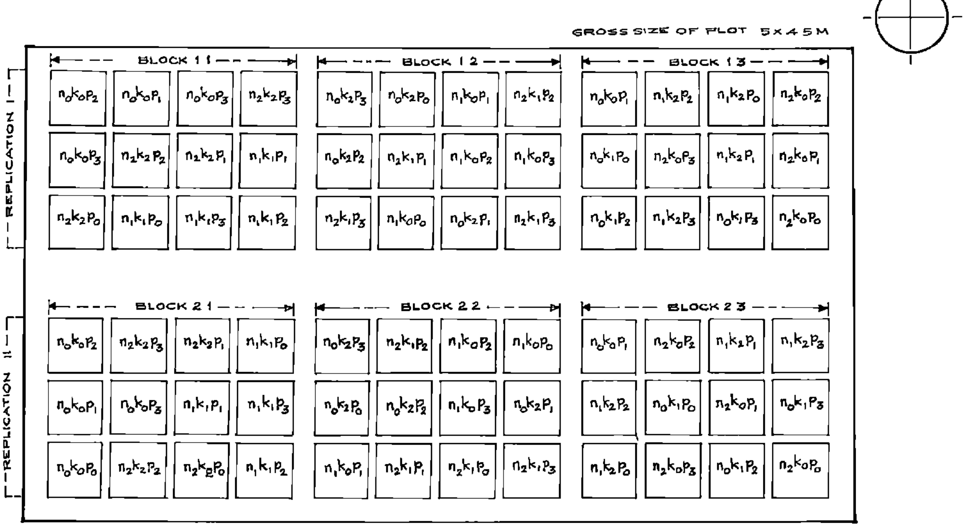
There are 36 treatment combinations as given below

| | | |
|---|---|---|
| $n_op_ok_o$ | $n_1p_ok_o$ | $n_2p_ok_o$ |
| $n_op_ok_1$ | $n_1p_ok_1$ | $n_2p_ok_1$ |
| $n_op_ok_2$ | $n_1p_ok_2$ | $n_2p_ok_2$ |
| $n_op_1k_o$ | $n_1p_1k_o$ | $n_2p_1k_o$ |
| $n_op_1k_1$ | $n_1p_1k_1$ | $n_2p_1k_1$ |
| $n_op_1k_2$ | $n1\,p_1k_2$ | $n_2p_1k_2$ |
| $n_op_2k_o$ | $n_1p_2k_o$ | $n_2p_2k_o$ |
| $n_op_2k_1$ | $n_1p_2k_1$ | $n_2p_2k_1$ |
| $n_op_2k_2$ | $n_1p_2k_2$ | $n_2p_2k_2$ |
| $n_op_3k_o$ | $n_1p_3k_o$ | $n_2p_3k_o$ |
| $n_op_3k_1$ | $n_1p_3k_1$ | $n_2p_3k_1$ |
| $n_op_3k_2$ | $n_1p_3k_2$ | $n_2p_3k_2$ |

(b) Experimental technique.

The design adopted for this investigation was $4 \times 3^2$ factorial experiment, confounding $NK^2$ in both replications. The layout plan is given in Fig.2. The details of the layout are furnished below

FIG 2 LAY OUT PLAN - CONFOUNDED FACTORIAL EXPERIMENT




TREATMENTS

| LEVELS OF NITROGEN | LEVELS OF PHOSPHORUS | LEVELS OF POTASSIUM |
|---|---|---|
| $n_0$ - 0 kg N/ha | $p_0$ - 0 kg $P_2O_5$/ha | $k_0$ - 0 kg $K_2O$/ha |
| $n_1$ - 15 kg N/ha | $p_1$ - 30 kg $P_2O_5$/ha | $k_1$ - 30 kg $K_2O$/ha |
| $n_2$ - 30 kg N/ha | $p_2$ - 60 kg $P_2O_5$/ha | $k_2$ - 60 kg $K_2O$/ha |
| | $p_3$ - 90 kg $P_2O_5$/ha | |

| | |
|---|---|
| Number of treatment combinations | 36 |
| Number of replications | 2 |
| Number of blocks | 6 |
| Number of plots per block | 12 |
| Gross plot size | 5 x 4.5 M |
| Net plot size | 3 x 3 M |
| Spacing | 100 x 75 cm |
| number of plants in gross plot | 30 |
| Number of plants in net plot | 12 |
| Number of observational plants | 3 |

B. <u>Field Culture.</u>

(a) Preparatory cultivation.

The experimental area was dug thrice and the stubbles, grasses and other weeds were removed. Lime at the rate of 500 kg per hectare was spread uniformly and thoroughly incorporated. The blocks and plots were then laid out as per the design. Shallow pits of 30 cm diameter were taken at a distance of 100 cm between rows and 75 cm in the rows.

(b) Sowing.

Two seeds each were dibbled in the pits on 27-7-1982 at uniform depth. Thinning was done fourteen days after germination and a single healthy plant was retained in each pit.

Irrigation was given to the crop during the cropping period in the absence of rain.

(c) Manuring.

Lime was applied by broadcasting and well incorporated. Cattle manure was dried, powdered and mixed well with the soil in the planting pits before dibbling.

The fertilizers were applied 20 days after the dibbling of seeds to protect the germinating seeds from fertilizer injury. Ammonium sulphate, single superphosphate and muriate of potash were applied in the pit by band placement, 5 cm deep and 15 cm apart from the base of the seedling.

(d) General Condition of the Crop.

Germination was noticed from 5th day onwards. Germination count was taken after a week and it was found to be more than 50 per cent. The vigour of germination was found to be good. Subsequent observations on growth conditions of the crop were made at weekly intervals and the crop condition was totally good.

(e) Aftercultivation.

Weeding was done as and when required. Interculturing was done systematically at fortnightly intervals. When the plants were about to twine pandals were raised with stakes. The plants were allowed to trail over the pandal without permitting to intertwine each other by careful management so that the measurements of biometric observations were made feasible and easy.

(f) Plant protection.

No serious incidence of pest or disease was noticed in the crop during the crop period and hence plant protection measures were not necessitated. The stakes used for pandal was protected from termite attack by dusting with B.H.C. 10 per cent.

(g) Flowering.

The first flowering of the crop was noticed on the 44th day of dibbling. Though the initial rate was comparatively less it progressively increased till about 90 days after first flowering and then decreased. Formation of pods was found 4 days after the opening of flowers and the pods were ready for picking for vegetable purpose after fourteen days.

(h) Harvest.

The pods were harvested green a fortnight after the formation of pods and the harvesting was done by hand picking. The harvest was commenced on the 2nd of October, 1982 and subsequent harvesting was done at weekly intervals. Seventeen harvests were done in total to collect the entire green pods and the harvesting was over by 17th January, 1983. The pods harvested from the three observational plants were kept separately for further observations and analysis. After completing the collection of pods the observational plants were pulled out, the tubers and haulms were separated and dried in the sun for a week for further analysis.

C. Observations Recorded.

One line of plants in the border of each plot was left out and 12 plants were maintained in the net plot. From the 12 plants in the net plot three plants were tagged at random for biometric observations.

(a) Observation on the growth characters.

i. Height of plants

The height of each observational plant was measured on the 40th day after germination. The height was measured from the base of the plant to its apex and recorded in cm. The observation on the height of the plant was done only once as the crop was about to trail over the pandal after 40 days.

ii. Number of leaves

The number of leaves produced per plant was recorded progressively at monthly intervals starting from 50th day after germination till final harvest.

iii. Number of branches

The number of branches produced was counted and recorded at monthly intervals from 50th day after germination till final harvest.

iv. Earliness in flowering

The number of days taken for attaining flowering in 50 per cent of the 12 plants in the net plot was recorded and from this earliness in flowering was worked out.

v. Number of flowers produced

Number of flowers produced per plant was recorded on every alternate day from the opening of the first flower till 7 days before the final harvest of the pods.

vi. Number of pods per plant

The number of pods harvested from each observational plant was separately recorded and from this data the total number of pods produced per plant was calculated.

vii. Setting percentage

The setting percentage was worked out from the total number of flowers produced per plant and the total number of pods harvested.

viii. Length of pods

Five pods from the observational plants from each harvest was taken at random and the average length of pod was worked out. Then the average of the 17 harvests was also worked out to express the mean length of the pods in cm.

ix. Yield of green pods

The total weight of green pods harvested from the 12 net plants in 17 harvests were recorded separately. The yield per hectare was then worked out in kg per ha for each treatments.

x. Bhusa yield

The plants were dug out, tubers separated and weight of bhusa taken and expressed in kg per hectare.

xi. Tuber yield

After separating bhusa the tubers left were weighed and expressed in kg per hectare.

xii. Harvest index

The harvest index was worked out based on the pod and bhusa yield obtained from the net plot using the following formula and expressed in per cent.

$$H.I(\%) = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

$$H.I(\%) = \frac{\text{Weight of pods}}{\text{Weight of pods + Weight of bhusa + weight of tubers.}} \times 100$$

xiii. Total dry matter production

The samples were dried in the sun and further in the air oven at a temperature of 80 $\pm$ 5° C for 48 hours to attain a constant weight. Dry matter content was computed in kg per hectare for each treatment.

(b) Soil analysis.

Soil from each experimental plot was taken and the composite sample from each plot was analysed for total nitrogen, available phosphorus and available potassium. It was then compared with the analytical data of the soil prior to the commencement of the experiment. Total nitrogen was determined by modified micro-kjeldahl method (Jackson, 1967) and available phosphorus by Bray's method (Jackson, 1967). Available potassium was determined by Ammonium acetate method (Jackson, 1967)

(c) Plant analysis.

Samples of green pods were taken at random from each harvest. It was when dried, ground, powdered and representative samples were taken to analysis. The samples of leaves, haulms, and roots were taken for analysis at the time of final harvest. Samples collected were oven dried at 80°C ± 5, ground in a wiley mill and used for chemical analysis. The nitrogen, phosphorus and potassium contents in roots, leaves, haulms and pods were separately analysed.

# *Results*

## RESULTS

The biometric and chemical analysis of the plant and soil samples under study were subjected to statistical analysis and the results are given below. The mean values are presented in Table 2 to 34. The analysis of variance is given in Appendix II to XVI. The economics of nitrogen, phosphorus and potassium application is given in Table 35.

### I Growth Characters

1. Height of Plants.

The observation on height of plants recorded on the 40th day after germination were analysed and the mean values are presented in Table 2 and the analysis of variance in Appendix II.

There were significant differences in the height of plants due to different levels of nitrogen. The height was increased significantly and progressively with higher doses of nitrogen upto 30 kg per hectare. The mean height of the plants due to $n_0$, $n_1$ and $n_2$ levels of nitrogen were 105.04, 145.44 and 182.61 cm respectively.

The effect of phosphorus and potassium levels on the

Table 2

Height of the plant on 40th day after germination (cm)

| | | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 30 | 60 | 90 | Mean |
| N Kg/ha | 0 | 91.72 | 112.00 | 102.78 | 113.66 | 105.04 |
| | 15 | 134.44 | 138.83 | 152.83 | 155.66 | 145.44 |
| | 30 | 168.16 | 180.00 | 200.33 | 181.94 | 182.61 |
| $K_2O$ Kg/ha | 0 | 129.22 | 148.89 | 146.16 | 134.11 | 139.60 |
| | 30 | 121.39 | 126.89 | 161.05 | 156.33 | 141.42 |
| | 60 | 143.72 | 155.05 | 148.72 | 160.83 | 152.08 |
| Mean | | 131.44 | 143.62 | 151.98 | 150.42 | |

C.D.(0.05) for N = 25.420

$S.E._M$ for K = 8.924

$S.E._M$ for P = 10.306

$S.E._M$ for NP or PK = 17.850

height of plants were not found significant. The interactions of nitrogen and phosphorus, and phosphorus and potassium were also not significant.

2. Number of leaves.

The observations on number of leaves per plant were recorded on 50th, 80th and 110th day after germination and at harvest. The data were analysed separately and the mean values are presented in Table 3(a) to 3(d). The analysis of variance is given in Appendix III.

The effect of nitrogen on the number of leaves produced at all the successive stages of observation were found to be significant. Application of 15 and 30 kg nitrogen per hectare were found to be significantly superior to control and were on par at all stages of observation except on 80th day.

Phosphorus and potassium levels did not show any marked influence on leaf production of winged bean on all the observations. The interaction effects between nitrogen and phosphorus, and phosphorus and potassium were also not significant.

Table 3 (a)

Number of leaves on 50th day after germination

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 21.55 | 42.27 | 26.72 | 25.44 | 29.00 |
| 15 | 33.22 | 32.94 | 34.66 | 37.61 | 34.62 |
| 30 | 36.05 | 39.61 | 43.05 | 41.16 | 39.97 |
| $K_2O$ kg/ha | | | | | |
| 0 | 31.72 | 33.05 | 36.94 | 38.61 | 35.08 |
| 30 | 31.11 | 46.22 | 31.72 | 34.16 | 35.80 |
| 60 | 28.00 | 35.55 | 35.77 | 31.44 | 32.69 |
| Mean | 30.28 | 38.27 | 34.81 | 34.74 | |

C.D.(0.05) for N = 5.485
$S.E._M$ for K = 1.926
$S.E._M$ for P = 2.224
$S.E._M$ for NP or PK = 3.852

Table 3 (b)

Number of leaves on 80th day after germination

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 50.17 | 74.61 | 60.87 | 58.11 | 60.94 |
| 15 | 67.61 | 72.44 | 82.44 | 76.78 | 74.90 |
| 30 | 88.22 | 75.61 | 104.00 | 93.05 | 90.22 |
| $K_2O$ kg/ha | | | | | |
| 0 | 71.78 | 61.22 | 88.72 | 80.50 | 75.56 |
| 30 | 69.66 | 88.11 | 68.61 | 79.83 | 76.55 |
| 60 | 64.55 | 73.33 | 90.33 | 67.61 | 73.96 |
| Mean | 68.66 | 74.22 | 82.55 | 75.98 | |

C.D.(0.05) for N = 13.065
$S.E._M$ for K = 4.587
$S.E._M$ for P = 5.297
$S.E._M$ for NP or PK = 9.174

Table 3(c)

Number of leaves on 110th day after germination

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 83.94 | 97.16 | 109.28 | 104.83 | 98.80 |
| 15 | 122.39 | 137.17 | 148.06 | 131.16 | 134.70 |
| 30 | 133.94 | 142.66 | 154.0 | 140.61 | 142.80 |
| $K_2O$ kg/ha | | | | | |
| 0 | 110.61 | 95.94 | 133.28 | 115.16 | 113.75 |
| 30 | 113.33 | 136.39 | 127.11 | 138.0 | 128.71 |
| 60 | 116.33 | 144.67 | 150.94 | 123.44 | 133.85 |
| Mean | 113.42 | 125.67 | 137.11 | 125.53 | |

C.D.(0.05) for N = 28.326
$S.E._M$ for K = 9.945
$S.E._M$ for P = 11.484
$S.E._M$ for NP or PK = 19.891

Table 3(d)

Number of leaves at the time of final harvest

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 133.83 | 166.83 | 167.50 | 151.83 | 155.00 |
| 15 | 178.66 | 184.05 | 208.61 | 183.11 | 188.61 |
| 30 | 183.27 | 199.44 | 245.28 | 211.89 | 208.97 |
| $K_2O$ kg/ha | | | | | |
| 0 | 155.00 | 151.28 | 216.61 | 182.39 | 176.32 |
| 30 | 172.22 | 205.16 | 215.44 | 186.94 | 194.94 |
| 60 | 169.50 | 193.89 | 189.39 | 177.50 | 182.32 |
| Mean | 165.24 | 183.44 | 207.15 | 182.28 | |

C.D.(0.05) for N = 25.688
$S.E._M$ for K = 9.019
$S.E._M$ for P = 10.414
$S.E._M$ for NP or PK = 18.038

3. <u>Number of branches</u>.

Data on the mean number of branches per plant are presented in Table 4(a) to 4(d) and the analysis of variance is given in Appendix IV.

In the case of nitrogen 15 kg level per hectare gave significantly higher number of branches per plant than zero level. However the higher levels were on par except at the final stage of harvest where 30 kg nitrogen per hectare was significantly superior to 15 kg nitrogen. In general, higher the levels of nitrogen higher the number of branches produced.

The effects of phosphorus and potassium were not significant. The interaction effects were also not significant in all the stages.

4. <u>Number of days for 50 per cent flowering</u>.

Number of days taken for attaining 50 per cent flowering in the 12 number of net plants were subjected to statistical analysis and the mean values are presented in Table 5 and the analysis of variance is given in Appendix V.

It can be seen from the table that nitrogen levels had significantly induced earliness in flowering over zero level

## Table 4(a)

Number of branches on 50th day after germination

| | $P_2O_5$ Kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 3.166 | 3.666 | 4.166 | 3.666 | 3.666 |
| 15 | 5.111 | 5.166 | 6.000 | 6.553 | 5.709 |
| 30 | 5.666 | 6.444 | 6.444 | 5.944 | 6.125 |
| $K_2O$ kg/ha | | | | | |
| 0 | 5.444 | 4.566 | 6.166 | 4.611 | 5.222 |
| 30 | 4.500 | 4.500 | 4.444 | 5.495 | 4.735 |
| 60 | 4.00 | 6.11 | 6.000 | 6.055 | 5.542 |
| Mean | 4.648 | 5.092 | 5.557 | 5.387 | |

C.D.(0.05) for N = 1.066

$S.E._M$ for K = 0.374

$S.E._M$ for P = 0.432

$S.E._M$ for NP or PK = 0.748

## Table 4(b)

Number of branches on 80th day after germination

| | $P_2O_5$ Kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 7.333 | 10.833 | 6.555 | 6.883 | 7.889 |
| 15 | 10.389 | 7.611 | 11.888 | 10.444 | 10.083 |
| 30 | 11.000 | 10.944 | 15.000 | 11.000 | 11.986 |
| $K_2O$ kg/ha | | | | | |
| 0 | 9.722 | 7.50 | 13.444 | 9.055 | 9.930 |
| 30 | 10.833 | 12.222 | 7.889 | 9.278 | 10.056 |
| 60 | 8.166 | 9.666 | 12.111 | 9.944 | 9.972 |
| Mean | 9.574 | 9.796 | 11.148 | 9.426 | |

C.D.(0.05) for N = 2.382

$S.E._M$ for K = 0.836

$S.E._M$ for P = 0.966

$S.E._M$ for NP or PK = 1.672

## Table 4(c)

Number of branches on 110th day after germination

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 10.278 | 18.111 | 14.166 | 12.388 | 12.486 |
| 15 | 13.833 | 16.611 | 18.222 | 16.556 | 16.306 |
| 30 | 16.388 | 17.056 | 19.000 | 18.111 | 17.639 |
| $K_2O$ kg/ha | | | | | |
| 0 | 13.333 | 11.333 | 17.888 | 15.222 | 14.444 |
| 30 | 14.611 | 16.333 | 16.277 | 17.333 | 16.139 |
| 60 | 12.555 | 19.111 | 17.222 | 14.500 | 15.847 |
| Mean | 13.500 | 15.592 | 17.129 | 15.685 | |

C.D.(0.05) for N = 2.539

$S.E._M$ for K = 0.891

$S.E._M$ for P = 1.029

$S.E._M$ for NP or PK = 1.783

## Table 4(d)

Number of branches at final harvest

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 14.111 | 16.339 | 18.055 | 14.166 | 15.680 |
| 15 | 18.000 | 17.555 | 20.444 | 19.389 | 18.847 |
| 30 | 21.278 | 19.777 | 25.500 | 20.333 | 21.722 |
| $K_2O$ kg/ha | | | | | |
| 0 | 16.055 | 14.555 | 23.278 | 18.166 | 18.014 |
| 30 | 19.944 | 20.278 | 19.833 | 18.444 | 19.625 |
| 60 | 17.389 | 18.889 | 20.889 | 17.278 | 18.611 |
| Mean | 17.796 | 17.097 | 21.333 | 17.963 | |

C.D.(0.05) for N = 2.547

$S.E._M$ for K = 0.894

$S.E._M$ for P = 1.032

$S.E._M$ for NP or PK = 1.788

wherein 50 per cent flowering was achieved 6 days ahead to that of the control. The $n_1$ and $n_2$ levels were not found to be significant over each other.

It was further observed that both phosphorus and potassium had no significant influence in the time taken for attaining 50 per cent flowering in winged beans. The interaction effects were also not found to be significant.

5. <u>Number of flowers produced.</u>

The mean values of number of flowers produced per plant are shown in Table 6 and the analysis of variance is given in Appendix VI.

The total number of flowers produced per plant was on the increase at all stages and also in the total counts. It was found that the effect of levels of nitrogen was significantly superior to each other; the highest nitrogen level (ie. 30 kg nitrogen per hectare) had produced a mean number of 277.23 flowers per plant, while $N_1$ and $N_0$ levels (15 kg and 0 kg per hectare) had produced only 236.92 and 193.58 flowers per plant respectively.

Table 5

Number of days taken for 50% flowering

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 68.00 | 62.11 | 62.94 | 65.22 | 65.47 |
| 15 | 61.55 | 59.55 | 60.16 | 56.61 | 59.47 |
| 30 | 61.05 | 60.83 | 60.28 | 56.16 | 59.98 |
| $K_2O$ kg/ha | | | | | |
| 0 | 62.11 | 59.00 | 59.39 | 59.61 | 60.03 |
| 30 | 60.83 | 61.61 | 60.39 | 59.28 | 60.32 |
| 60 | 67.66 | 61.85 | 63.61 | 59.11 | 63.07 |
| Mean | 63.53 | 60.83 | 61.13 | 59.33 | |

C.D.(0.05) for N = 2.906

$S.E._M$ for K = 1.020

$S.E._M$ for P = 1.178

$S.E._M$ for NP or PK = 2.040

The number of flowers produced per plant was not found to be influenced by either P or K levels.

However nitrogen-phosphorus interaction was found to be significant at higher levels in maximising flower production. The maximum number of flowers (292.61) was produced by the combination $n_2p_3$ (30 kg N and 90 kg $P_2O_5$ per hectare) while $n_0p_0$ had produced only 168.55 flowers per plant. Phosphorus-potassium interaction was not found to be significant.

6. Number of pods per plant.

The mean values on the number of pods produced per plant are furnished on Table 7 and the analysis of variance in Appendix VI.

Application of 30 kg nitrogen per hectare recorded the maximum number of pods. However the increase was not statistically significant over the $n_1$ level, though both were superior to zero level. The maximum pods produced per plant for $n_0$, $n_1$ and $n_2$ levels of nitrogen per hectare were 61.61, 74.91 and 85.55 respectively. No significant effect on the number of pods per plant was noticed in the case of P and K levels used in this investigation.

Table 6

Number of flowers per plant

| | $P_2O_5$ Kg/ha 0 | 30 | 60 | 90 | Mean |
|---|---|---|---|---|---|
| N kg/ha | | | | | |
| 0 | 168.55 | 226.11 | 209.89 | 169.77 | 193.58 |
| 15 | 212,11 | 198.22 | 259.78 | 277.55 | 236.92 |
| 30 | 286.22 | 250.44 | 279.66 | 292.61 | 277.23 |
| $K_2O$ kg/ha | | | | | |
| 0 | 208.83 | 232.05 | 241.39 | 234.05 | 229.08 |
| 30 | 237 .05 | 193.94 | 268.55 | 244.16 | 235.93 |
| 60 | 221 .0 | 248.78 | 239.39 | 261.72 | 242.72 |
| Mean | 222.29 | 224.92 | 249.78 | 246.64 | |

C.D.(0.05) for N = 29.270

$S.E._M$ for K = 10.276

$S.E._M$ for P = 11.866

$S.E._M$ for PK = 20.553

C.D.(0.05) for NP = 58.542

Table 7

Number of pods per plant

| | $P_2O_5$ Kg/ha 0 | 30 | 60 | 90 | Mean |
|---|---|---|---|---|---|
| N kg/ha | | | | | |
| 0 | 45.33 | 77.16 | 72.78 | 51.11 | 61.61 |
| 15 | 71.33 | 57.94 | 88.61 | 81.77 | 74.91 |
| 30 | 87.67 | 74.01 | 91.27 | 89.27 | 85.55 |
| $K_2O$ kg/ha | | | | | |
| 0 | 69.83 | 54.28 | 76.33 | 72.89 | 68.33 |
| 30 | 69.83 | 73.72 | 97.50 | 81.44 | 80.62 |
| 60 | 64.66 | 81.11 | 78.83 | 67.83 | 73.11 |
| Mean | 68.11 | 69.71 | 84.22 | 74.05 | |

C.D.(0.05) for N = 11.30

$S.E._M$ for K = 3.068

$S.E._M$ for P = 4.582

$S.E._M$ for PK = 7.936

C.D. (0.05) for NP = 22.601

Among the treatment combinations np interaction alone was found to be significant.

7. Setting percentage.

The mean values on percentage of setting are given in Table 8. and the analysis of variance in Appendix VI.

There was no significant difference in the setting percentage either due to individual effects of different nutrients or their interactions.

8. Length of pods.

The data regarding the length of pods under various treatments were analysed and the mean length of pods corresponding to different treatment is given in Table 9. and the analysis of variance in Appendix VII.

Higher levels of nitrogen had significantly increased the length of pods. Application of nitrogen at the levels of 15 kg and 30 kg per hectare had significant influence over control but was found to be on par with each other. However as the level of nitrogen increased from $N_1$ to $N_2$ the length was decreased slightly.

Table 8
Setting percentage of pods

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 26.26 | 27.16 | 35.17 | 29.74 | 29.58 |
| 15 | 33.44 | 28.84 | 34.93 | 29.47 | 31.67 |
| 30 | 30.99 | 30.89 | 32.07 | 30.45 | 31.10 |
| $K_2O$ kg/ha | | | | | |
| 0 | 32.44 | 22.72 | 31.91 | 30.38 | 29.36 |
| 30 | 28.68 | 30.69 | 36.94 | 32.69 | 32.25 |
| 60 | 29.57 | 33.48 | 33.32 | 26.60 | 30.74 |
| Mean | 30.23 | 28.96 | 34.06 | 29.89 | |

$S.E._M$ for N or K = 1.593

$S.E._M$ for P = 1.839

$S.E._M$ for NP or PK = 3.185

Table 9
Length of pods (cm)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 16.60 | 16.83 | 16.49 | 16.33 | 16.54 |
| 15 | 16.90 | 16.98 | 17.56 | 16.88 | 17.08 |
| 30 | 17.04 | 16.80 | 16.70 | 17.37 | 16.98 |
| $K_2O$ kg/ha | | | | | |
| 0 | 16.13 | 15.98 | 16.00 | 16.48 | 16.15 |
| 30 | 17.04 | 17.32 | 17.13 | 17.15 | 17.16 |
| 60 | 17.27 | 17.32 | 17.61 | 16.92 | 17.28 |
| Mean | 16.81 | 16.87 | 16.91 | 16.85 | |

C.D.(0.05) for N or K = 0.308

$S.E._M$ for P = 0.125

$S.E._M$ for PK = 0.216

C.D. (0.05) for NP = 0.616

The data further showed that the length of pods was not significantly influenced by phosphorus levels.

But higher levels of potassium significantly increased the length of pods. Maximum length of 17.28 cm was recorded by the application of 60 kg $K_2O$ per hectare and was on par with 30 kg $K_2O$ per hectare.

Among the interaction np interaction was found to be significant. The maximum length of 17.56 cm was recorded by $n_1p_2$ interaction (15 kg N and 60 kg $P_2O_5$ per hectare). However pk interaction was not significant.

9. <u>Yield of green pods per plant</u>.

The yield of green pods obtained from the 17 harvests were grouped into four according to the number of pluckings per month (1 to 5, 6 to 9, 10 to 13 and 14-17) so as to arrive the monthly yield per plant. They were analysed separately and the mean values are presented in Tables 10(a) to 10(d) and the analysis of variance in Appendix VIII. The total yield per plant from all the harvests were analysed and the mean yield presented in Table 10(e) and the analysis of variance in

Appendix VIII. The yield per hectare was computed and was analysed and the mean yield in kg per hectare is presented in Table 10(f) and analysis of variance in Appendix VIII.

From the data analysed it was found that the yield obtained in the first month grouped as 1 (1-5 harvest) with levels of nitrogen significantly increased the yield. The levels of 15 kg and 30 kg nitrogen per hectare significantly increased the yield over control, but not found to be significantly superior to one another. Phosphorus and potassium levels and the interactions were not found to be significant.

In the case of second grouping (the harvest from 6 to 9) ie. during the second month of harvest application of nitrogen at the rate of 30 kg per hectare produced the highest yield though it was found to be on par with its immediate lower level. However both $n_1$ and $n_2$ levels showed significant yield increase over the control.

With regard to phosphorus 60 and 90 kg $P_2O_5$ per hectare significantly increased pod yield over 30 and zero level of $P_2O_5$ per hectare. However, 60 and 90 kg $P_2O_5$ per hectare were

## Table 10(a)

Yield of green pods per plant for the first month (harvest number 1-5)

(g/plant)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 45.28 | 81.53 | 88.71 | 75.1 | 67.66 |
| 15 | 79.29 | 83.54 | 131.60 | 108.40 | 105.21 |
| 30 | 128.13 | 117.5 | 150.00 | 125.72 | 130.34 |
| $K_2O$ kg/ha | | | | | |
| 0 | 94.65 | 95.70 | 106.89 | 110.03 | 101.82 |
| 30 | 88.06 | 85.83 | 126.18 | 113.13 | 103.3 |
| 60 | 87.99 | 101.04 | 117.25 | 86.07 | 98.09 |
| Mean | 90.23 | 94.19 | 116.77 | 103.08 | |

C.D.(0.05) for N = 33.374

$S.E._M$ for K = 11.717

$S.E._M$ for P = 13.530

$S.E._M$ for NP or PK = 23.435

## Table 10(b)

Yield of green pods per plant for the second month (harvest number 6-9)

(g/plant)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 131.95 | 175.63 | 243.47 | 165.67 | 179.18 |
| 15 | 210.79 | 220.42 | 276.11 | 248.06 | 238.85 |
| 30 | 223.68 | 202.57 | 276.39 | 321.74 | 256.10 |
| $K_2O$ kg/ha | | | | | |
| 0 | 203.82 | 144.24 | 228.33 | 263.79 | 210.05 |
| 30 | 189.86 | 181.39 | 322.43 | 300.28 | 248.49 |
| 60 | 172.74 | 272.99 | 254.21 | 171.39 | 215.58 |
| Mean | 188.81 | 199.54 | 265.32 | 245.15 | |

C.D.(0.05) for N = 42.782

C.D.(0.05) for P = 49.400

C.D.(0.05) for PK = 85.563

$S.E._M$ for K = 15.020

$S.E._M$ for NP = 30.041

on par. Application of potassium had no significant effect on the yield of green pods. The interaction between phosphorus and potassium was significant and the maximum yield was noted in the interaction of 60 kg $P_2O_5$ and 30 kg $K_2O$ per hectare.

In the third month (10-13 harvests) also nitrogen, phosphorus and pk interaction had significantly influenced the yield. Application of 30 kg nitrogen per hectare was found to produce maximum yield of green pods which was on par with 15 kg nitrogen per hectare. The level of 60 kg $P_2O_5$ per hectare recorded the maximum yield and was significantly superior to its lower level. Phosphorus-potassium interaction was significant and the maximum yield was noted in $P_3K_1$ interaction viz.90 kg $P_2O_5$ and 30 kg $K_2O$ per hectare.

In the fourth group ie. harvest from (14-17) it was found that all the individual nutrients N, P and K and the interaction pk were significantly affecting the yield of green pods. The level of 15 kg nitrogen per hectare gave significantly higher yield over zero level and was on par with 30 kg nitrogen per hectare. The maximum yield of green pods was produced by 60 kg $P_2O_5$ per hectare and it was significantly superior to all the other levels. The effect of potassium was also significant

Table 10 (c)

Yield of green pods per plant for the 3rd month (harvest number 10-13)

(g/plant)

| | $P_2O_5$ kg/ha 0 | 30 | 60 | 90 | Mean |
|---|---|---|---|---|---|
| N kg/ha | | | | | |
| 0 | 146.81 | 207.79 | 230.42 | 206.46 | 198.37 |
| 15 | 217.78 | 199.10 | 375.63 | 286.67 | 269.80 |
| 30 | 265.0 | 256.11 | 267.15 | 300.70 | 272.24 |
| $K_2O$ kg/ha | | | | | |
| 0 | 195.21 | 165.56 | 301.74 | 256.53 | 229.76 |
| 30 | 248.20 | 196.60 | 287.92 | 307.85 | 260.14 |
| 60 | 196.18 | 302.85 | 283.54 | 229.45 | 250.51 |
| Mean | 209.86 | 221.67 | 291.07 | 264.61 | |

C.D.(0.05) for N = 41.867
C.D.(0.05) for P = 48.344
C.D.(0.05) for PK = 83.725
$S.E._M$ for K = 14.700
$S.E._M$ for NP = 29.399

Table 10 (d)

Yield of green pods per plant for the 4th month (harvest number 14-17)

(g/plant)

| | $P_2O_5$ kg/ha 0 | 30 | 60 | 90 | Mean |
|---|---|---|---|---|---|
| N kg/ha | | | | | |
| 0 | 104.51 | 151.81 | 166.46 | 113.89 | 134.17 |
| 15 | 173.75 | 131.95 | 229.58 | 173.82 | 177.28 |
| 30 | 160.31 | 140.70 | 208.47 | 138.89 | 162.09 |
| $K_2O$ kg/ha | | | | | |
| 0 | 131.49 | 94.63 | 158.13 | 134.72 | 129.59 |
| 30 | 162.02 | 124.93 | 222.08 | 175.97 | 171.25 |
| 60 | 145.07 | 205.49 | 224.31 | 115.90 | 172.69 |
| Mean | 146.19 | 141.48 | 201.51 | 142.20 | |

C.D.(0.05) for N or K = 29.263
C.D.(0.05) for P = 33.79
C.D.(0.05) for PK = 58.527
$S.E._M$ for NP = 20.548

and the maximum yield was obtained from the plots received 60 kg $K_2O$ per hectare though it was on par with the immediate lower level of 30 kg $K_2O$ per hectare. The np interaction was not significant while pk interaction was significant and the maximum yield of 224.31 g per plant was received from the combination of 60 kg $P_2O_5$ and 60 kg $K_2O$ per hectare.

When the total yield of green pods per plant from all the harvests was computed and analysed it was revealed that nitrogen, phosphorus and pk interactions only were significantly affecting the yield.

Nitrogen at all levels increased the yield progressively at each harvest upto the peak period of harvest in the 3rd month but the difference in yield due to the higher doses were not significant.

When the total yield of green pods per hectare from all the harvests was computed and analysed it was observed that nitrogen, phosphorus and pk interaction were significantly influencing the yield. The level of 15 kg N per hectare resulted in significantly higher yield than zero level and was on par with 30 kg per hectare. Application of 60 kg $P_2O_5$ per hectare was found significantly superior to the lower doses. pk interaction was significant and maximum yield was realised from a combination of 60 kg $P_2O_5$ and 30 kg $K_2O$ per hectare.

## Table 10 (e)

### Total yield of green pods per plant

(g)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 428.54 | 618.75 | 696.56 | 561.11 | 576.24 |
| 15 | 699.61 | 635.0 | 1012.92 | 817.64 | 791.29 |
| 30 | 778.36 | 702.99 | 902.01 | 887.04 | 817.60 |
| $K_2O$ kg/ha | | | | | |
| 0 | 625.17 | 485.63 | 795.07 | 765.07 | 667.74 |
| 30 | 688.13 | 588.75 | 946.11 | 896.53 | 779.72 |
| 60 | 593.22 | 882.36 | 870.31 | 604.20 | 737.52 |
| Mean | 635.50 | 652.25 | 870.50 | 755.26 | |

C.D.(0.05) for N = 124.439
C.D.(0.05) for P = 149.690
C.D.(0.05) for PK = 248.877

$S.E._M$ for K = 43.690
$S.E._M$ for NP = 87.380

## Table 10 (f)

### Total yield of green pods per hectare

(kg)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 5713.91 | 8249.78 | 9286.69 | 7481.49 | 7682.82 |
| 15 | 9328.13 | 8466.64 | 13503.73 | 10901.84 | 10550.08 |
| 30 | 10378.11 | 9373.13 | 12026.86 | 11827.22 | 10901.33 |
| $K_2O$ kg/ha | | | | | |
| 0 | 8335.53 | 6474.98 | 10600.96 | 10220.93 | 8903.10 |
| 30 | 9175.00 | 7849.98 | 12612.98 | 11972.20 | 10402.54 |
| 60 | 7909.62 | 11764.60 | 11602.75 | 8037.42 | 9828.60 |
| Mean | 8473.88 | 8696.52 | 11605.56 | 10070.18 | |

C.D.(0.05) for N = 1650.63
C.D.(0.05) for P = 2858.97
C.D.(0.05) for PK = 3301.25

$S.E._M$ for K = 579.528
$S.E._M$ for NP = 1159.056

10. Bhusa yield.

The mean yield of bhusa calculated in kg per hectare is presented in Table 11 and the analysis of variance in Appendix IX.

Nitrogen, potassium and the np interaction significantly increased the yield of bhusa. A total green matter yield of 3728.94 kg per hectare was obtained with 30 kg level of nitrogen per hectare which was on par with 15 kg nitrogen. Phosphorus did not affect the bhusa yield significantly. Application of 30 kg potassium per hectare resulted in a total bhusa yield of 3651.74 kg per hectare which was the second to nitrogen levels. The bhusa yield was the maximum under the combination effect of 15 kg N and 60 kg $P_2O_5$ per hectare and it was 4469.07 kg/ha.

11. Tuber yield.

The yield of tuber in kg per hectare was also computed and analysed statistically. The mean values are presented in Table 12 and the analysis of variance on Appendix IX.

It was seen that application of nutrients individually or in combination had no significant effect on the yield of tuber.

Table 11

Bhusa yield (kg/ha)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 2044.67 | 3491.31 | 2655.31 | 2521.47 | 2678.17 |
| 15 | 3571.33 | 2629.60 | 4469.07 | 3589.53 | 3563.13 |
| 30 | 3931.87 | 3812.67 | 3762.53 | 3408.67 | 3728.94 |
| $K_2O$ kg/ha | | | | | |
| 0 | 2993.33 | 2580.00 | 3433.20 | 2767.86 | 2949.60 |
| 30 | 3562.93 | 3772.53 | 3486.66 | 3785.33 | 3651.74 |
| 60 | 2991.60 | 3580.80 | 3967.60 | 2959.33 | 3374.83 |
| Mean | 3188.65 | 3311.15 | 3628.95 | 3170.88 | |

C.D. (0.05) for N or K = 470.74

C.D.(0.05) for NP = 941.48

$S.E._M$ for P = 190.84

$S.E._M$ for PK = 330.55

Table 12

Tuber yield(kg/ha)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 755.33 | 886.93 | 818.40 | 671.33 | 758.00 |
| 15 | 836.00 | 911.33 | 1145.87 | 819.73 | 928.23 |
| 30 | 780.80 | 730.53 | 1026.93 | 1037.87 | 894.03 |
| $K_2O$ kg/ha | | | | | |
| 0 | 632.80 | 711.07 | 812.80 | 982.53 | 859.80 |
| 30 | 782.46 | 934.00 | 882.13 | 848.00 | 861.63 |
| 60 | 757.07 | 883.60 | 1196.40 | 598.53 | 858.90 |
| Mean | 790.70 | 842.93 | 997.09 | 809.66 | |

$S.E._M$ for N or K = 57.67

$S.E._M$ for P = 66.59

$S.E._M$ for NP or PK = 115.34

12. Harvest index.

The mean values of the harvest index are presented in Table 13 and the analysis of variance in Appendix X.

Neither the individual effect of nitrogen, phosphorus and potassium nor their interactions was found to influence the harvest index significantly.

13. Total dry matter production.

The data on the total dry matter production in kg per hectare was analysed statistically and the mean values in kg per hectare are presented in Table 14 and the analysis of variance in Appendix X.

Higher rates of nitrogen application had significant effect in increasing the dry matter production. Though application of 30 kg nitrogen per hectare produced the maximum dry matter yield of 2622.39 kg per hectare it was on par with 15 kg nitrogen which produced 2411.59 kg of dry matter yield per hectare.

Phosphorus had significant effect in increasing the dry matter production. A maximum dry matter yield of 2643.59 kg

Table 13

Harvest index(%)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 65.83 | 65.12 | 72.42 | 68.52 | 67.98 |
| 15 | 67.90 | 66.94 | 68.37 | 70.17 | 68.35 |
| 30 | 67.78 | 65.10 | 68.31 | 71.32 | 68.13 |
| $K_2O$ kg/ha | | | | | |
| 0 | 67.44 | 63.55 | 68.93 | 70.79 | 67.68 |
| 30 | 66.68 | 62.84 | 73.02 | 70.57 | 68.28 |
| 60 | 67.40 | 70.78 | 67.16 | 68.66 | 68.50 |
| Mean | 67.17 | 65.72 | 69.70 | 70.01 | |

$S.E._M$ for N or K = 1.293

$S.E._M$ for P = 1.499

$S.E._M$ for NP or PK = 2.596

Table 14

Total dry matter production (kg/ha)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 1544.33 | 2286.76 | 2101.31 | 1746.47 | 1920.23 |
| 15 | 2413.00 | 1972.31 | 2859.58 | 2401.45 | 2411.59 |
| 30 | 2491.60 | 2403.91 | 2969.89 | 2624.16 | 2622.39 |
| $K_2O$ kg/ha | | | | | |
| 0 | 2228.36 | 1763.40 | 2680.82 | 2295.47 | 2227.01 |
| 30 | 2365.82 | 2273.36 | 2676.84 | 2532.80 | 2462.21 |
| 60 | 1854.76 | 2628.22 | 2633.11 | 1943.80 | 2264.97 |
| Mean | 2149.64 | 2221.66 | 2643.59 | 2257.36 | |

C.D.(0.05) for N = 239.74

C.D.(0.05) for P = 276.83

C.D.(0.05) for PK = 479.49

$S.E._M$ for K = 84.17

$S.E._M$ for NP = 168.35

per hectare was obtained with the level of 60 kg $P_2O_5$ per hectare and this was significantly superior to all other phosphorus levels.

The effect of potassium in increasing the dry matter production was the least and was not significant. The interaction effects were also not significant.

II Quality Characters

(a) Protein content of tender pods.

The pods matured optimum for vegetable purpose were analysed for protein and the analysis of variance is given in Appendix XI and the mean values in Table 15. It was observed that neither the individual nutrients nor their interactions had any significant effect on the protein content of pods.

(b) Protein content of tuber.

The data on the protein content of tuber was statistically analysed and the mean values are given in Table 16 and the analysis of variance in Appendix XI.

It was noted that nitrogen, phosphorus, and pk interaction had significant effect in increasing the protein content of tuber. Application of 15 kg nitrogen per hectare resulted in the maximum protein content which was on par with the highest

Table 15

Protein content of tender pods (percentage)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 20.7[illegible]7 | 21.0[illegible]1. | 21.007 | 20.872 | 20.902 |
| 15 | 20.293 | 21.143 | 21.715 | 21.152 | 21.076 |
| 30 | 20.72 | 20.448 | 20.303 | 21.573 | 20.761 |
| $K_2O$ kg/ha | | | | | |
| 0 | 20.573 | 21.018 | 20.585 | 21.582 | 20.940 |
| 30 | 21.435 | 20.72 | 21.29 | 21.008 | 21.113 |
| 60 | 19.722 | 20.865 | 21.15 | 21.007 | 20.686 |
| Mean | 20.977 | 20.868 | 21.008 | 21.199 | |

$S.E._M$ for N or K = 0.314

$S.E._M$ for P = 0.363

$S.E._M$ for NP or PK = 0.628

Table 16

Protein content of tuber(percentage)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 18.990 | 18.719 | 17.719 | 19.156 | 18.646 |
| 15 | 21.854 | 18.719 | 16.583 | 21.427 | 20.146 |
| 30 | 20.573 | 18.427 | 17.708 | 20.278 | 19.247 |
| $K_2O$ kg/ha | | | | | |
| 0 | 19.844 | 18.573 | 17.583 | 21.146 | 19.287 |
| 30 | 21.573 | 17.854 | 17.708 | 21.146 | 19.570 |
| 60 | 20.0 | 19.438 | 18.719 | 18.573 | 19.18 |
| Mean | 20.472 | 18.622 | 18.004 | 20.278 | |

C.D.(0.05) for N = 1.071

C.D.(0.050) for P = 1.237

C.D.(0.05) for PK = 2.143

$S.E._M$ for K = 0.376

$S.E._M$ for NP = 0.752

level of 30 kg nitrogen per hectare. Application of 90 kg $P_2O_5$ per hectare gave a protein content of 20.288 per cent which was significantly superior to 30 and 60 kg $P_2O_5$ per hectare. Potassium had no effect on the protein content of tubers.

### III Uptake Studies

(a) Uptake of nitrogen.

The mean values on the uptake of nitrogen due to application of NPK at different levels on the soil are presented in Table 17 and the analysis of variance in Appendix XII.

The effect of nitrogen, phosphorus and pk interaction were found to influence the uptake of nitrogen signficantly. Nitrogen at 30 kg per hectare recorded an uptake of 76.614 kg nitrogen per hectare, which was on par with its immediate lower level but both were significantly superior to the lowest level of nitrogen. Phosphorus at 60 kg $P_2O_5$ per hectare recorded a higher uptake of 78.892 kg of nitrogen per hectare which was significantly superior to all other levels of phosphorus. Potassium by itself has not influenced nitrogen uptake. Of the interactions np interaction had remarkable effect on the uptake of nitrogen but phosphorus-potassium interaction was significant and the maximum uptake of 85.456 kg nitrogen per hectare was obtained by a combination of 60 kg $P_2O_5$ and 30 kg $K_2O$ per hectare.

(b) Uptake of phosphorus.

The uptake of phosphorus by the plant was also analysed statistically and the mean values are presented in Table 18 and the analysis of variance in Appendix XII.

Significant increase in the uptake of phosphorus was noted by the application of nitrogen and phosphorus. As the nitrogen level has increased from zero to 15 kg and from 15 to 30 kg hectare, the uptake rates of P was significantly higher over one another. Application of 60 kg phosphorus per hectare resulted in the maximum uptake of 18.352 kg $P_2O_5$ per hectare which was significantly superior to all other levels. Potassium application and the interaction effects were not found to have significant influence in the uptake of phosphorus.

Table 17

Uptake of nitrogen(kg/ha)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 43.045 | 59.422 | 66.511 | 50.067 | 54.761 |
| 15 | 69.778 | 56.427 | 84.222 | 72.200 | 70.657 |
| 30 | 72.711 | 67.866 | 85.944 | 79.939 | 76.614 |
| $K_2O$ kg/ha | | | | | |
| 0 | 65.556 | 50.756 | 75.711 | 70.822 | 65.711 |
| 30 | 68.956 | 56.956 | 85.456 | 75.267 | 71.659 |
| 60 | 51.022 | 76.004 | 75.511 | 56.111 | 64.662 |
| Mean | 61.844 | 61.24 | 79.893 | 67.400 | |

C.D.(0.05) for N = 7.463

C.D.(0.05) for P = 8.617

C.D.(0.050) for PK = 14.926

$S.E._M$ for K = 2.620

$S.E._M$ for NP = 5.240

Table 18

Uptake of phosphorus($P_2O_5$-kg/ha)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 11.080 | 14.475. | 15.132 | 11.200 | 12.971 |
| 15 | 15.678 | 13.014 | 18.536 | 14.602 | 15.457 |
| 30 | 17.967 | 15.131 | 21.387 | 18.832 | 18.329 |
| $K_2O$ kg/ha | | | | | |
| 0 | 15.809 | 11.502 | 18.603 | 16.129 | 15.511 |
| 30 | 16.299 | 14.541 | 19.503 | 16.035 | 16.594 |
| 60 | 12.617 | 16.576 | 16.949 | 12.470 | 14.653 |
| Mean | 14.908 | 14.207 | 18.352 | 14.878 | |

C.D.(0.05) for N = 1.952

C.D.(0.05) for P = 2.254

$S.E._M$ for K = 0.685

$S.E._M$ for NP or PK = 1.371

(c) Uptake of potassium

The mean values on the uptake of potassium are presented in Table 19 and the analysis of variance in Appendix XIIc.

Application of nitrogen and potassium gave significant increase in the uptake of potassium. Nitrogen at the rate of 30 kg per hectare was found to result in a comparatively higher uptake of 61.826 kg $K_2O$ per hectare which was however on par with its immediate lower levels viz. 15 kg and both levels were superior to the zero level. Application of 30 kg $K_2O$ per hectare gave a maximum uptake of 64.743 kg $K_2O$ per hectare and was on par with the level of 60 kg per hectare. Phosphorus by itself and the interaction effect of N, P and K had no significant influence in the uptake of potassium.

## IV NPK content in Plant Parts

(a) Nitrogen content in pods.

The data on the nitrogen content of pods were analysed and the mean values are presented in Table 20 and the analysis of variance in Appendix XIII.

It was seen that neither the individual nor the

## Table 19

Uptake of Potassium

($K_2O$ - kg/ha)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 40.901 | 62.291 | 54.648 | 40.923 | 49.691 |
| 15 | 63.944 | 50.648 | 66.844 | 61.637 | 60.768 |
| 30 | 63.659 | 58.638 | 68.002 | 57.007 | 61.826 |
| $K_2O$ kg/ha | | | | | |
| 0 | 51.465 | 41.308 | 61.648 | 46.111 | 50.133 |
| 30 | 64.594 | 60.869 | 67.073 | 66.434 | 64.743 |
| 60 | 52.445 | 69.400 | 60.773 | 47.022 | 57.410 |
| Mean | 56.168 | 57.192 | 63.165 | 53.189 | |

C.D.(0.05) for N and K = 8.181

$S.E._m$ for P = 3.317

$S.E._m$ for NP or PK = 5.745

interaction effect of nutrients had significantly influenced the nitrogen content of pods..

6. <u>Nitrogen content in tuber</u>.

The analysis of variance is presented in Appendix XIII and the mean values in Table 21

Nitrogen, phosphorus and pk interaction had significant effect in increasing the nitrogen content of tubor. The nitrogen content of tuber was 3.223 per cent due to 15 kg nitrogen per hectare which was on par with 30 kg nitrogen per hectare and both were superior to the zero level. Phosphorus at the rate of 90 kg per hectare gave 3.246 per cent nitrogen in the tuber which was superior to 30 and 60 kg $P_2O_5$ per hectare. Potassium and np interaction had no significant effect in influencing the nitrogen content of tuber.

(c) <u>Nitrogen content in leaf</u>.

The mean values on the nitrogen content of leaves are given in Table 22 and the analysis of variance in Appendix XIII.

Neither the individual effect nor the interaction effect of nutrients had significantly influenced the nitrogen content of leaves.

Table 20

Nitrogen content in pods

(Percentage of N)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 3.315 | 3.362 | 3.362 | 3.34 | 3.345 |
| 15 | 3.247 | 3.383 | 3.475 | 3.385 | 3.373 |
| 30 | 3.315 | 3.272 | 3.248 | 3.452 | 3.322 |
| $K_2O$ kg/ha | | | | | |
| 0 | 3.292 | 3.363 | 3.293 | 3.453 | 3.350 |
| 30 | 3.43 | 3.315 | 3.407 | 3.362 | 3.378 |
| 60 | 3.155 | 3.333 | 3.385 | 3.362 | 3.310 |
| Mean | 3.292 | 3.339 | 3.362 | 3.392 | |

$S.E._M$ for N or K = 0.0500
$S.E._M$ for P = 0.0580
$S.E._M$ for NP or PK = 0.1010

Table 21

Nitrogen content in Tuber

(Percentage of N)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 3.038 | 2.995 | 2.835 | 3.065 | 2.983 |
| 15 | 3.497 | 2.995 | 2.973 | 3.428 | 3.223 |
| 30 | 3.292 | 2.948 | 2.833 | 3.245 | 3.080 |
| $K_2O$ kg/ha | | | | | |
| 0 | 3.175 | 2.972 | 2.813 | 3.383 | 3.086 |
| 30 | 3.452 | 2.857 | 2.833 | 3.383 | 3.131 |
| 60 | 3.200 | 3.11 | 2.995 | 2.972 | 3.070 |
| Mean | 3.276 | 2.980 | 2.880 | 3.246 | |

C.D.(0.05) for N = 0.172
C.D.(0.05) for P = 0.179
C.D.(0.05) for PK = 0.344
$S.E._M$ for K ± 0.0604
$S.E._M$ for NP = 0.1208

(d) Nitrogen content in haulms.

The data on the nitrogen content in haulms were analysed and the mean values are presented in Table 23 and the analysis of variance in Appendix XIII.

Potassium and nitrogen-phosphorus interaction had significantly influenced the nitrogen content of haulms. The potassium at the rate of 30 kg per hectare resulted in the maximum content of nitrogen in the haulms which was on par with its lower levels. However the dose of 60 kg $K_2O$ per hectare showed a significant decrease in the nitrogen content of haulms.

(e) Phosphorus content in pods.

The mean values of Phosphorus content in pods are presented in Table 24 and the analysis of variance in Appendix XIV.

Neither the individual nor the interaction effect of nutrients were found to be significant in increasing the phosphorus content in pods.

(f) Phosphorus content in tuber.

The data on the phosphorus content in tuber were statistically analysed and the analysis of variance is given in Appendix XIV and the mean values in Table 25.

Table 22

Nitrogen content in leaves

(percentage of N)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 3.178 | 3.477 | 3.292 | 3.178 | 3.231 |
| 15 | 3.702 | 3.315 | 3.408 | 3.475 | 3.475 |
| 30 | 2.995 | 3.362 | 3.317 | 3.202 | 3.219 |
| $K_2O$ kg/ha | | | | | |
| 0 | 3.132 | 3.545 | 3.407 | 3.383 | 3.367 |
| 30 | 3.383 | 3.065 | 3.225 | 3.453 | 3.282 |
| 60 | 3.360 | 3.543 | 3.385 | 3.018 | 3.327 |
| Mean | 3.292 | 3.384 | 3.338 | 3.285 | |

$S.E._M$ for N or K = 0.0846

$S.E._M$ for P = 0.0977

$S.E._M$ for NP or PK = 0.1692

Table 23

Nitrogen content in haulm

(percentage of N)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0. | 1.828 | 2.218 | 2.583 | 2.218 | 2.212 |
| 15 | 2.103 | 2.173 | 1.92 | 2.22 | 2.104 |
| 30 | 2.24 | 2.127 | 2.225 | 2.105 | 2.167 |
| $K_2O$ kg/ha | | | | | |
| 0 | 2.24 | 2.127 | 2.103 | 2.105 | 2.144 |
| 30 | 2.08 | 2.287 | 2.445 | 2.287 | 2.275 |
| 60 | 1.852 | 2.105 | 2.15 | 2.152 | 2.065 |
| Mean | 2.057 | 2.173 | 2.233 | 2.181 | |

C.D.(0.05) for K = 0.143

$S.E._M$ for P = 0.057

C.D.(0.05) for NP = 0.285

$S.E._M$ for N = 0.0501

$S.E._M$ for PK = 0.1002

Table 24

Phosphorus content in pods

(Percentage of P)

| | $P_2O_5$/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 0.436 | 0.402 | 0.431 | 0.386 | 0.426 |
| 15 | 0.411 | 0.409 | 0.367 | 0.369 | 0.389 |
| 30 | 0.440 | 0.388 | 0.450 | 0.419 | 0.424 |
| $K_2O$ kg/ha | | | | | |
| 0 | 0.473 | 0.400 | 0.450 | 0.388 | 0.428 |
| 30 | 0.436 | 0.404 | 0.417 | 0.359 | 0.404 |
| 60 | 0.428 | 0.394 | 0.381 | 0.427 | 0.407 |
| Mean | 0.450 | 0.399 | 0.416 | 0.391 | |

$S.E._M$ for N or K = 0.0158
$S.E._M$ for P = 0.0182
$S.E._M$ for NP or PK = 0.0315

Table 25

Phosphorus content in tuber

(Percentage of P)

| | $P_2O_5$/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 0.354 | 0.402 | 0.398 | 0.328 | 0.371 |
| 15 | 0.388 | 0.390 | 0.398 | 0.352 | 0.382 |
| 30 | 0.394 | 0.402 | 0.338 | 0.338 | 0.368 |
| $K_2O$ kg/ha | | | | | |
| 0 | 0.354 | 0.396 | 0.371 | 0.342 | 0.366 |
| 30 | 0.375 | 0.394 | 0.392 | 0.344 | 0.376 |
| 60 | 0.407 | 0.404 | 0.371 | 0.332 | 0.378 |
| Mean | 0.379 | 0.398 | 0.378 | 0.339 | |

C.D.(0.05) for N = 0.0200
$S.E._M$ for K = 0.0097
$S.E._M$ for P = 0.0112
$S.E._M$ for NP or PK = 0.0194

Application of phosphorus alone was found to be significantly affecting the phosphorus content of tuber. Maximum phosphorus content of 0.398 per cent was noticed when 30 kg $P_2O_5$ was applied per hectare.

8. <u>Phosphorus content in leaf.</u>

The mean values on the phosphorus content of leaves are presented in Table 26 and the analysis of variance in Appendix XIV.

None of the treatment effect was found to be significant in increasing the phosphorus content in leaves.

(h) <u>Phosphorus content in haulm.</u>

The analysis of variance of the phosphorus content of haulms are given in Appendix XIV and the mean values in Table 27.

Neither the individual nor the interaction effects were found to be significant in influencing the phosphorus content in haulms.

(i) <u>Potassium content in pods.</u>

The mean values on the potassium content on pods were presented in Table 28 and the analysis of variance in Appendix XV.

Application of potassium alone influenced the potassium content in pods and 60 kg $K_2O$ per hectare resulted in the maximum

### Table 26

### Phosphorus content in leaf

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 0.240 | 0.277 | 0.242 | 0.265 | 0.256 |
| 15 | 0.263 | 0.256 | 0.290 | 0.236 | 0.260 |
| 30 | 0.233 | 0.273 | 0.244 | 0.246 | 0.249 |
| $K_2O$ kg/ha | | | | | |
| 0 | 0.233 | 0.284 | 0.250 | 0.288 | 0.264 |
| 30 | 0.261 | 0.273 | 0.269 | 0.238 | 0.260 |
| 60 | 0.242 | 0.244 | 0.257 | 0.221 | 0.241 |
| Mean | 0.245 | 0.267 | 0.259 | 0.249 | |

$S.E._M$ for N or K = 0.0095
$S.E._M$ for P = 0.0110
$S.E._M$ for NP or PK = 0.0190

### Table 27

### Phosphorus content in haulm

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 0.150 | 0.150 | 0.139 | 0.155 | 0.148 |
| 15 | 0.125 | 0.144 | 0.144 | 0.155 | 0.142 |
| 30 | 0.163 | 0.144 | 0.157 | 0.146 | 0.152 |
| $K_2O$ kg/ha | | | | | |
| 0 | 0.165 | 0.146 | 0.131 | 0.142 | 0.146 |
| 30 | 0.144 | 0.152 | 0.148 | 0.167 | 0.153 |
| 60 | 0.129 | 0.140 | 0.159 | 0.146 | 0.143 |
| Mean | 0.146 | 0.145 | 0.146 | 0.152 | |

$S.E._M$ for N or K = 0.0059
$S.E._M$ for P = 0.0068
$S.E._M$ for NP or PK = 0.0117

potassium content of 2.513 per cent in the pods which was on par with 30 kg $K_2O$ per hectare.

(j) Potassium content in tuber.

The data on the potassium content of tuber was analysed statistically and the analysis of variance is given in Appendix XV and the mean values in Table 29.

None of the treatment was found to be significantly affecting the potassium content of tuber.

(k) Potassium content in leaves.

The analysis of variance on the potassium content in leaves is presented in Appendix XV and the mean values in Table 30.

Application of potassium only had significantly and progressively increased the potassium content in leaves. Potassium at the rate of 60 kg per hectare resulted in a content of 1.397 per cent potassium in leaves.

(l) Potassium content in haulm.

The data on the potassium content in haulm were analysed for statistical inference and the analysis of variance is presented in Appendix XV and the means in Table 31.

Table 28

Potassium content in pods

(Percentage of K)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 2.300 | 2.600 | 1.917 | 2.183 | 2.250 |
| 15 | 2.500 | 2.067 | 2.233 | 2.380 | 2.295 |
| 30 | 2.438 | 2.117 | 2.417 | 2.067 | 2.271 |
| $K_2O$ kg/a | | | | | |
| 0 | 2.083 | 2.000 | 1.983 | 1.817 | 1.971 |
| 30 | 2.333 | 2.333 | 2.133 | 2.533 | 2.333 |
| 60 | 2.867 | 2.450 | 2.450 | 2.283 | 2.513 |
| Mean | 2.428 | 2.261 | 2.189 | 2.211 | |

$S.E._M$ for N = 0.1184

$S.E._M$ for P = 0.1368

$S.E._M$ for N or PK = 0.2370

Table 29

Potassium content in Tuber

(Percentage of K)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 1.550 | 1.300 | 1.330 | 1.467 | 1.413 |
| 15 | 1.383 | 1.733 | 1.267 | 1.350 | 1.433 |
| 30 | 1.433 | 1.350 | 1.117 | 1.483 | 1.356 |
| $K_2O$ kg/ha | | | | | |
| 0 | 1.467 | 1.583 | 1.233 | 1.400 | 1.421 |
| 30 | 1.450 | 1.467 | 1.200 | 1.450 | 1.392 |
| 60 | 1.450 | 1.333 | 1.283 | 1.450 | 1.379 |
| Mean | 1.456 | 1.461 | 1.239 | 1.433 | |

$S.E._M$ for N or K = 0.0566

$S.E._M$ for P = 0.0654

$S.E._M$ for NP or PK = 0.1133

## Table 30

Potassium content in leaf
(Percentage of K)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 1.217 | 1.230 | 1.142 | 1.295 | 1.221 |
| 15 | 1.375 | 1.263 | 1.358 | 1.362 | 1.340 |
| 30 | 1.080 | 1.045 | 1.183 | 1.188 | 1.124 |
| $K_2O$ kg/ha | | | | | |
| 0 | 0.967 | 1.068 | 1.183 | 1.100 | 1.080 |
| 30 | 1.367 | 1.092 | 1.250 | 1.125 | 1.209 |
| 60 | 1.338 | 1.378 | 1.250 | 1.620 | 1.397 |
| Mean | 1.224 | 1.179 | 1.228 | 1.252 | |

$S.E._M$ for N = 0.0626
$S.E._M$ for P = 0.0723
$S.E._M$ for NP or PK = 0.1252
C.D. (0.05) for K = 0.1780

## Table 31

Potassium content in haulm
(percentage of K)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 2.40 | 2.567 | 2.533 | 2.117 | 2.404 |
| 15 | 2.567 | 2.533 | 2.217 | 2.517 | 2.458 |
| 30 | 2.400 | 2.480 | 1.967 | 2.383 | 2.308 |
| $K_2O$ kg/ha | | | | | |
| 0 | 2.317 | 2.567 | 2.300 | 2.417 | 2.400 |
| 30 | 2.567 | 2.533 | 2.200 | 2.483 | 2,446 |
| 60 | 2.483 | 2.483 | 2.217 | 2.117 | 2.325 |
| Mean | 2.456 | 2.523 | 2.239 | 2.339 | |

$S.E._M$ for N or K = 0.0875
$S.E._M$ for P = 0.1010
$S.E._M$ for NP or PK = 0.1750

None of the individual effects of the treatments nor their interaction was observed to be significant in influencing the potassium content of haulms.

V Soil Analysis

(a) Nitrogen content of the soil after the experiment.

The mean values are presented in Table 32 and the analysis of variance in Appendix XVI.

The total nitrogen content of the soil was not directly influenced by any of the level of nitrogen, phosphorus and potassium used in the experiment. But the interaction of nitrogen and phosphorus was found to be significant.

(b) Available phosphorus content in the soil after the experiment.

The mean values are presented in Table 33 and the analysis of variance in Appendix XVI.

None of the treatment was found to significantly affect the phosphorus content of the soil after the experiment.

Table 32

Nitrogen content in the soil after the experiment

(Percentage of N, ~)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| | 0 | 30 | 60 | 90 | Mean |
| N kg/ha | | | | | |
| 0 | 0.092 | 0.081 | 0.0858 | 0.0978 | 0.0892 |
| 15 | 0.0883 | 0.0965 | 0.0965 | 0.0822 | 0.0901 |
| 30 | 0.0823 | 0.0978 | 0.0917 | 0.0860 | 0.0894 |
| $K_2O$ kg/ha | | | | | |
| 0 | 0.086 | 0.0941 | 0.0918 | 0.0907 | 0.0907 |
| 30 | 0.0951 | 0.0918 | 0.093 | 0.0982 | 0.0915 |
| 60 | 0.0835 | 0.0892 | 0.0892 | 0.0872 | 0.08273 |
| Mean | 0.0875 | 0.0917 | 0.0913 | 0.0887 | |

S.E.$_M$ for N or K = 0.0026

S.E.$_M$ for P = 0.0030

S.E.$_M$ for PK = 0.0052

(c) Available potassium content in the soil after the experiment.

The analysis of variance is given in Appendix XVI and the mean values in Table 34.

Potassium and pk interaction were found to be significantly affecting the potassium content in the soil.

Economics of fertilizer application.

The economics of fertilizer application for the estimated yield at various levels of nitrogen, phosphorus and potassium are given in Table 35. The maximum profit was obtained due to the individual application of 60 kg $P_2O_5$, 30 kg N, and 30 kg $K_2O$ per hectare when compared to the profit from the lower levels.

The optimum combination of N, $P_2O_5$ and $K_2O$ was found to be 18, 48 and 36 kg/ha respectively. But the economic optimum was 16 kg N, 42 kg $P_2O_5$ and 29 kg $K_2O$ per hectare.

## Table 33

Available Phosphorus content in the soil after the experiment

(P kg/ha)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| N kg/ha | | | | | |
| 0 | 95.52 | 95.76 | 85.74 | 94.77 | 92.95 |
| 15 | 79.80 | 87.10 | 111.23 | 135.76 | 104.08 |
| 30 | 92.30 | 93.79 | 89.08 | 123.26 | 99.61 |
| $K_2O$ kg/ha | | | | | |
| 0 | 82.77 | 84.63 | 95.76 | 110.34 | 93.39 |
| 30 | 107.27 | 96.26 | 97.99 | 122.52 | 106.01 |
| 60 | 77.58 | 95.76 | 92.30 | 123.35 | 99.43 |
| Mean | 89.21 | 92.22 | 95.35 | 118.30 | |

$S.E._M$ for N or K = 6.979

$S.E._M$ for P = 8.059

$S.E._M$ for NP or PK =13.958

## Table 34

Available Potassium content in the soil after the experiment

(K Kg/ha)

| | $P_2O_5$ kg/ha | | | | |
|---|---|---|---|---|---|
| N kg/ha | | | | | |
| 0 | 103.56 | 102.23 | 90.94 | 98.91 | 98.91 |
| 15 | 89.62 | 88.64 | 80.32 | 110.20 | 90.94 |
| 30 | 93.6 | 98.25 | 80.99 | 92.94 | 91.44 |
| $K_2O$ kg/ha | | | | | |
| 0 | 92.27 | 121.48 | 85.06 | 83.64 | 90.61 |
| 30 | 76.34 | 76.34 | 89.62 | 90.28 | 83.14 |
| 60 | 118.16 | 86.30 | 97.58 | 128.12 | 107.54 |
| Mean | 95.59 | 94.70 | 84.08 | 100.68 | |

$S.E._M$ for K = 4.923

C.D.(0.05) for K =14.023

C.D.(0.050) for PK =28.056

$S.E._M$ for P = 5.685

$S.E._M$ for NP = 9.847

Table 35

Economics of fertilizer application

| Treatments | Yield of pods in kg/ha | Value of produce Rs.Ps. | Increase or decrease over the lowest level Rs.Ps. | Cost of fertilizers ($N$, $P_2O_5$ or $K_2O$) Rs.Ps. | Profit due to the fertilizer application over the lowest level Rs.Ps. |
|---|---|---|---|---|---|
| 0 kg N/ha | 7682.82 | 11524.23 | - | - | - |
| 15 " | 10550.08 | 15825.12 | 4300.89 | 135.00 | 4165.89 |
| 30 " | 10901.33 | 16352.00 | 4827.77 | 270.00 | 4557.77 |
| 0 kg $P_2O_5$/ha | 8473.88 | 12710.82 | - | - | - |
| 30 " | 8696.52 | 13044.78 | 333.96 | 171.00 | 162.96 |
| 60 " | 11605.56 | 17408.34 | 4697.52 | 342.00 | 4355.52 |
| 90 " | 10070.18 | 15105.27 | 2394.45 | 513.00 | 1881.45 |
| 0 kg $K_2O$/ha | 8903.10 | 13354.65 | - | - | - |
| 30 " | 10402.54 | 15603.81 | 2249.16 | 66.00 | 2183.16 |
| 60 " | 9828.60 | 14742.90 | 1388.25 | 132.00 | 1256.25 |

Cost of 1 kg of N = Rs.9.00

Cost of 1 kg of $P_2O_5$ = Rs.5.70

Cost of 1 kg of $K_2O$ = Rs.2.20

Cost of 1 Kg of Pod = Rs.1 50

# Discussion

# DISCUSSION

The present investigation was an attempt to find out the effect of nitrogen, phosphorus and potassium on growth characters, yield attributes and yield and quality of winged bean grown in red loam soils of Vellayani . The results obtained from the study are discussed below.

## 1. Growth Characteristics

### 1. Height of plants.

(Table 2, Fig. 3, Appendix II)

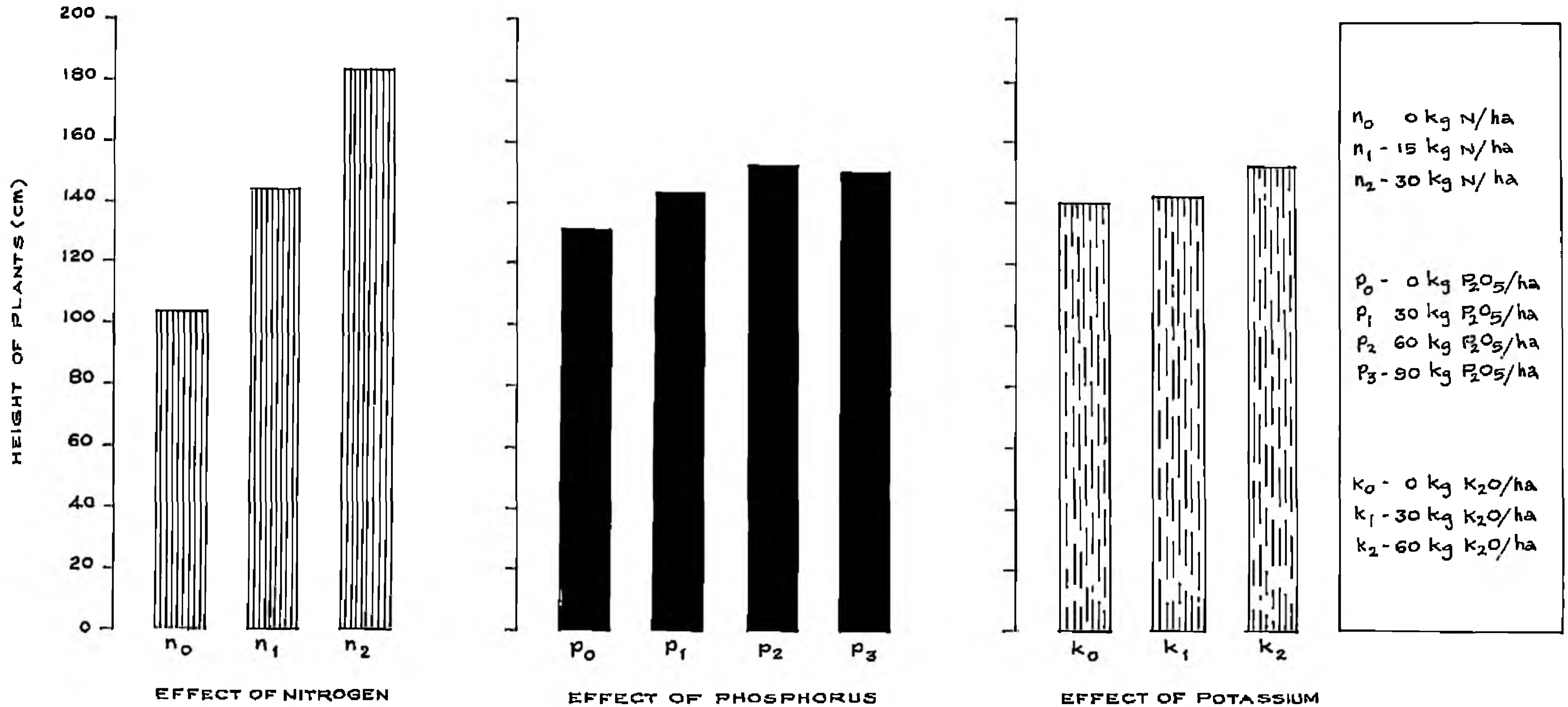
It is seen from the results that higher levels of nitrogen had significant influence on the height of plants. This was due to the role of nitrogen in enhancing the vegetative growth of plants. Russel (1977) stated that nitrogen increases the size of plant cells, promotes leaf growth and thus brings about enhanced photosynthesis which assists the growth processes. The significant increase in height obtained by all levels of nitrogen in this investigation is in conformity with the results obtained by

Edje *et al* (1975) in snap bean and Saadati and Samadi (1978) in Soybean.

The results also indicated that the effect of phosphorus was not so marked as that of nitrogen. The lack of response for graded levels of phosphorus as compared to nitrogen was not due to the unavailability of phosphorus as indicated by the data on Soil analysis (Table 33), but might be due to the fact that phosphorus does not directly involve in enhancing the vegetative growth as compared with nitrogen. Moreover, Black (1966) reported that the role of phosphorus is more towards the development of productive attributes rather than the vegetative characteristics of a crop. It has been reported by Raheja (1966) that the leguminous crops like gram and pigeon pea are able to tap even the subsoil phosphorus pretty effectively with their deep extensive root system. Soil analysis data of the experimental plot also have shown that the soil was adequately supplied with phosphorus and plants were hence able to derive their requirements from the native phosphorus.

The observation on the height of plants with higher doses of nitrogen in the present study is in conformity with

FIG 3 HEIGHT OF PLANTS (cm) AT 40th DAY



the results obtained by Singh *et al* (1980) and Mahatanya (1976) with similar crops.

The height of plants was not significantly influenced by the application of potassium. This is in line with the general role of potassium in the growth of plants. Investigations conducted on similar crops to study the effect of potassium on vegetative growth have also shown only very slight increase in the height of the plants (Sasidhar, 1969)

No significant increase in height of plants was noticed with different combination of nitrogen and phosphorus.

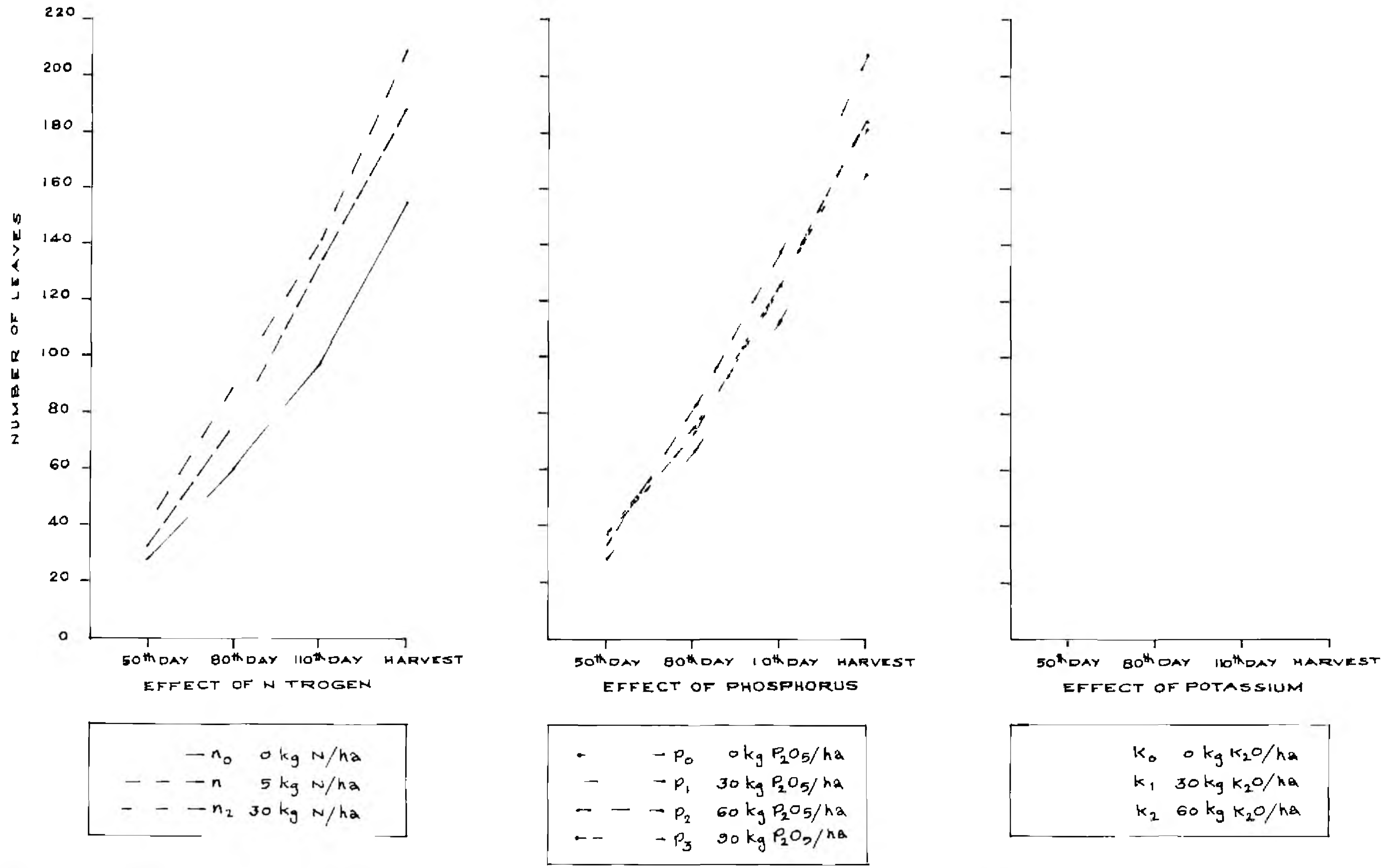
2. Number of leaves.

(Tables 3(a) to 3(d), Fig. 4, Appendix III)

It is seen that nitrogen levels had significant effect in altering the number of leaves in all the stages of crop growth. Almost all studies carried out in different leguminous crops showed that application of nitrogen had a beneficial effect in increasing the general growth and vigour of the plant including the number and size of leaves. On 80th day after germination application of 30 kg nitrogen per hectare had significant influence in the production of leaves over 15 kg nitrogen per hectare and both were superior to the control but in all other stages 15 and 30 kg nitrogen per hectare were on par. This was in conformity with the trials of Hasegawa and Nomura (1978) who observed that the efficiency of nitrogen was low during early growth, then increased upto the end of pod elongation but was low during pod filling in dwarf kidney beans. So also Hilderbrand et al (1981) concluded that higher nitrate application resulted in greater growth of all plant parts except roots in winged bean.

The effect of different levels of phosphorus and potassium was not significant in influencing the leaf production at any growth periods studied. However, the general trend revealed that the medium dose of phosphorus ie. 60 kg $P_2O_5$ per hectare was found to produce higher number of leaves as compared to the other levels beyond 80th day after germination. In the case of potassium a similar trend can be observed from the results presented. Here in all the stages of growth except on 110th day, 30 kg $K_2O$ per hectare had a beneficial effect in the leaf production of the crop. The

FIG 4 NUMBER OF LEAVES PER PLANT AT VARIOUS GROWTH PERIODS



lack of response obtained in the vegetative growth for the higher levels of phosphorus and potassium above certain levels as seen in the study may be due to the fact that this crop may not be requiring phosphorus and potassium>60 Kg $P_2O_5$ and 30 kg $K_2O$ per hectare respectively for increasing the vegetative growth.

The combinations of the nutrient did not show any influence in increasing the number of leaves. This is an indication that phosphorus and potassium had shown their desired effect in regulating the vegetative growth of the plant and on the number of leaves produced per plant as compared with the nitrogen fertilization.

3. Number of branches.

(Tables 4(a) to 4(d), Fig.5, Appendix IV)

It is seen that the production of branches was significantly influenced by the application of nitrogen. This may be due to the established effect of nitrogen in increasing the biometric characters of the plants. Increase in the number of branches in lupins due to nitrogen application was reported by Moursi et al (1976). In the case of winged bean an increase in the growth of all plant parts except root growth was noticed by Hilderbrand et al (1981) which is in agreement with the findings of the present investigation.

The various levels of phosphorus and potassium under study have not influenced this character significantly. This may be due to the fact that the added phosphorus and potassium had their influence in regulating growth of plants especially under the situations of a higher level of nitrogen supply by way of added fertilizers.

Production of branches was also found to be limited and controlled under the combined effect of the nutrients which has been revealed by the data on the interaction effects of nutrients. Shahidullah et al (1979) reported that though the combination of 40 kg phosphorus and 40 kg potassium per hectare resulted in the maximum height of soybeans, the number of branches per plant was not affected by the same fertilizers. Similarly Canoy and Pahm (1980) noted that np interaction had no significant effect in influencing the number of branches in mungo.

FIG 5 NUMBER OF BRANCHES PER PLANT AT VARIOUS GROWTH PERIODS

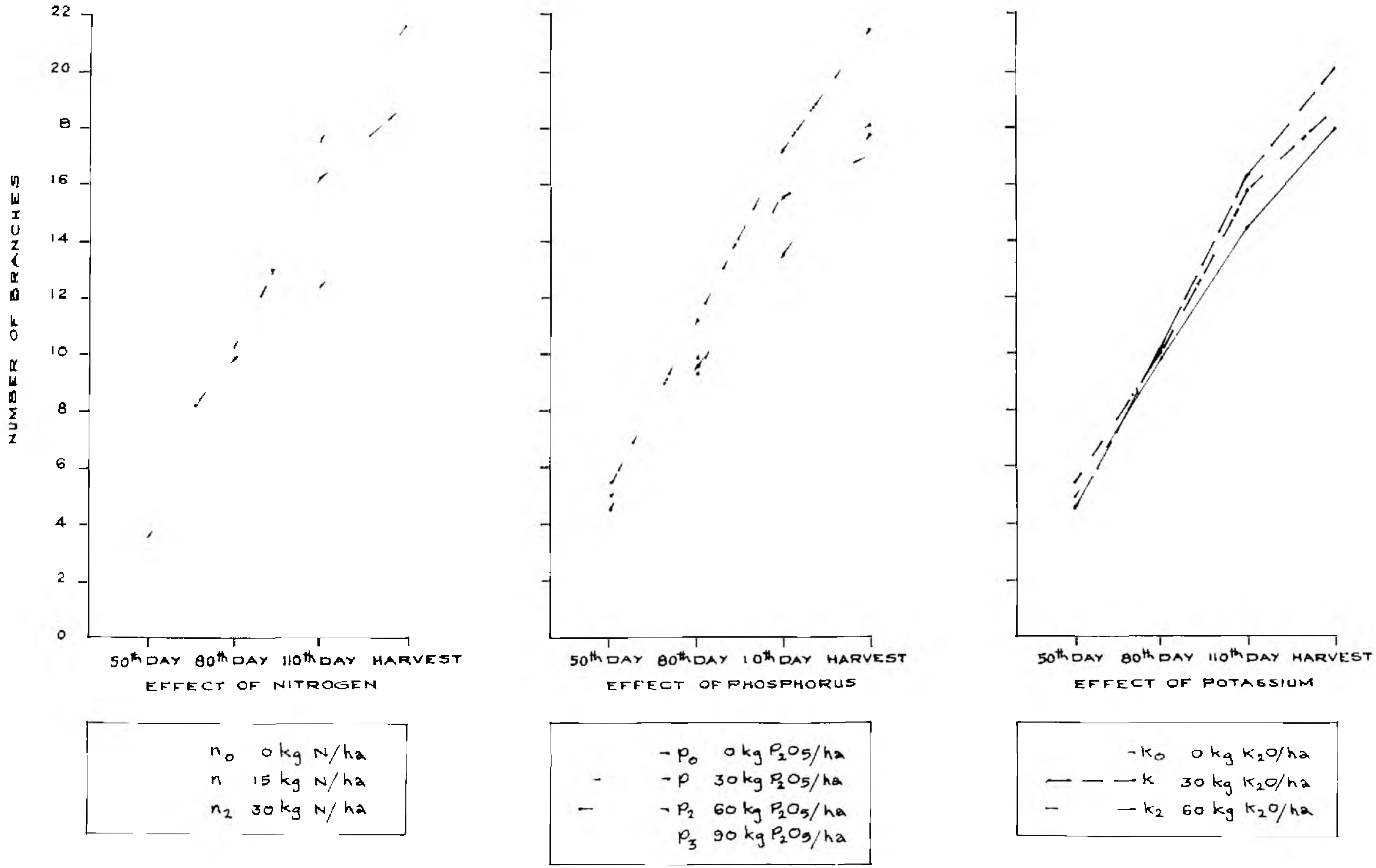
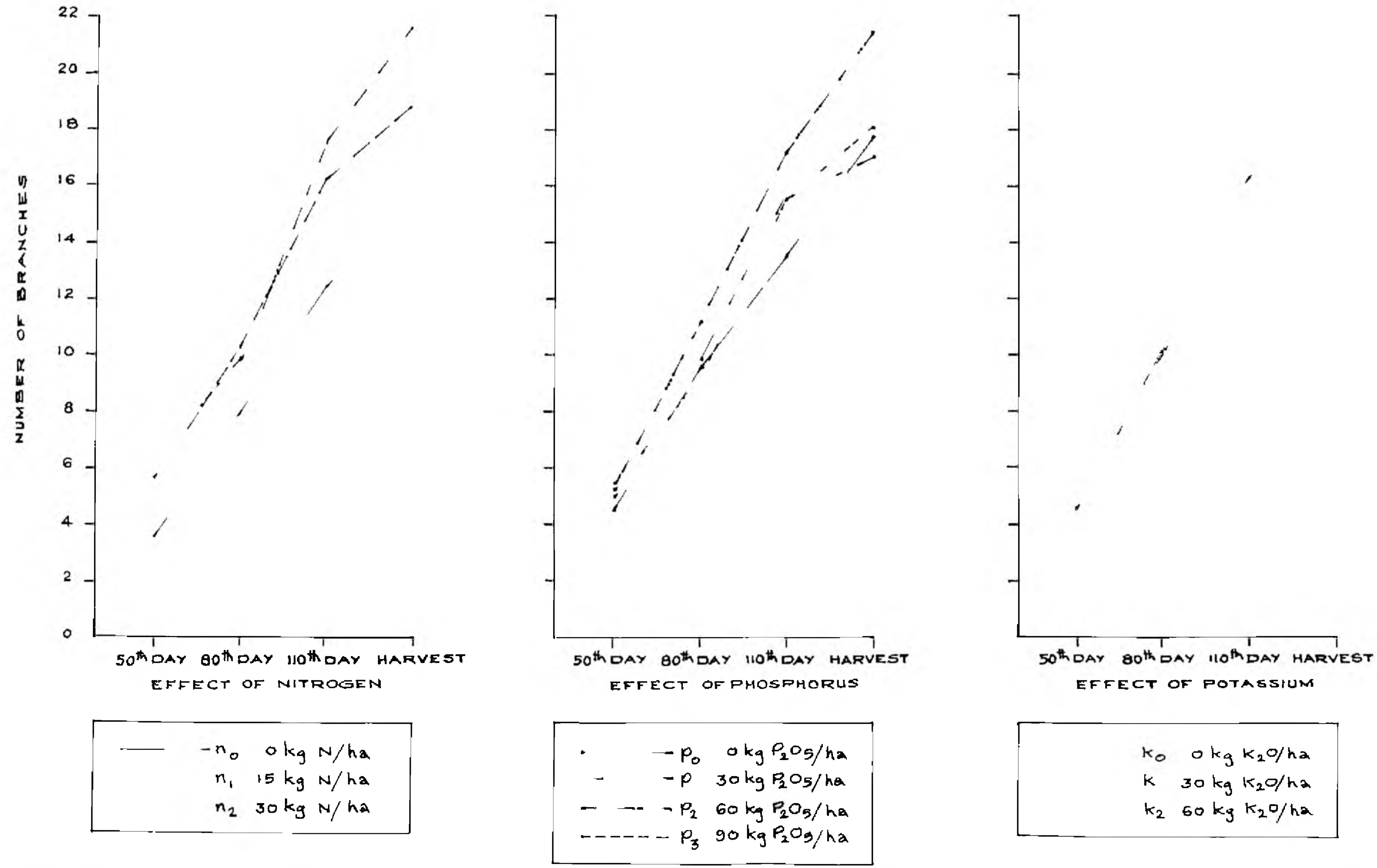


FIG 5 NUMBER OF BRANCHES PER PLANT AT VARIOUS GROWTH PERIODS



4. <u>Earliness in flowering.</u>

(Table 5, Fig.6, Appendix V)

The results given in Table 5 revealed that the added nitrogen had induced earliness in flowering by six days. The increased vegetative growth and other growth attributes contributed by the addition of nitrogen might have induced earliness in flowering also.

Eventhough the addition of phosphatic fertilizers induced a noticeable reduction in the number of days taken for flowering the results observed were not significant.

The effect of potassium on earliness in flowering was not significant. Though this result is in contrary to the results reported by Cutcliffe and Munro (1980) the negetive results noticed here can be due to the effect of added nitrogen in offsetting the influence of potassium as postulated by Dastur (1962). The interaction effects were also not found significant.

5. <u>Number of flowers produced.</u>

(Table 6, Fig.7, Appendix VI)

The results given in Table 6 revealed that different levels of nitrogen had significant effect in increasing the number of flowers produced per plant. The number of flowers produced progressively increased with higher levels of nitrogen and it was significant at all levels. This indicates the favourable effect of nitrogen in influencing the productive characters in addition to its influence on growth characteristics. The result of this investigation is in conformity with one reported by Kogure et al (1977) where the number of flowers and flowering nodes were increased in broad bean with the application of nitrogen. Plants supplied with graded doses of nitrogen have produced corresponding increase in the number of buds. Almeida et al (1973) also emphasised the importance of nitrogen for flowering and good yields.

The beneficial effect of phosphorus in flower production was reported by Kogure et al (1977) in broadbeans. The present study with winged bean also revealed that there was progressive increase in the flower production with the higher levels of phosphorus upto 60 kg per hectare although it was not statistically significant.

A slight increase in the flower production was also

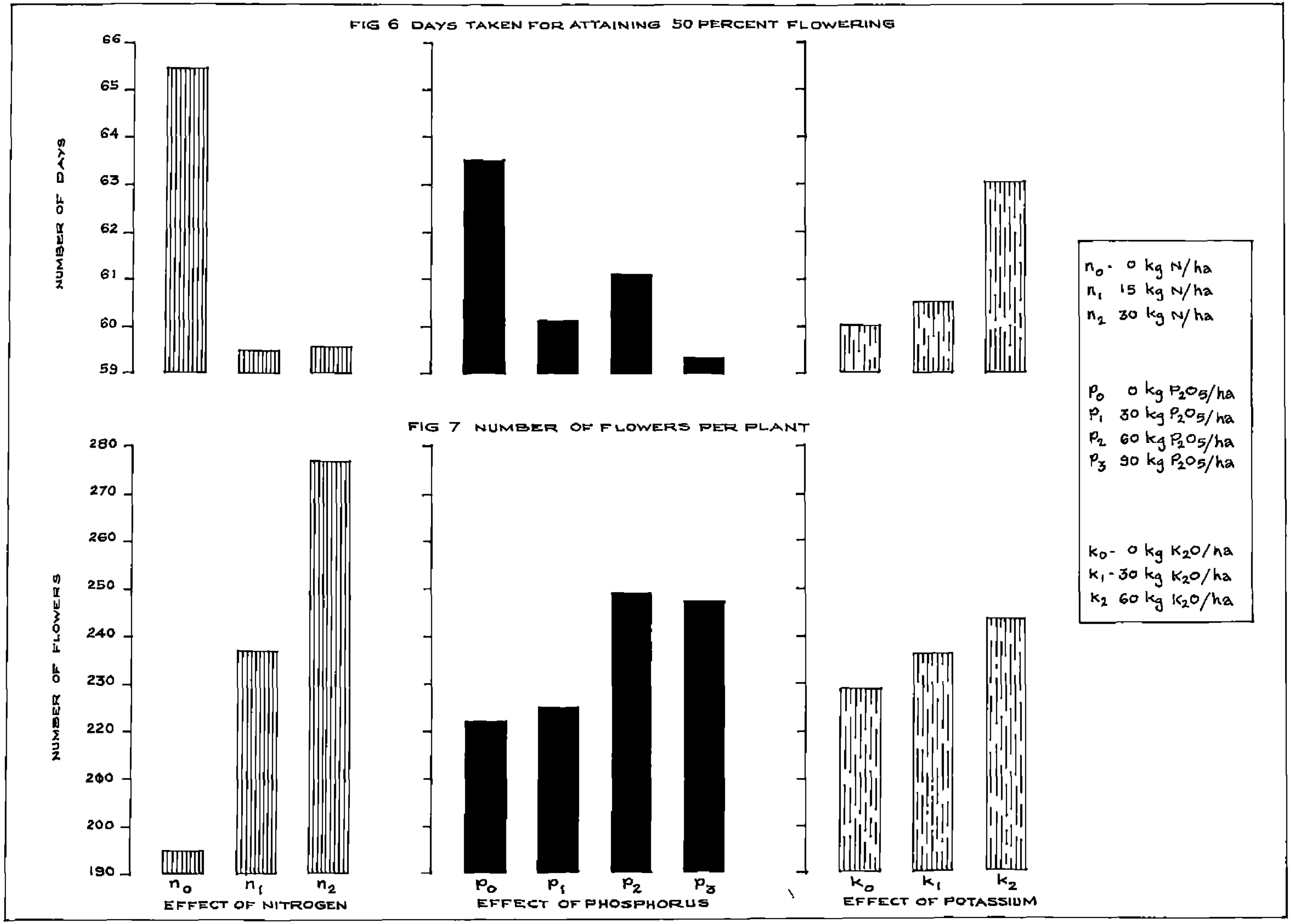



FIG 6 DAYS TAKEN FOR ATTAINING 50 PERCENT FLOWERING

FIG 7 NUMBER OF FLOWERS PER PLANT

observed due to the higher levels of potassium. Kogure et al (1977) reported similar effect of potassium in increasing the flower production in broadbean.

The application of nitrogen and phosphorus in different combination had significant influence in the flower production of winged bean. From the mean table it can be seen that higher levels of nitrogen with higher levels of phosphorus had marked influence in flower production.

6. Number of pods per plant.

(Table 7, Fig.8, Appendix VI)

The results clearly revealed the beneficial influence of nitrogen in increasing the number of pods per plant. The higher levels of this nutrient have given significantly higher number of pods at each level of application. The main effect of nitrogen on all the other yield attributing characters such as number of leaves, number of branches and number of flowers would have resulted in the increased production of pods. Similar results have been reported by Edje et al (1975) in snap beans and Ahmad and Shafi (1975) in field peas.

The effect of phosphorus in the production of pods was found to be not significant, though progressive increase in production of pods was noticed with each addition of phosphorus upto 60 kg per hectare. This might be due to the fact that with increased levels of added phosphorus the rate of crop removal was also correspondingly increased which resulted in higher production of pods. But at the highest level of 90 kg $P_2O_5$ per hectare tried in this investigation, the yield of pods was found to be depressed. The lack of response in the production of pods due to phosphorus application at the highest level of 90 kg per hectare might not be due to the non availability and uptake, rather, phosphorus beyond a certain level in the plant might not have further influence in the initiation of flower buds. However, the role of phosphorus cannot be completely ruled out since a trend to increase the yield has been noticed at each levels of phosphorus. It would therefore be clear that the optimum requirement of phosphorus might be probably slightly above the control but lower than that of other treatments.

Potassium application also showed a similar trend as evinced by phosphorus. This was in conformity with the results of Sasidhar and George (1972a) in lab-lab beans and Viswanathan et al (1978) in cowpea.

Nitrogen-phosphorus interaction was found to be significant. This might be the result of the cumulative effect of other yield attributing characters in the number of pods produced per plant. Haag et al (1978) also reported that in snap beans np interaction increased the pod number per plant.

7. Setting percentage.

(Table 8, Fig.9, Appendix VI)

From the results presented it can be seen that nitrogen had no significant influence in the setting percentage of pods. Nitrogen is directly related to the vegetative growth of the plants. Eventhough the number of flowers and the number of pods per plant have been increased by the application of nitrogen, the setting percentage almost remained constant. This indicates that with the addition of nitrogen the increased number of flowers alone contributed the corresponding increase in pod yield but not the increased setting of flowers to pods. Moursi et al (1975) reported a similar finding in snap beans where ammonium sulphate have no marked effect on the percentage of fruit set but increased the total number of flowers and fruits per plant.

The effect of phosphorus in increasing the setting of pods was also not significant. This may be due to the fact that the increase in the number of pods by the application of phosphorus was mainly due to the increased number of flowers produced and not due to the increase in the setting percentage which was found to be more or less constant.

As seen in the case of nitrogen and phosphorus, the effect of potassium in influencing the setting percentage was also not found to be significant in winged bean. The increase in the number of pods was corresponding to the increase in the number of flowers produced per plant but not due to the influence of higher setting percentage.

8. Length of pods.

(Table 9, Fig.10, Appendix VII)

Significant increase in the length of pods has been obtained by the influence of nitrogen. The role of nitrogen in the synthesis of protein and protoplasm is well established. With adequate quantity of nitrogen application, more protoplasm would have been produced which in turn would have increased the succulence of pods and thereby the increased length of pods (Tisdale and Nelson, 1975). This is in conformity with the results of Hasegawa and Nomura (1978) who found that the efficiency of nitrogen was more upto the end of pod elongation but was low during pod filling. Here, it was observed that the application of phosphorus did not influence the length of pods. The poor response of applied phosphorus may be due to its contribution towards the development of roots rather than the growth and development of pods.

The main effect of potassium was found to be significant in increasing the length of pods. Potassium is directly related to the formation and development of reproductive organs and thus application of potassium might have resulted in the increased length of pods. The interaction of nitrogen and phosphorus was found to be significant. Of the np interactions nitrogen at 15 kg and phosphorus at 60 kg per hectare gave

FIG 8 NUMBER OF PODS PER PLANT

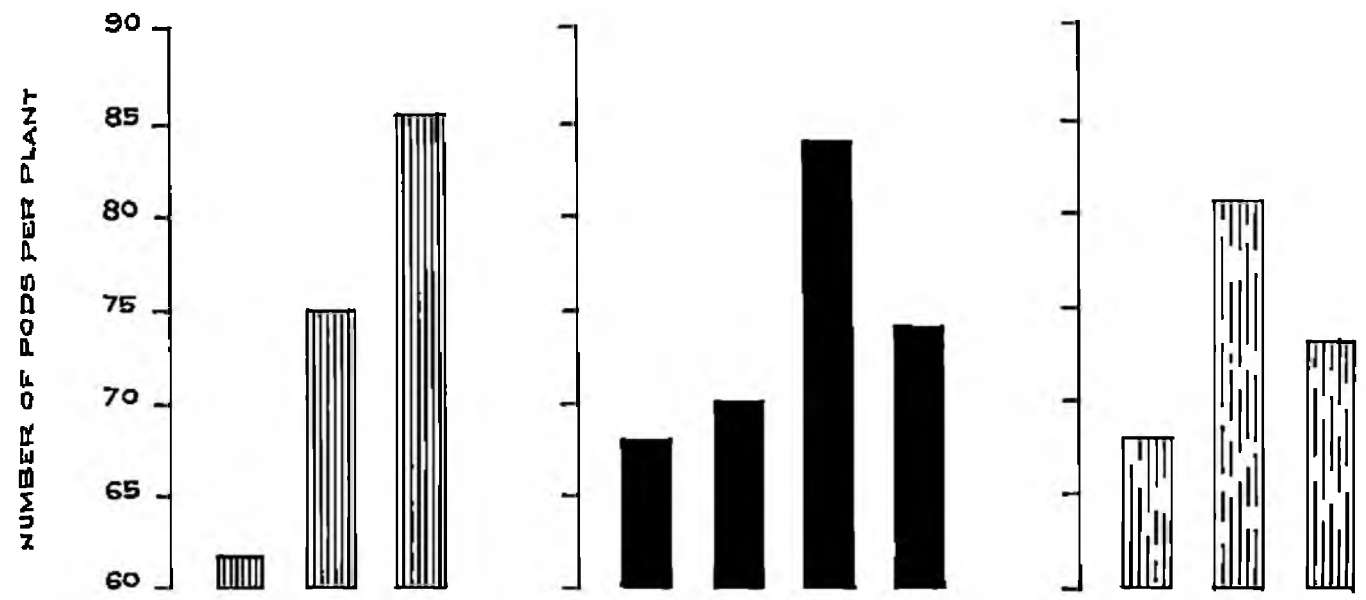



FIG 9 SETTING PERCENTAGE OF PODS

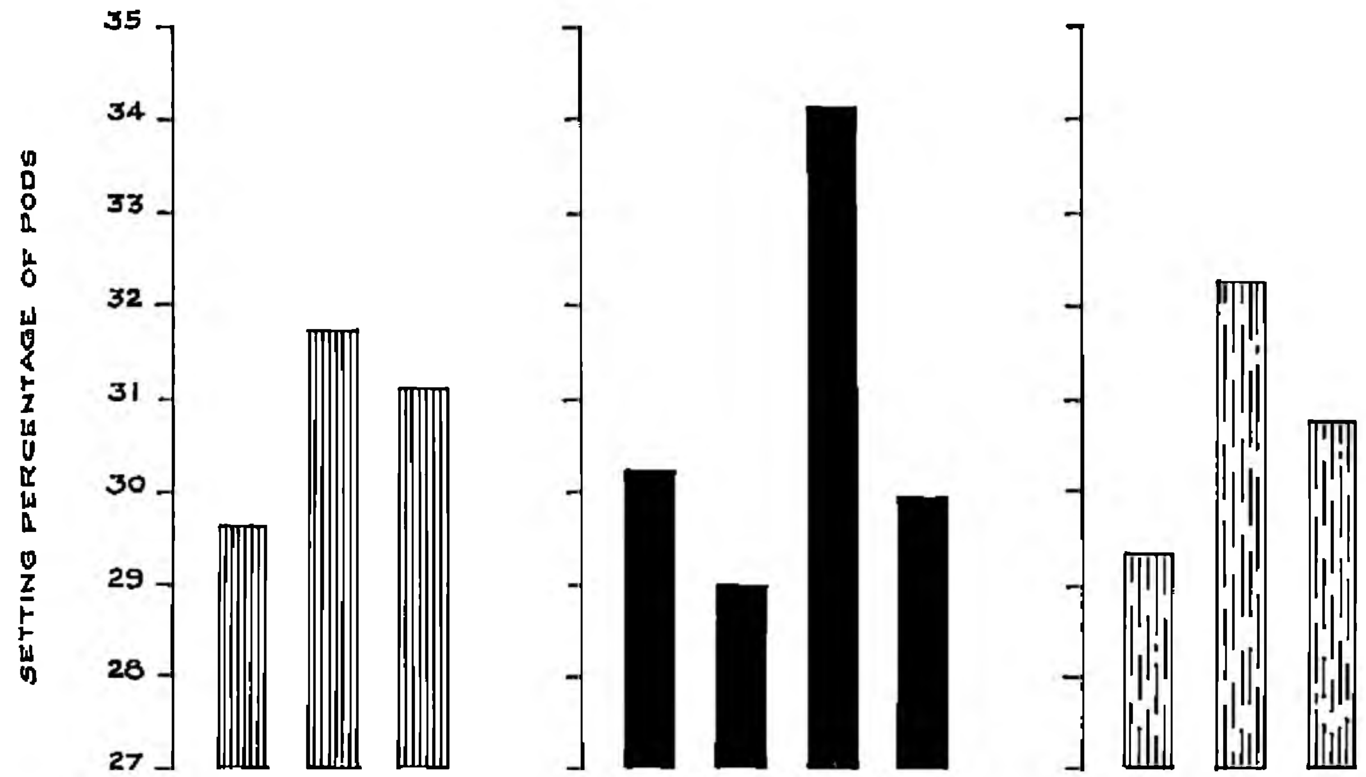
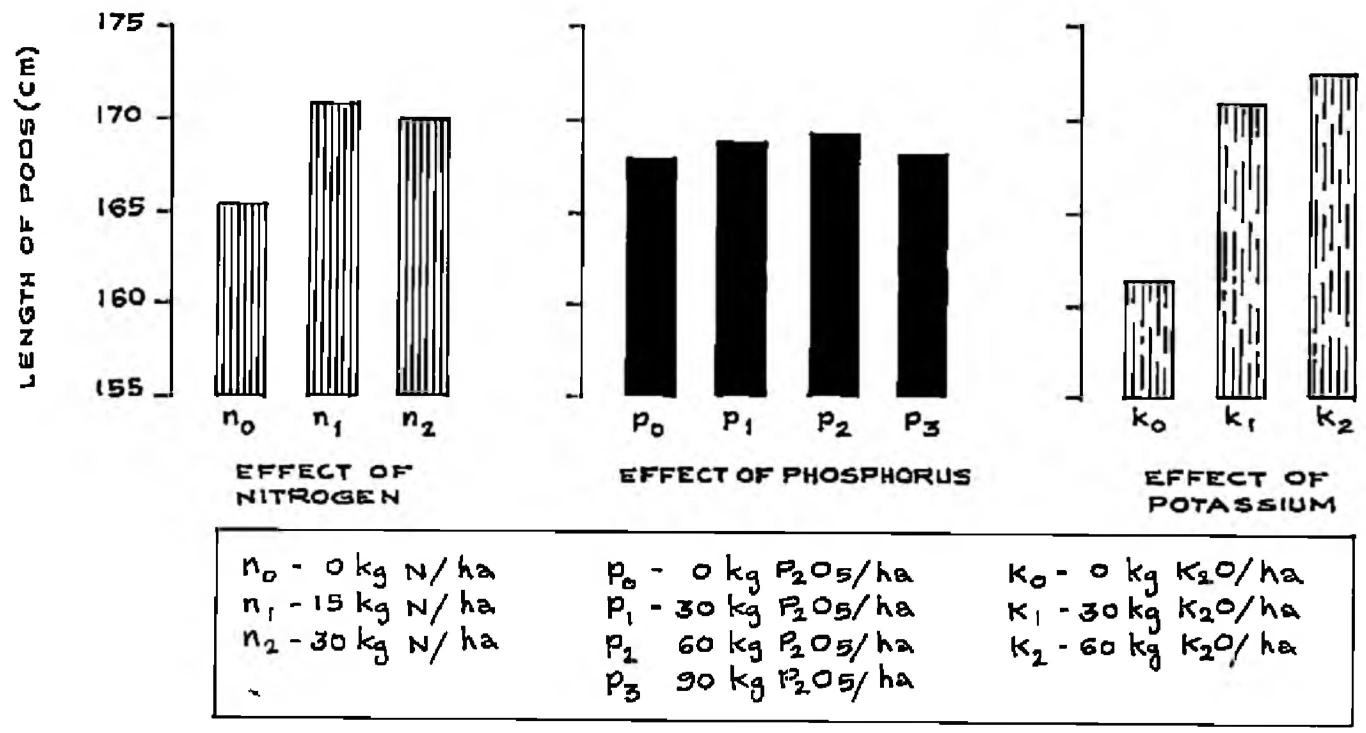



FIG 10 LENGTH OF PODS



maximum length of pods while the other levels gave varied results.

9. Yield of green pods per plant.

(Tables 10(a) to 10(f), Fig. 11(a) and 11(b) Appendix VIII)

The results revealed that addition of nitrogen at 15 kg per hectare gave significant increase in yield per plant over control at each stage of harvest as well as the total yield per plant, though the highest level of 30 kg nitrogen per hectare was found to be on par with the level of 15 kg per hectare. The contributing effects of graded doses of nitrogen in increasing height, branching, number of leaves, number of flowers, length of pods and number of pods etc. might have resulted in an increase in the total yield of pods per plant. The relative low response at the highest level of 30 kg over 15 kg per hectare may be due to the fact that 15 kg nitrogen per hectare would have been sufficient to produce the maximum yield of green pods. Trials conducted by Ahmad and Shafi (1975), Hamissa et al (1975), Gnetieva (1978), Hasegawa and Nomura (1978) and Haque et al (1980) on other legume crops confirmed the above finding in winged bean.

The data also revealed that phosphorus application at 60 kg per hectare had significant influence on the yield of pods in all the months except the first. The pooled analysis of the data also showed significant influence of phosphorus on the yield of green pods at 60 kg per hectare. The above finding agrees with the results reported by Pande et al (1974), Ahmad and Shafi (1975) and Hamissa et al (1975). Prummel et al (1975) also concluded that in snap beans yield was much higher by increasing the level from 30 to 200 kg $P_2O_5$ per hectare, but the yield increase curve was flattened out when the level of $P_2O_5$ was increased above 120 kg per hectare. The reason for the low response of phosphorus at the first month of harvest might be that the crop utilised the added phosphorus fully only during the peak periods of harvest and hence its manifestations at later stages.

The comparatively low response to phosphorus over 60 kg per hectare might be due to the fact that for a legume crop like winged bean higher doses above 60 kg per hectare might not be required for higher production.

The results indicated that the graded doses of potassium had no significant effect in increasing the yield of winged bean except at the last month where a significant difference was noticed for 30 kg per hectare. In all other stages though the differences were not significant there was an apparent increase in the yield of pods. The lack of significance at the higher levels might be due to the fact that it does not directly involve in increasing the yield and also due to the sufficiency of potassium at lower levels. Similar results were also obtained by Sasidhar and George (1972b), Braga et al (1973), Ahmad and Shafi (1975) and Almedia et al (1980) with other leguminous crops.

Neptune et al (1978) and Midan et al (1980) reported the non-significant interaction between nitrogen and phosphorus in beans. Addy (1975) from glass house and field trials in cowpea concluded that application of nitrogen and phosphorus in the early wet season had no significant effect on

FIG 11a YIELD OF GREEN PODS PER PLANT AT DIFFERENT MONTHS

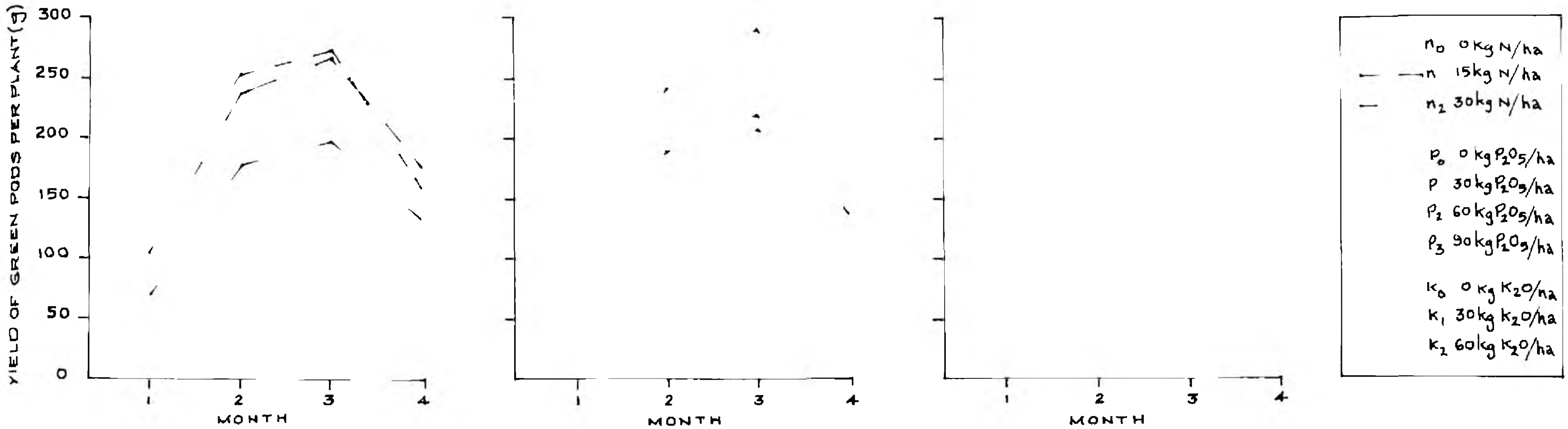
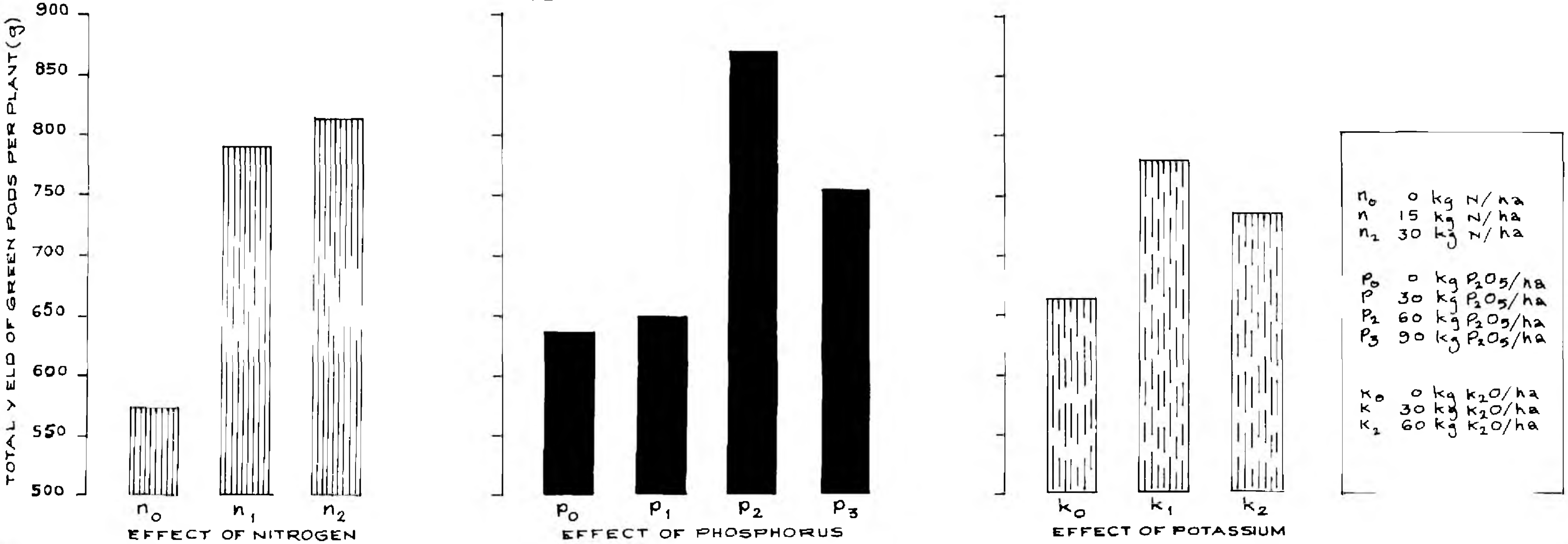



FIG 11b YIELD OF GREEN PODS PER PLANT



seed yield, though the applied nitrogen tended to increase it slightly phosphorus tended to decrease it.

As against this pk interaction was found to be significant. In general application of 60 kg $P_2O_5$ and 30 kg $K_2O$ per hectare had a significant influence in increasing the pod yield when compared to other levels.

10. Bhusa yield.

(Table 11, Fig.12, Appendix IX)

The results revealed that different levels of nitrogen had significant influence in increasing the bhusa yield of winged bean. Nitrogen is the element which is required for the vegetative growth of the plant. Thus bhusa yield was increased by the higher doses of nitrogen, but there was no significant difference between the 15 and 30 kg nitrogen per hectare. Similar results were reported by Mc Lean et al (1974) and Moursi et al (1976).

Phosphorus application was not found to affect the bhusa yield of winged bean. Eventhough 60 kg $P_2O_5$ per hectare increased the bhusa yield it was not significant over the lower level of 30 kg per hectare. This is in conformity with the results obtained in the experiments of Staud (1974) who has reported that phosphate level had no significant effect on the yield components such as vine, pod etc. in peas. The comparative poor response of higher level of phosphorus viz. 60 kg $P_2O_5$ per hectare can be attributed to the fact that though phosphorus is beneficial for the general growth and yield as evidenced by various results of field experiment conducted at different places in the country, the response of legumes to phosphorus has been conspicuous only in soils poor in available phosphorus.

Significant influence in the bhusa yield was obtained by the application of potassium in winged bean. It was observed that application of potassium at 30 kg per hectare produced the maximum bhusa yield beyond which the yield was decreased. Results of experiments conducted by Peck and Buren (1975) and El-Leboudi <u>et al</u> (1974) also showed that application of potassium upto 100 kg per acre increased the vegetative growth of snap beans and hence the bhusa yield. This might be due to the fact that potassium is not directly involved in the vegetative growth of the plant and hence the highest dose had quadratic response.

The interaction effect of nitrogen and phosphorus was found to influence the bhusa yield significantly. This shows that 15 kg N and 60 kg $P_2O_5$ per hectare would be a suitable combination of nitrogen and phosphorus over other combinations.

11. Tuber yield.

(Table 12, Fig. 13, Appendix IX)

The results indicated that the levels of nutrients either individually or in combination had no significant influence in the production of tubers. According to National Academy of Sciences (1975), for tuber development in winged beans, its vegetative growth should be reduced and it should not be allowed to develop pods. In the present study the crop was grown as a vegetable crop permitting increased vegetative

FIG 12 BHUSA YIELD

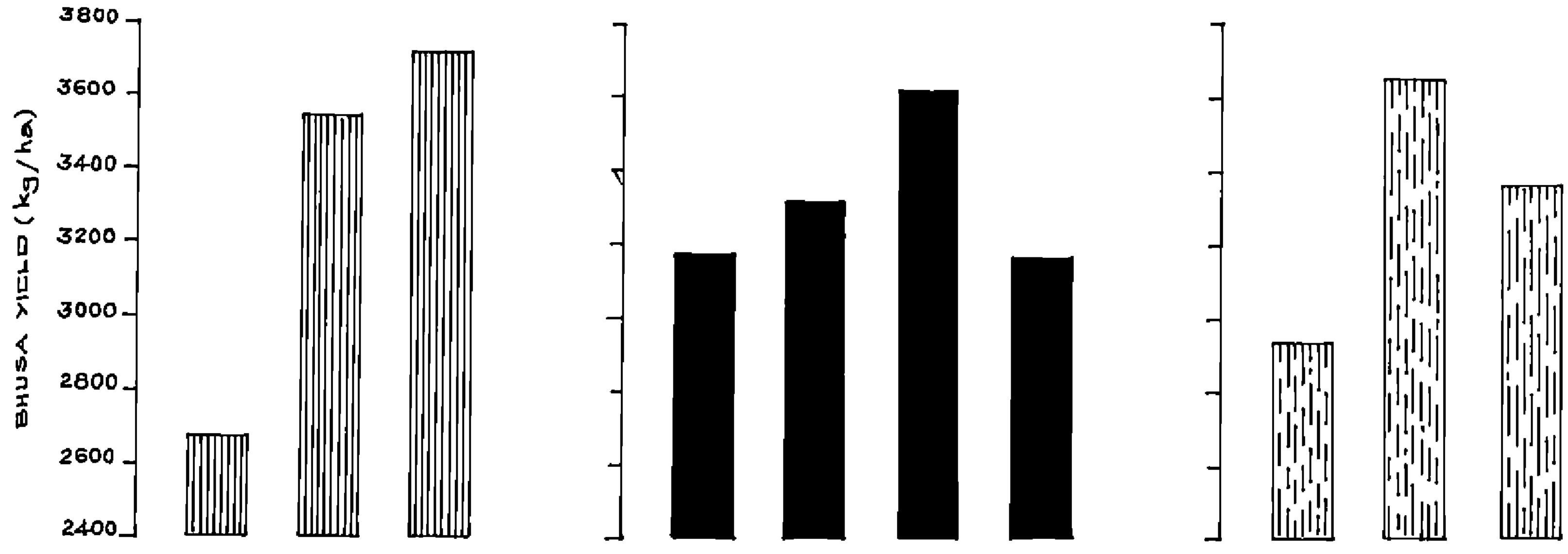
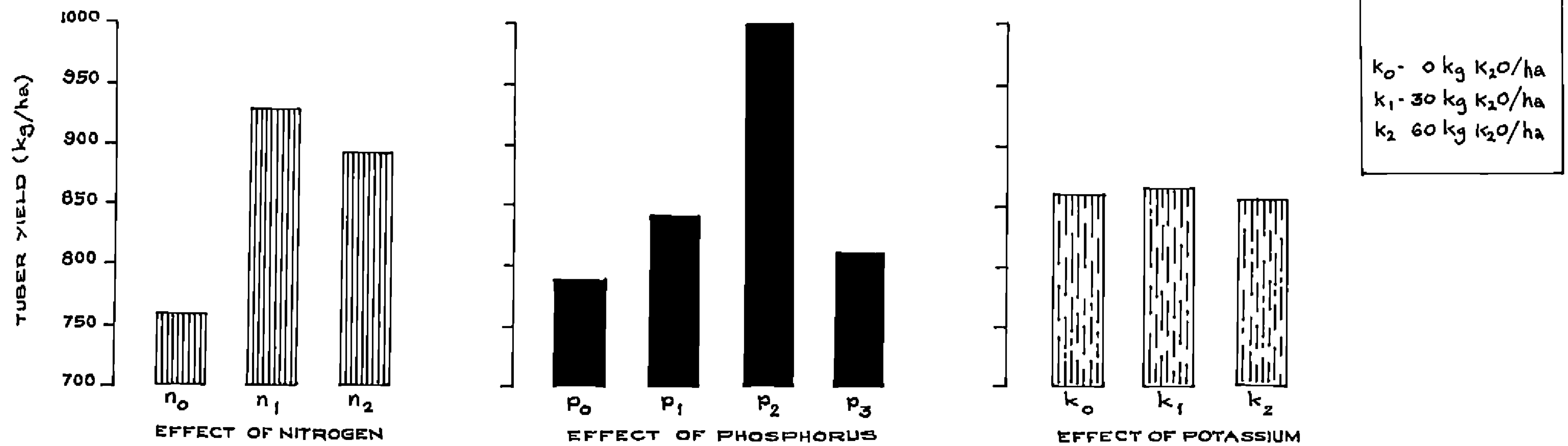



FIG 13 TUBER YIELD



growth and formation of pods which might have curtailed the formation of tubers and hence no response to nutrients either individually or in combination. The report of Hilderbrand et al (1981) was that higher nitrate application resulted in greater growth of all plant parts except roots in winged bean and is corroborative to the present observation.

12. Dry matter production.

(Table 13, Fig. 14, Appendix X)

From the results it was clear that nitrogen and phosphorus had significant influence in increasing the dry matter production of winged bean. Significant positive response of nitrogen to height of plants, number of branches, number of leaves, number of flowers and number of pods was recorded earlier which might have resulted in the increased dry matter production. Studies by Okutan (1970) in Snap beans, Ahmad and Shafi (1975) in peas and Sadar (1979) in Snap beans resulted in similar findings as discussed above.

Phosphorus is an element essential for better root growth enabling higher uptake of nutrients. This might have resulted in the higher vegetative growth and consequent dry matter yield of winged bean. Experiment conducted by Agboola and Obigbesan (1977) in cowpea, Dagaduan (1980) in winged bean, Singh et al (1980) in field bean and Ali et al (1981) in broad bean also revealed that phosphorus application resulted in increased dry matter yield.

The effect of potassium was not significant. Potassium as a plant nutrient does not directly involve in increasing the vegetative growth of the crop but only offers resistance to pest and diseases in plants and hastens its maturity. It does not form an integral part of plant components such as protoplasam, fats, cellulose etc.

13. Harvest index.

(Table 14, Fig.15, Appendix X)

None of the treatments was found to influence the harvest index in winged bean. Harvest index was calculated

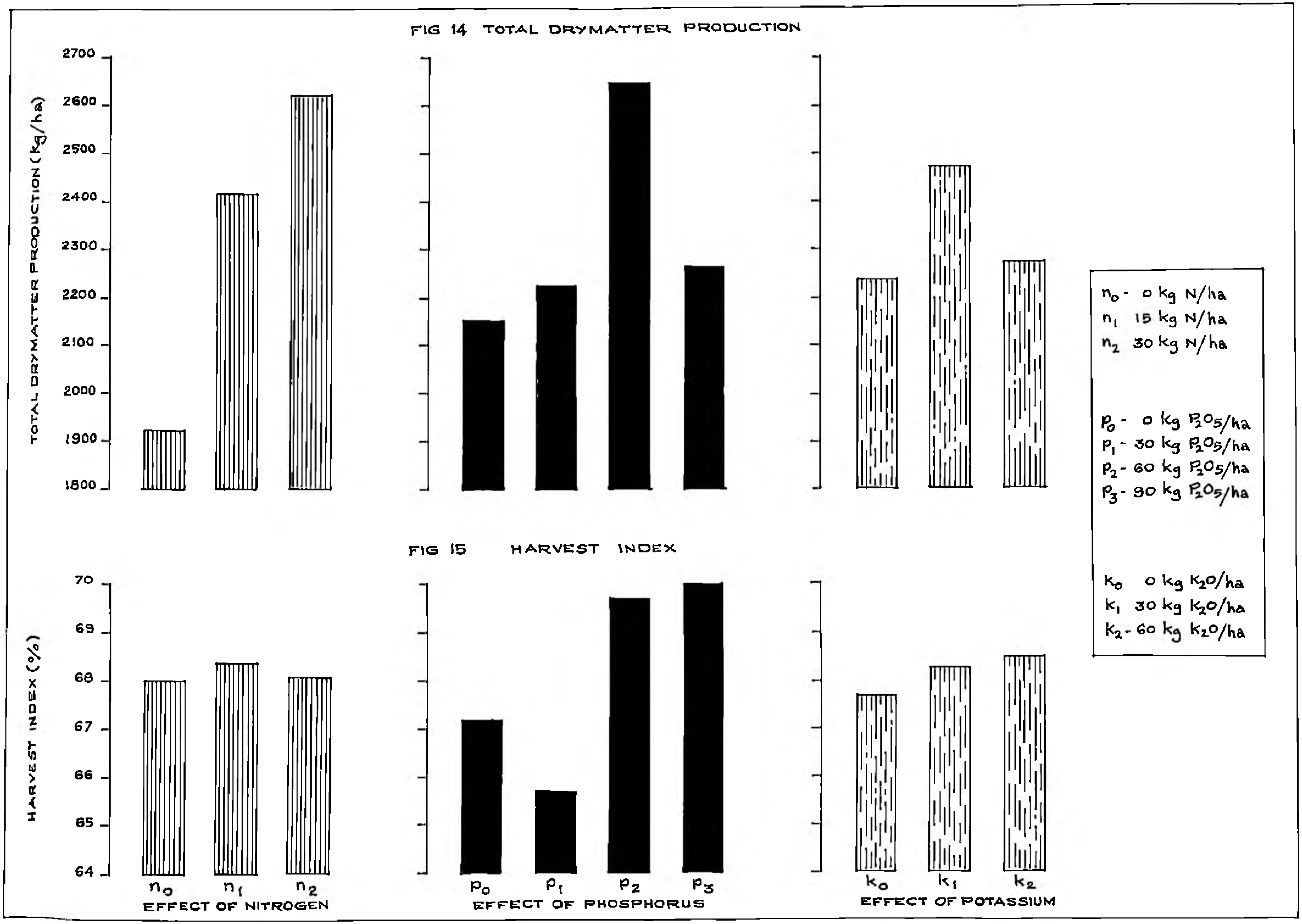


FIG 14 TOTAL DRYMATTER PRODUCTION
TOTAL DRYMATTER PRODUCTION (kg/ha)
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
FIG 15 HARVEST INDEX
HARVEST INDEX (%)
70
69
68
67
66
65
64
n0 n1 n2
EFFECT OF NITROGEN
p0 p1 p2 p3
EFFECT OF PHOSPHORUS
k0 k1 k2
EFFECT OF POTASSIUM
n0 - 0 kg N/ha
n1 15 kg N/ha
n2 30 kg N/ha
p0 - 0 kg P2O5/ha
p1 - 30 kg P2O5/ha
p2 - 60 kg P2O5/ha
p3 - 90 kg P2O5/ha
k0 0 kg K2O/ha
k1 30 kg K2O/ha
k2 - 60 kg K2O/ha

from the economic yield and biological yield. The biological yield includes both economic yield viz. pods and vegetative yield viz. bhusa and tuber. Both the biological and economical yield of the crop were increased with higher levels of NP and K tried in this experiment and hence the harvest index was not altered much resulting in non significance.

## Chemical Analysis

A. Quality Characters.

(a) Protein content of pods.

(Table 15, Fig. 16, Appendix XI)

From the data presented it is clear that none of the treatments had significantly influenced the protein content of pods. Though application of nitrogen and phosphorus at higher levels increased the uptake of nitrogen by the plant its influence on the protein content of the pods was not conspicuous. This might be due to the fact that the pods were harvested as vegetable at half maturity in its active development phase. Hence the possibility of accumulation of protein is naturally less. Similar results have also been reported by

Richards and Soper (1979) in field beans and Bishop *et al* (1976) in Soyabean.

(b) Protein content of tuber.

(Table 16, Fig. 17, Appendix XI)

The effect of nitrogen, phosphorus and the phosphorus-potassium interaction were found to influence the protein content of tuber. Winged bean is a crop that is mainly grown for its tender pods to be used as a vegetable. When it is grown as vegetable crop not much tuber development is possible as vegetative growth and pod formation are not curtailed. In the case of tubers the effect of nitrogen, phosphorus and potassium on protein content could be fully expressed as the tubers were permitted to grow to its full maturity and there was adequate time for the synthesis, formation and accumulation of protein in the tubers.

B. Uptake Studies.

(a) Uptake of nitrogen.

(Table 17, Fig.18, Appendix XII)

FIG 16 PROTEIN CONTENT OF TENDER PODS

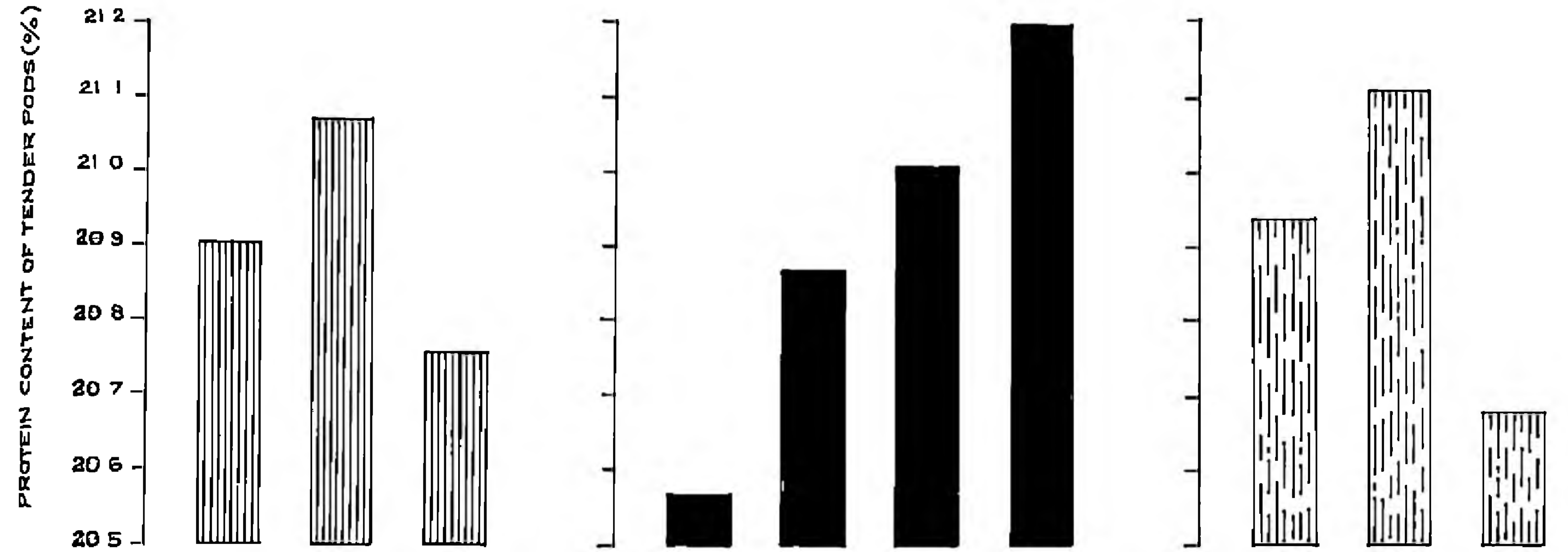
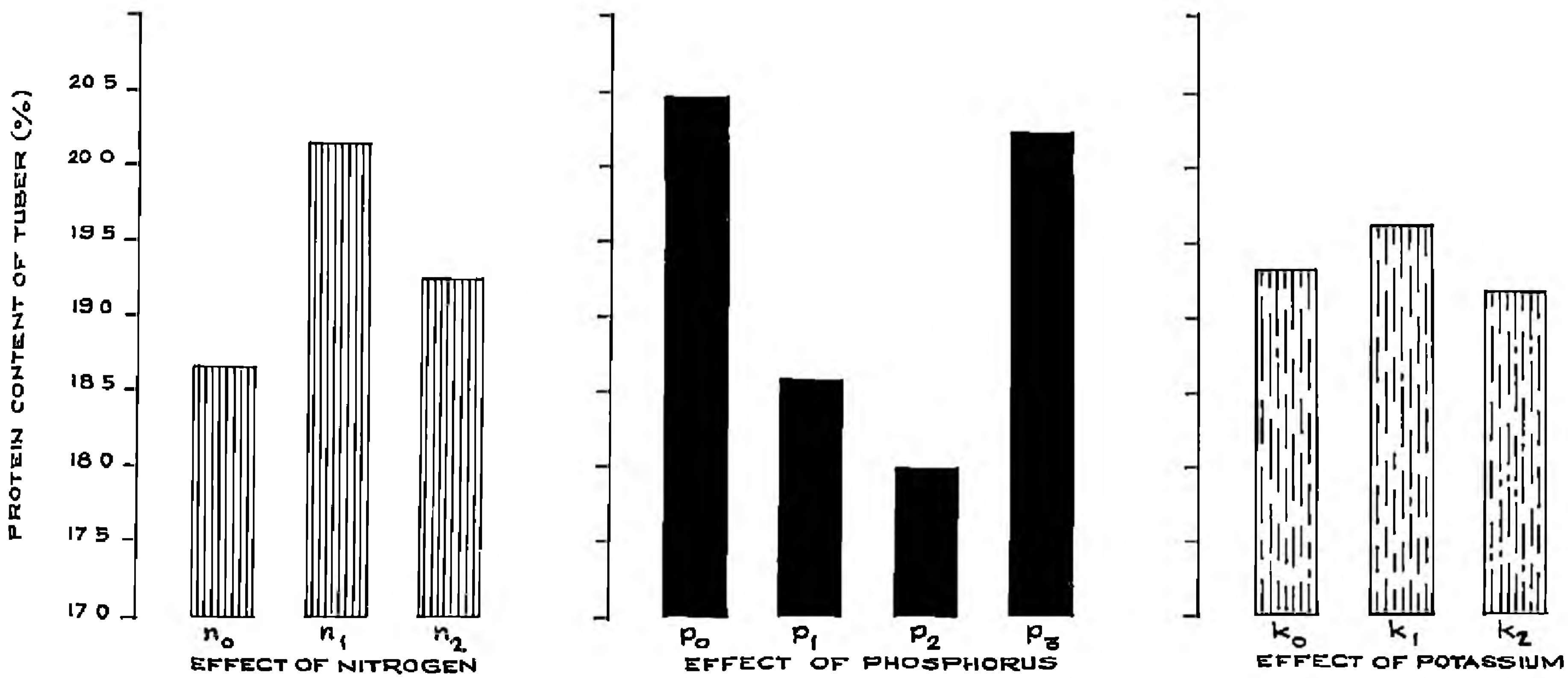



FIG 17 PROTEIN CONTENT OF TUBER




$n_0$ 0 kg N/ha
$n_1$ - 15 kg N/ha
$n_2$ 30 kg N/ha

$p_0$ - 0 kg $P_2O_5$/ha
$p_1$ 30 kg $P_2O_5$/ha
$p_2$ - 60 kg $P_2O_5$/ha
$p_3$ 90 kg $P_2O_5$/ha

$k_0$ - 0 kg $K_2O$/ha
$k_1$ - 30 kg $K_2O$/ha
$k_2$ - 60 kg $K_2O$/ha

The result revealed that with increased level of nitrogen supplied to the crop the uptake of nitrogen by the plant was also correspondingly increased significantly. Thus the higher amount of nitrogen absorbed by the plant had its influence in the growth and yield attributes viz. number of leaves, branches, flowers, pods and bhusa as shown in this experiment. El-Bakry (1980) also reported that higher rates of nitrogen increased the nitrogen uptake by the plants.

Phosphorus application resulted in the higher uptake of nitrogen. Sasidhar and George (1972a) and Singh et al (1981a) also recorded similar results when phosphorus was applied to leguminous crops. It can be inferred that the effect of phosphorus in increasing the root growth and development might have resulted in higher uptake by the plant as well as uptake from a wide spectrum of the soil.

The influence of potassium in the uptake of nitrogen was not significant. The pk interaction was significant and the combination of 60 kg $P_2O_5$ and 30 kg $K_2O$ per hectare resulted in the maximum uptake of nitrogen. The higher root growth at higher level of phosphorus coupled with the beneficial influence of potassium as a carrier nutrient might have resulted in higher leaf production, production of assimilates and finally the uptake of nitrogen.

(b) Uptake of phosphorus.

(Table 17, Fig.19, Appendix XII)

From the table it is clear that application of nitrogen at both the higher levels had resulted in a significant increase in the uptake of phosphorus. The direct effect of nitrogen in increasing the vegetative growth of plants might have resulted in a corresponding higher uptake of phosphorus. Sarkar and Jones (1980) obtained higher translocation of phosphorus from root to the shoot when nitrogen was applied to snap beans. This translocation of phosphorus by applied nitrogen might have resulted in the higher uptake of phosphorus in winged bean. Similarly Posypanov and Knyaseva (1974) found that in peas application of mineral nitrogen resulted in the higher uptake of nitrogen, phosphorus and potassium and synthesised more organic matter and raw protein than those limited to symbiotic nitrogen. Similar positive influence of nitrogen in increasing the phosphorus uptake of plant was reported by El-Bakry _et al_ (1980) in snap beans.

Results showed that 60 kg $P_2O_5$ per hectare was found to be giving the maximum uptake of phosphorus. The significant effect of phosphorus in the uptake of phosphorus might be due to the significant influence of this nutrient in the growth and yield attributes of the crop. This is in conformity with the findings of Amer (1978) in beans and Ali _et al_ (1981) in lentil. In addition Singh _et al_ (1981b) received the maximum yield and uptake of nitrogen and phosphorus when 60 kg $P_2O_5$ per hectare was applied. Similarly Kalyan and Prasad (1976) found that in red gram, increasing the phosphorus rates from zero to 100kg per hectare increased seed nitrogen and phosphorus uptake in seeds and stem.

The non significant influence of potassium in increasing the phosphorus uptake shows that potassium had no direct influence on the uptake of phosphorus.

(c) Uptake of potassium

(Table 18, Fig.20, Appendix XII)

Nitrogen had significantly increased the uptake of potassium in winged bean. In this trial application of nitrogen had resulted in the higher number of pods, branches flowers, pod yield, bhusa yield and the dry matter yield. All these might have resulted in the higher uptake of potassium. Asif and Greig (1972) also found that higher levels of nitrogen had resulted in higher uptake of potassium in snap beans. Similarly Posypanov and Knyaseva (1974) observed that peas provided with mineral nitrogen took up more nitrogen, phosphorus and potassium and synthesised more organic matter and raw protein than those limited to symbiotic nitrogen.

Raheja (1966) reported that potassium uptake of plants is normally independent of the concentration of available or total phosphorus in the soil. The non-significant effect of phosphorus on potassium uptake observed in this study in in agreement with the above finding.

The potassium uptake of plants increased significantly with the higher levels of potassium. The significant

FIG 18 UPTAKE OF NITROGEN

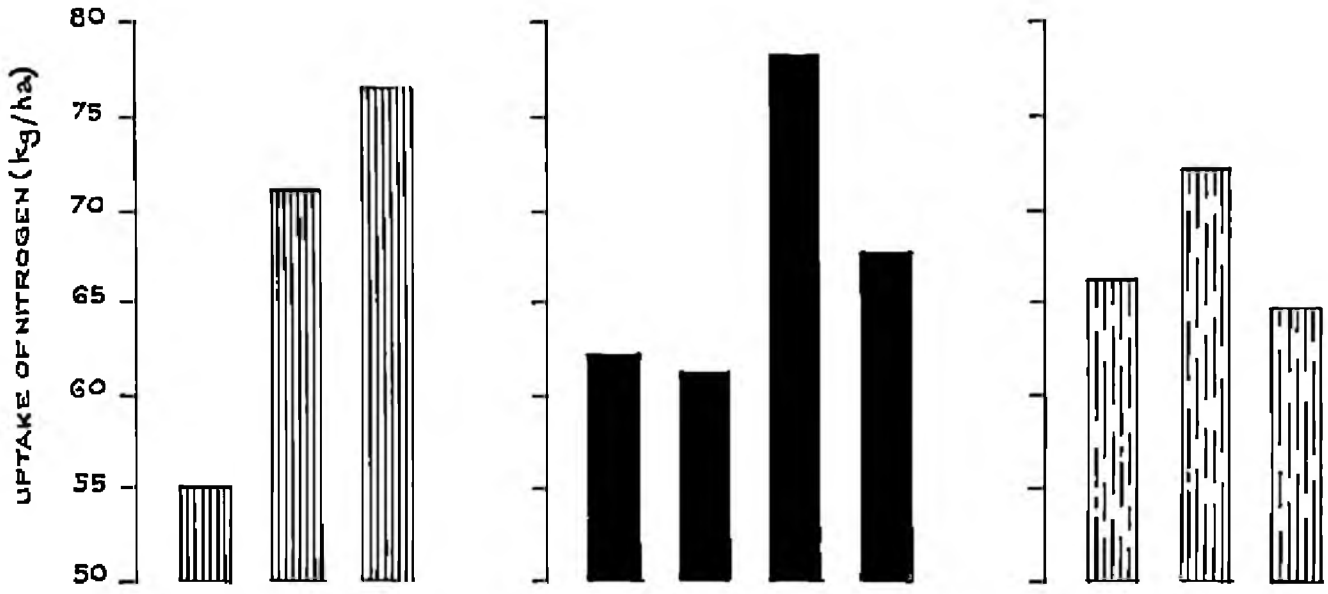



FIG 19 UPTAKE OF PHOSPHORUS

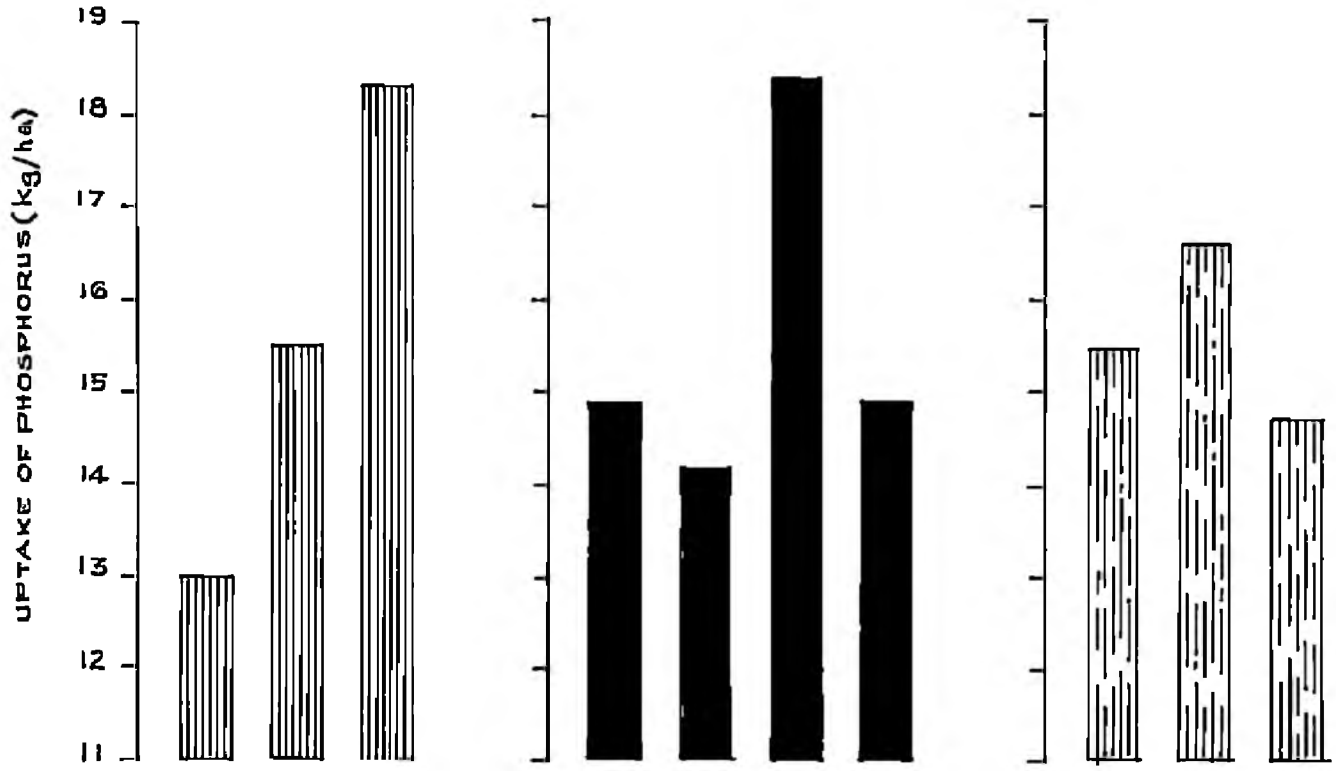
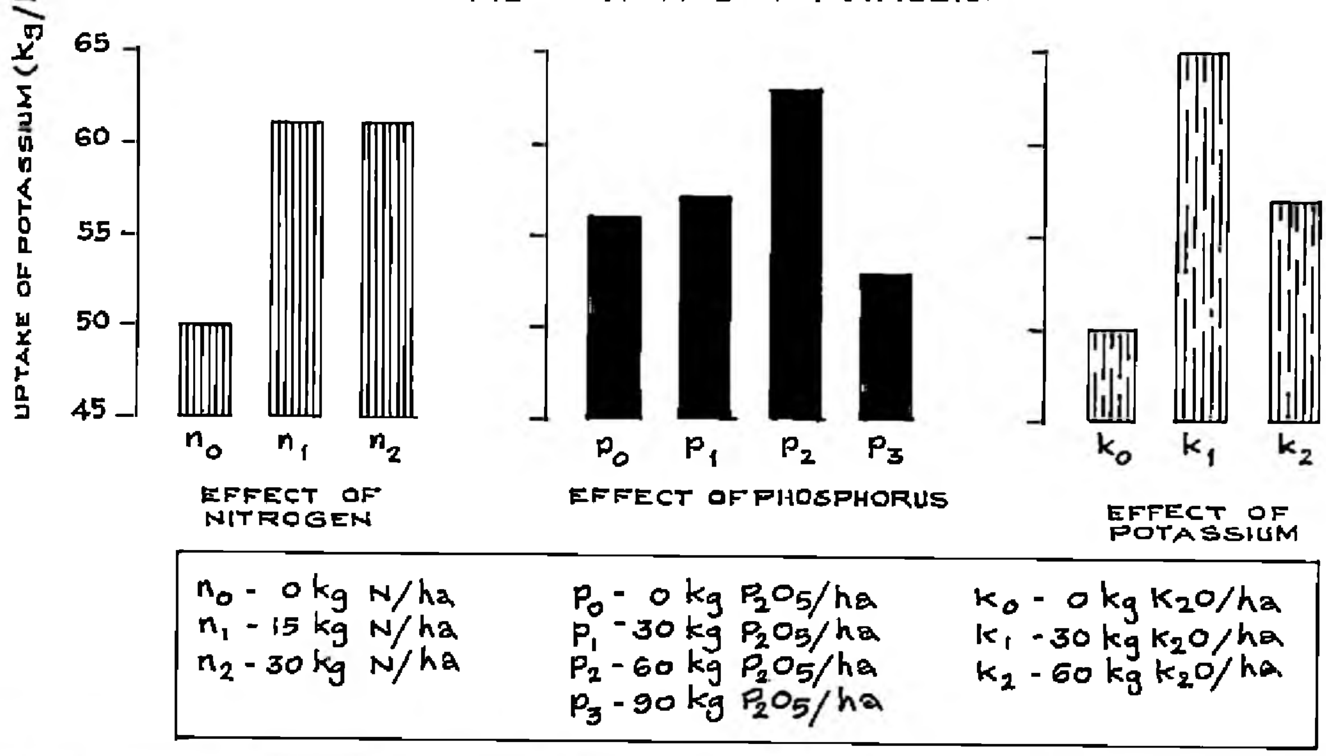



FIG 20 UPTAKE OF POTASSIUM



increase in the pod yield and bhusa yield by potassium is a clear indication of potassium uptake. Further, the higher content of potassium in leaves and pods with higher doses of potassium might have contributed to higher uptake of these elements. Moreover, the luxuary consumption of potassium is a well known phenomenon noticed in crop plants under higher levels of potassium. These factors together might have resulted in the higher uptake of this nutrient. Similar results have also been reported by Johnson and Evans (1975) in southern peas and Singh and Saxena (1978) in Soyabean.

C. <u>NPK content in plant parts.</u>

(a) Nitrogen content in pods.

(Table 20, Appendix XIII)

The non significant effect of nitrogen, phosphorus, potassium and their interaction in the nitrogen content of pods might be due to the non accumulation of this element in the pods as the pods were harvested at half maturity. But an increasing trend was noticed on the nitrogen content of pods due to the higher levels of nitrogen from zero to 15 kg per hectare.

Application of phosphorus slightly increased the nitrogen content of pods showing the favourable influence of this nutrient, though the effect was not significant. Similar non significant effect of phosphorus on the nitrogen content of winged bean pods was also reported by Dagaduan (1980). Similar to nitrogen and phosphorus, levels of potassium and the interaction of nutrients also have not influenced the nitrogen content of pods significantly. Though the effect of nitrogen, phosphorus and potassium on the nitrogen content of pods was not found to be significant, the total nitrogen content in pods due to the higher levels of nitrogen, phosphorus and potassium was substantially high when the total harvest of pods was taken into account.

(b) Nitrogen content of tuber.

(Table 21, Appendix XIII)

As the nitrogen levels were raised increase in the nitrogen content of tuber was significant. The reduced number of tubers and the sufficiency of time for synthesis and accumulation might have contributed to increased content of nitrogen in tubers. This is in agreement with the findings of Posypanov and Knyaseva (1974).

The effect of phosphorus was found to significantly influence the nitrogen content of tubers which might be due to better absorption of the nutrient by the well developed root system of the plants with the addition of phosphorus.

Though the individual effect of potassium was not significant the pk interaction was found significant. This may be due to the combined effect of phosphorus and potassium in increasing the nitrogen content of tuber by increased root formation and tuber development.

(c) Nitrogen content of leaves.

(Table 22, Appendix XIII)

Though the nitrogen application resulted in higher number of leaves per plant, the nitrogen content in the leaves was not significantly affected. Thephosphorus and potassium levels also had no significant effect in increasing the nitrogen content in leaves. This may be due to the fact that though the nitrogen absorption by the plant was increased, with the application of various nutrients the absorbed nitrogen was better utilised for increasing the number of leaves, branches etc. thus keeping the nitrogen content at a minimum.

(d) Nitrogen content of haulms.

(Table 23, Appendix XIII)

Application of nitrogen and phosphorus did not show any significant effect in the nitrogen content of haulms. This might be due to the effect of nitrogen and phosphorus for higher production of haulms rather than in increasing the nitrogen content in haulms.

(e) Phosphorus content of pods.

(Table 24, Appendix XIV)

The results revealed that the application of nutrients had no significant effect in the phosphorus content of pods. Eventhough application of nitrogen and phosphorus had produced increased growth and uptake of phosphorus, the content in the pods remained more or less same. There was no change in the phosphorus content of pods due to potassium as seen earlier. This is quite natural as the level of potassium could not influence the uptake of phosphorus.

(f) Phosphorus content of tuber.

(Table 25, Appendix XIV)

Application of phosphorus alone was found to be significantly influencing the phosphorus content of tuber and the maximum content of 0.398 per cent phosphorus was noted when 30 kg $P_2O_5$ was applied per hectare. In the uptake studies, it was seen that the phosphorus uptake was increased by the application of nitrogen and phosphorus. Though the nitrogen enhanced the absorption and translocation of phosphorus from root to shoot resulting in increased absorption and vegetative growth at earlier stages, phosphorus might not have been effectively translocated from roots to shoots at the later stages of crop maturity and might have accumulated in the tubers. Potassium application had no significant effect in the uptake of phosphorus.

(g) Phosphorus content of leaves.

(Table 26, Appendix XIV)

From the table it is clear that none of the treatment was found to be significant in influencing the phosphorus content of leaves. Though nitrogen and phosphorus application had resulted in increased total uptake of phosphorus, it was better utilised for higher vegetative growth and yield rather its accumulation in the leaves. Johnson and Evans (1975) and Boudreaux (1979) reported that phosphorus application had no effect on the phosphorus content of leaves. The non significant influence of the levels of potassium on phosphorus uptake was observed in the case of leaves also.

(h) Phosphorus content in haulms.

(Table 27, Appendix XIV)

None of the treatments was found to be influencing the phosphorus content in haulms. Application of nitrogen and phosphorus though resulted in the higher uptake of phosphorus the simultaneous increase in vegetative growth due to nitrogen and phosphorus application kept the phosphorus level in haulms without significant variation. potassium had no significant influence on the accumulation of this nutrient.

(i) Potassium content in pods

(Table 28, Appendix XV)

There was no significant effect by nitrogen levels in the potassium content of pods. El-Leboudi et al (1976) reported that nitrogen had no effect on the potassium content in seeds of snap beans. Dalal and Quilt (1977) also have reported a similar finding in pigeon pea.

Potassium uptake of plants is normally independent of the concentration of available or total phosphorus in the soil as reported by Rabieja (1966). The non significant effect of phosphorus in the potassium content of pods observed in this study is in agreement with the above report.

The potassium content of pods increased with higher levels of potassium. The increase on the potassium uptake observed between successive levels of potassium indicates the continued absorption of this nutrient upto the highest level applied. Moreover the luxuary consumption of potassium by plants is well known. The higher absorption of potassium might have resulted in the higher content of this nutrient in pods. Earlier experiment have also shown that application of potassium increased the potassium content of seeds in broad beans (Furlan, 1977).

(j) Potassium content of tuber.

(Table 29, Appendix XV)

Potassium content in the tuber was not influenced by any of the treatments. The main function of nitrogen is to increase the vegetative growth thereby increasing the photosynethtic area. Similarly phosphorus application resulted in the increased root growth and better absorption of nutrient. Since the crop was mainly grown for vegetable purpose and an increase in the absorption of potassium by nitrogen and potassium application would have been utilised more for vegetable growth and yield rather than storing in the roots.

(k) Potassium content of leaves.

(Table 30, Appendix XV)

The application of nitrogen and potassium had no significant influence in the potassium content of leaves. However there was an increase in potassium content in leaves by potassium levels which is a common phenomenon with higher levels of potassium. Higher potassium content in the leaf was also obtained by Yuan et al (1979) when potassium was applied to southern peas.

(1) Potassium content in haulms.

(Table 31, Appendix XV)

None of the treatment was found to be influencing the potassium content in haulms. The potassium that has been absorbed in to the plants might have been translocated to the leaves and pods as was observed in the experiment.

Soil Analysis

(a) <u>Total nitrogen content in the soil after the experiment.</u>

(Table 32, Appendix XVI)

The results revealed that the total nitrogen content of the soil after the experiment was not influenced by any of the treatments. Though the uptake of nitrogen by the plant was increased significantly with applied nitrogen, this loss would have been made up by the enrichment of nitrogen by the root nodules of winged bean. Thus the initial status of soil nitrogen almost remained the same after the experiment.

The effect of phosphorus on the residual nitrogen content of the soil was not significant which may be due to the fact that with increased level of phosphorus and uptake of phosphorus, the uptake of nitrogen was also correspondingly increased. But in the plot with zero level of nitrogen the crop removal was less resulting in the level of soil nitrogen to almost same before the experiment.

Potassium application had no significant influence in this respect. As potassium did not influence the uptake of nitrogen it could not make any change in the soil status of nitrogen also.

(b) Available phosphorus in the soil after the experiment.

(Table 33, Appendix XVI)

The non significant influence of nitrogen, phosphorus, potassium and their interaction on the available phosphorus content of the soil after the experiment revealed that the treatments under this trial had no influence on the residual availability.

The data on the P content of the soil at the time of final harvest substantiates that deep rooted legumes are capable of converting the unavailable subsoil P into available form. According to Raheja (1966) subsoil contain adequate quantities of P which the deep rooted crops are able to tap and make use of in the growth. The results of this present investigation substantiate the unique character of deep rooted legumes. So also uptake of P was also increased with higher levels of P application. Potassium had no significant influence in the uptake of P and total dry matter production.

(c) Available potassium in the soil after the experiment.
(Table 34, Appendix XVI)

The data on the available potassium revealed that increment doses of nitrogen from zero to 15 kg and 30 kg per hectare depressed the available potassium content in the soil. This might be due to the fact that by higher levels of nitrogen the vegetative growth was increased and the plant might have absorbed much of the potassium from the potassium reservoir of the soil resulting in the potassium depletion.

Application of 60 kg $K_2O$ per hectare resulted in the highest content of potassium in the soil while, addition of 30 kg per hectare depleted the available potassium. This is in agreement with the results obtained by Sasidhar (1969).

Economic and Optimum requirement of fertilizers.

Yield response of Nitrogen, phosphorus and potassium was computed statistically and is representbd as

$$y = 68.5045 + 43.5413\ N + 28.3726\ P + 8.0993\ K - 1.1916\ N^2 - 0.2816\ P^2 - 0.086\ K^2 + 0.0056\ NP - 0.0396\ PK$$

Since $NK^2$ interaction is confounded in the experiment, NK term is excluded from the response function. The optimum combination of N, $P_2O_5$ and $K_2O$ was found to be 18, 48 and 36 kg/ha respectively. But the economic optimum was 16 kg N, 42 kg $P_2O_5$ and 29 kg $K_2O$ using the prices of per kg nitrogen, phosphorus and potassium as 9.00, 5.70 and 2.20 rupees respectively and that of beans as rupees 1.5 per kg.

The economics of fertilizer application for the estimated yields at various levels of nitrogen, phosphorus and potassium are given in Table 35. The maximum profit was obtained due to the individual application of 30 kg, N, 60 kg $P_2O_5$ and 30 kg $K_2O$ per hectare when compared to the profit from the lower levels.

# Summary

# SUMMARY

An investigation was undertaken in the Instructional Farm attached to the College of Agriculture, Vellayani, Trivandrum during the period from 27th July, 1982 to 17th January, 1983 to find out the effect of graded doses of nitrogen (0, 15 and 30 kg/ha), phosphorus (0,30, 60 and 90 kg $P_2O_5$/ha) and potassium (0, 30 and 60 kg $K_2O$/ha) on growth characters, yield and yield attributes, quality characters, chemical composition and uptake of macronutrients in winged bean (Psophocarpus tetragonolobus (L.) DC.). A $4 \times 3^2$ confounded factorial experiment was laid out confounding $NK^2$ and higher order interactions in both the replications. The results of the study are summarised below.

1. Different levels of nitrogen had significant effect on the height of plants at 40th day after germination.

2. Significant increase in the number of leaves per plant was noted when 15 kg nitrogen was applied per hectare at all the stages except on 80th day where 30 kg nitrogen per

hectare also increased the number of leaves significantly.

3. Significant increase in the number of branches per plant was observed when 15 kg N was applied per hectare in all stages except at final harvest where 30 kg nitrogen also significantly influenced this character.

4. Application of nitrogen induced earliness in attaining 50 per cent flowering in the plants significantly by about six days.

5. Application of nitrogen as well as a combination of 30 kg N and 90 kg $P_2O_5$/ha resulted in higher production of flowers per plant.

6. Nitrogen at 15 kg per hectare and a combination of 30 kg N and 60 kg $P_2O_5$/ha had significantly increased the number of pods per plant.

7. No significant change in the setting percentage was noted due to any of the nutrients.

8. Application of 15 kg nitrogen, 60 kg potassium and a combination of 15 kg N and 60 kg $P_2O_5$/ha had significantly

increased the length of pods.

9. Nitrogen at 15 kg/ha, phosphorus at 60 kg $P_2O_5$/ha and a combination of 60 kg $P_2O_5$ and 30 kg $K_2O$/ha had significantly increased the yield of pods per plant.

10. Application of 15 kg N/ha, 30 kg $K_2O$/ha and a combination of 60 kg $P_2O_5$ and 60 kg $K_2O$/ha had significant influence in increasing the haulm yield.

11. Application of nutrients individually or at various combination had no significant effect on the yield of tuber.

12. Neither the individual effect of nitrogen, phosphorus and potassium nor their combination were found to be significant in influencing the harvest index.

13. Nitrogen at 15 kg and 60 kg $P_2O_5$/ha only had significant influence in the total dry matter production.

14. Neither the individual nutrients nor their combinations had significantly affected the protein content of pods.

15. Application of 15 kg N and 90 kg $P_2O_5$/ha was found to influence the protein content of tuber significantly over the other levels.

16. The uptake of nitrogen was significantly increased by an application of 15 kg N, 60 kg $P_2O_5$ and a combination of 60 kg $P_2O_5$ and 30 kg $K_2O$ per hectare.

17. Significant increase in the uptake of phosphorus was observed by an application of 30 kg N as well as 60 kg $P_2O_5$/ha.

18. Nitrogen at 15 kg and potassium at 30 kg per ha influenced the uptake of potassium significantly.

19. No significant change in the nitrogen content of pods was observed due to any of the nutrients.

20. Applications of nitrogen (15 kg/ha) and phosphorus (90 kg per/ha) were observed to give significant increase in the nitrogen content of tuber.

21. Neither the individual effect nor the combination of nutrients had significantly imfluenced the nitrogen content of leaves.

22. The level of 60 kg $K_2O$/ha showed a significant reduction on the nitrogen content of haulms.

23. No significant change in the phosphorus content of pods was observed due to any of the nutrients or their combinations.

24. Application of 90 kg $P_2O_5$/ha had significantly reduced the phosphorus content of tuber.

25. None of the treatments was found to be significant in increasing the phosphorus content of leaves and haulms.

26. Application of 30 kg $K_2O$/ha alone had influenced the potassium content of pods significantly.

27. None of the treatments was found to be significantly affecting the potassium content of tuber.

28. Potassium application significantly influenced the potassium content of leaves.

29. No significant influence in the potassium content of haulms was observed due to any of the treatments.

30. The total nitrogen content of soil after the

experiment was not directly influenced by the levels of nutrients.

31. The available phosphorus content in the soil after the experiment was not influenced by the individual effects of nutrients or their combinations.

32. The available potassium content in the soil after the experiment was influenced by the individual effect of potassium and pk interaction.

33. A combination of 16 kg N, 42 kg $P_2O_5$ and 29 kg $K_2O$ was found to be the economic level of nutrients for obtaining maximum profit from winged bean grown for green tender pods.

34. The optimum requirement of N, $P_2O_5$ and $K_2O$ was found to be 18, 48 and 36 kg per hectare respectively for getting maximum yield of pods from winged bean.

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* Originals not Seen.

APPENDIX I

Weather data during the crop year and its variation from the past 25 years
(Feb.1982 - Jan.1983)

| Months | Maximum temperature °C | | | Minimum temperature °C | | | Rainfall (mm) | | | Relative humidity | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Crop year | Average for 25 years | Variation | Crop year | Average for 25 years | Variation | Crop year | Average for 25 years | Variation | Crop year | Average for 25 years | Variation |
| Feb | 31.76 | 31.35 | +0.41 | 20.67 | 22.78 | -2.11 | - | 35.20 | -35.20 | 71.20 | 82.49 | -9.29 |
| Mar | 32.43 | 32.16 | +0.27 | 22.62 | 23.97 | -1.35 | 16.5 | 34.34 | -17.84 | 73.00 | 81.62 | -8.62 |
| Apr | 32.97 | 32.21 | +0.76 | 24.20 | 24.96 | -0.76 | 73.0 | 94.27 | -21.27 | 74.12 | 83.54 | -9.42 |
| May | 32.21 | 31.77 | +0.44 | 23.73 | 24.87 | -1.14 | 254.0 | 193.31 | +60.69 | 79.17 | 85.27 | -6.10 |
| Jun | 29.65 | 30.46 | -0.75 | 22.77 | 23.89 | -1.12 | 500.5 | 299.01 | +201.49 | 81.52 | 85.57 | -4.05 |
| Jul | 30.16 | 29.73 | +0.43 | 22.51 | 23.44 | -0.93 | 120.0 | 217.08 | - 97.08 | 81.82 | 87.43 | -5.61 |
| Aug | 30.05 | 29.77 | +0.28 | 21.25 | 23.21 | -1.96 | 91.0 | 143.82 | - 52.82 | 81.95 | 86.30 | -4.35 |
| Sep | 30.48 | 30.09 | +0.39 | 22.12 | 23.29 | -1.17 | 66.0 | 156.75 | - 90.75 | 79.65 | 86.12 | -6.47 |
| Oct | 30.99 | 29.70 | +1.29 | 22.50 | 23.69 | -1.19 | 181.5 | 266.97 | - 85.47 | 80.64 | 87.68 | -7.04 |
| Nov | 31.03 | 29.95 | +1.08 | 22.36 | 23.77 | -1.41 | 149.0 | 209.85 | -60.85 | 82.40 | 87.24 | -4.84 |
| Dec | 31.30 | 30.62 | +0.68 | 20.70 | 23.19 | -2.49 | 19.5 | 69.44 | -49.94 | 78.02 | 84.78 | -6.76 |
| Jan | 31.58 | 30.91 | +0.67 | 20.54 | 22.41 | -1.87 | - | 33.55 | -33.55 | 69.90 | 80.28 | -10.38 |

Positive sign (+) shows increase over the average data and negative sign (-) the decrease.

APPENDIX II

Abstract of analysis of variance table for height of plants (cm)

| Source | df | Mean Square: Height of plants (cm) |
|---|---|---|
| Block | 5 | 7552.24** |
| N | 2 | 18070.40** |
| P | 3 | 1574.06 |
| K | 2 | 1092.75 |
| NP | 6 | 883.10 |
| PK | 6 | 867.21 |
| Error | 47 | 1911.68 |

** Significant at 0.01 level

* Significant at 0.05 level

## APPENDIX III

Abstract of analysis of variance table for number of leaves per plant at 4 stages

| Source | df | Mean Square | | | |
|---|---|---|---|---|---|
| | | Number of leaves per plant on 50th day after germination | Number of leaves per plant on 90th day after germination. | Number of leaves per plant on 110th day after germination | Number of leaves per plant at the time of final harvest |
| Block | 5 | 48.054 | 627.100 | 3595.14 | 15740.76** |
| N | 2 | 722.389** | 5146.430** | 13198.80** | 18435.30** |
| P | 3 | 193.488 | 589.583 | 1683.73 | 5332.66 |
| K | 2 | 63.59 | 41.180 | 2616.40 | 2172.35 |
| NP | 6 | 192.263 | 556.255 | 84.90 | 711.66 |
| PK | 6 | 125.742 | 774.696 | 1077.11 | 1578.68 |
| Error | 47 | 89.017 | 504.959 | 2373.31 | 1952.26 |

** Significant at 0.01 level

* Significant at 0.05 level

# APPENDIX IV

Abstract of analysis of variance table for number of branches per plant at 4 stages

| Source | df | Mean Square | | | |
|---|---|---|---|---|---|
| | | Number of branches per plant on 50th day after germination | Number of branches per plant on 80th day after germination | Number of branches per plant on 110th day after germination | Number of branches per plant at the time of final harvest |
| Block | 5 | 16.54256** | 44.67482* | 41.2072 | 78.7048** |
| N | 2 | 41.54145** | 100.89280** | 171.6715** | 219.1805** |
| P | 3 | 2.76210 | 11.21943 | 40.1800 | 53.4773 |
| K | 2 | 5.10240 | 0.13735 | 19.6995 | 15.9205 |
| NP | 6 | 1.01876 | 21.96978 | 15.4543 | 9.5688 |
| PK | 6 | 3.81166 | 31.96885 | 32.3526 | 27.2958 |
| Error | 47 | 3.35937 | 16.79279 | 19.0645 | 19.1881 |

** Significant at 0.01 level

* Significant at 0.05 level

## APPENDIX V

Abstract of analysis of variance table for earliness in flowering
(number of days taken for 50% flowering)

| Source | df | Mean Square<br>Number of days taken for 50% flowering |
|---|---|---|
| Block | 5 | 57.78200 |
| N | 2 | 203.45500** |
| P | 3 | 54.51330 |
| K | 2 | 63.84000 |
| PK | 6 | 22.53660 |
| NK | 6 | 20.05000 |
| Error | 47 | 24.97872 |

** Significant at 0.01 level
* Significant at 0.05 level

## APPENDIX VI

**Abstract of analysis of variance table for total number of flowers per plant, number of pods per plant and setting percentage of pods**

| Source | df | Mean Square | | |
|---|---|---|---|---|
| | | Total number of flower per plant | Total number of pods per plant | Setting percentage |
| Block | 5 | 7729.80** | 3500.91** | 321.829** |
| N | 2 | 42010.35** | 3458.37** | 18.589 |
| P | 3 | 3685.20 | 945.73 | 90.797 |
| K | 2 | 1098.95 | 921.38 | 50.070 |
| NP | 6 | 6001.80* | 989.14* | 33.543 |
| PK | 6 | 2536.93 | 457.07 | 85.752 |
| Error | 47 | 2534.51 | 377.85 | 60.874 |

** Significant at 0.01 level

* Significant at 0.05 level

## APPENDIX VII

Abstract of analysis of variance table for length of pods (cm)

| Source | df | Mean Square<br>Length of pods (cm) |
|---|---|---|
| Block | 5 | 2.79140** |
| N | 2 | 2.06450** |
| P | 3 | 0.03260 |
| K | 2 | 9.27400** |
| NP | 6 | 0.71183* |
| PK | 6 | 0.42083 |
| Error | 47 | 0.28034 |

** Significant at 0.01 level

* Significant at 0.05 level

APPENDIX VIII

Abstract of analysis of variance table for yield of green pods per plant

| Source | df | Mean Square | | | | | |
|---|---|---|---|---|---|---|---|
| | | Yield of green pods in first month (g/plant) | Yield of green pods in second month (g/plant) | Yield of green pods in third month (g/plant) | Yield of green pods in fourth month (g/plant) | Total yield of green pods (g/plant) | Total yiled of green pods (kg/ha) |
| Block | 5 | 10903.43* | 28285.70** | 100410.78** | 55793.52** | 594900.00** | 105776000** |
| N | 2 | 23884.39** | 39102.00** | 42256.95** | 11478.05* | 420812.50** | 74815000** |
| P | 3 | 2491.52 | 23945.56** | 25637.33** | 15329.76** | 212074.00** | 37676666** |
| K | 2 | 172.97 | 10373.25 | 5777.80 | 14384.70** | 77000.00 | 13730000 |
| NP | 6 | 1520.19 | 5823.55 | 11400.90 | 2945.25 | 39220.00 | 7385000 |
| PK | 6 | 715.91 | 19670.76** | 14038.21* | 7008.48* | 118018.50* | 21108333* |
| Error | 47 | 3295.17 | 5414.75 | 5185.76 | 2533.42 | 45811.51 | 8060468 |

** Significant at 0.01 level

* Significant at 0.05 level

## APPENDIX IX

### Abstract of analysis of variance table for Bhusa and Tuber yield(kg/ha)

| Source | df | Mean Square | |
|---|---|---|---|
| | | Bhusa yield (kg/ha) | Tuber yiled (kg/ha) |
| Block | 5 | 2162600* | 210322.20 |
| N | 2 | 7366000** | 218035.5 |
| P | 3 | 627000 | 167666.66 |
| K | 2 | 2757500* | 24930.50 |
| NP | 6 | 2619666** | 115944.50 |
| PK | 6 | 876500 | 161736.16 |
| Error | 47 | 655574 | 78818.55 |

** Significant at 0.01 level

* Significant at 0.05 level

APPENDIX IX

Abstract of analysis of variance table for harvest index/ total dry matter production

| Source | df | Mean Square | |
|---|---|---|---|
| | | Harvest index (%) | Total dry matter production (kg/ha) |
| Block | 5 | 426.9940** | 5253200.00** |
| N | 2 | 0.9350 | 4563500.00** |
| P | 3 | 76.217 | 884333.33** |
| K | 2 | 4.355 | 383500.00 |
| NP | 6 | 19.742 | 5166.66 |
| PK | 6 | 58.250 | 567333.33** |
| Error | 47 | 40.440 | 170042.55 |

** Significant at 0.01 level

* Significant at 0.05 level

## APPENDIX XI

Abstract of analysis of variance table for protein content on pods and tuber

| Source | df | Mean Square | |
|---|---|---|---|
| | | Protein content of of tender pods (percentage) | Protein content of tuber (percentage) |
| Block | 5 | 3.6750000 | 7.62720 |
| N | 2 | 0.5960000 | 13.67550* |
| P | 3 | 1.2360000 | 26.90030** |
| K | 2 | 1.1095000 | 0.96800 |
| NP | 6 | 1.4401700 | 2.69883 |
| PK | 6 | 1.6406700 | 7.95217* |
| Error | 47 | 2.3680212 | 3.39570 |

** Significant at 0.01 level

* Significant at 0.05 level

APPENDIX XII

Abstract of analysis of variance table for uptake of nitrogen, Phosphorus & Potassium

| Source | df | Mean Square | | |
|---|---|---|---|---|
| | | Uptake of nitrogen by the plant (N - kg/ha) | Uptake of Phosphorus by the plant ($P_2O_5$-kg/ha) | Uptake of potassium the plant ($K_2O$ - kg/ha) |
| Block | 5 | 4482.18** | 265.0358** | 2322.9460** |
| N | 2 | 3062.75** | 172.5015** | 1084.4450** |
| P | 3 | 1205.35** | 63.0633** | 315.1300 |
| K | 2 | 342.53 | 22.7195 | 1280.6400** |
| NP | 6 | 295.92 | 18.3013 | 404.9833 |
| PK | 6 | 679.37** | 25.5275 | 381.8067 |
| Error | 47 | 164.77 | 11.2740 | 193.0176 |

** Significant at 0.01 level

* Significant at 0.05 level

## APPENDIX XIII

Abstract of analysis of variance table for nitrogen content in pods, tuber, leaf and haulm (Percentage)

| Sourse | df | Mean Square | | | |
|---|---|---|---|---|---|
| | | Nitrogen content in pods (Percentage N) | Nitrogen content in tuber (Percentage N) | Nitrogen content in leaf (Percentage N) | Nitroten content in haulm (Percentage N) |
| Block | 5 | 0.094348 | 0.188060 | 0.418592* | 0.210156** |
| N | 2 | 0.015540 | 0.350100* | 0.092943 | 0.070460 |
| P | 3 | 0.031943 | 0.688626** | 0.038610 | 0.098790 |
| K | 2 | 0.028330 | 0.0244770 | 0.043395 | 0.269940* |
| NP | 6 | 0.036950 | 0.069105 | 0.201966 | 0.299476** |
| PK | 6 | 0.042382 | 0.203593* | 0.306090 | 0.092340 |
| Error | 47 | 0.060304 | 0.087572 | 0.171829 | 0.060259 |

** Significant at 0.01 level

* Significant at 0.05 level

## APPENDIX XIV

Abstract of analysis of variance table for phosphorus content in pods, tuber, leaf and haulm (percentage of P)

| Source | df | Mean Square | | | |
|---|---|---|---|---|---|
| | | Phosphorus content in pods (percentage of P) | Phosphorus content in tuber (percentage of P) | Phosphorus content in leaf (percentage of P) | Phosphorus content in haulm (percentage of P) |
| Block | 5 | 0.000403 | 0.002036 | 0.00594116* | 0.0021671 4* |
| N | 2 | 0.010611 | 0.001340 | 0.00066645 | 0.00065560 |
| P | 3 | 0.010369 | 0.010981** | 0.00173756 | 0.00014646 |
| K | 2 | 0.003969 | 0.001087 | 0.00361750 | 0.00055740 |
| NP | 6 | 0.004654 | 0.003318 | 0.00256476 | 0.00076443 |
| PK | 6 | 0.004664 | 0.001460 | 0.00261268 | 0.00125650 |
| Error | 47 | 0.005969 | 0.002265 | 0.00217108 | 0.00082635 |

** Significant at 0.01 level

* Significant at 0.05 level

## APPENDIX XV

Abstract of analysis of variance table for potassium content in pods, tuber, leaf and haulm (Percentage of K)

| Source | df | Mean Square | | | |
|---|---|---|---|---|---|
| | | Potassium content in pods (Percentage of K) | Potassium content in tuber (Percentage of K) | Potassium content of leaf (Percentage of K) | Potassium content of haulms (Percentage of K) |
| Block | 5 | 0.725222 | 0.099656 | 0.073918 | 6.14806** |
| N | 2 | 0.012640 | 0.050140 | 0.281845 | 0.158475 |
| P | 3 | 0.210000 | 0.203150 | 0.031526 | 0.292360 |
| K | 2 | 1.827640** | 0.010975 | 0.610350** | 0.089305 |
| NP | 6 | 0.373195 | 0.145503 | 0.019035 | 0.220138 |
| PK | 6 | 0.198195 | 0.032925 | 0.130783 | 0.088195 |
| Error | 47 | 0.337009 | 0.076996 | 0.094097 | 0.183642 |

** Significant at 0.01 level

* Significant at 0.05 level

## APPENDIX XVI

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

(kg/ha)

| Source | df | Mean Square | | |
|---|---|---|---|---|
| | | Total nitrogen content in the soil after the experiment (N - kg/ha) | Phosphorus content in the soil after the experiment (P-kg/ha) | Potassium content in the soil after the experiment (K-kg/ha) |
| Block | 5 | .00023064 | 30846.776** | 1410.414 |
| N | 2 | .00002045 | 752 .540 | 477.935 |
| P | 3 | .00007420 | 3267.420 | 874.530 |
| K | 2 | .00012345 | 1004.645 | 3749.890** |
| NP | 6 | .00040438* | 1284.636 | 359.430 |
| PK | 6 | .00003595 | 377.456 | 2492.210** |
| Error | 47 | .00016117 | 1169.112 | 581.765 |

** Significant at 0.01 level

* Significant at 0.05 level

# NUTRITIONAL REQUIREMENTS OF WINGED BEAN [*Psophocarpus tetragonolobus* (L.) DC.]

by

**C. BRILLIN**

ABSTRACT OF A THESIS

submitted in partial fulfilment of the requirement for the degree

**MASTER OF SCIENCE IN AGRICULTURE**

Faculty of Agriculture

Kerala Agricultural University

DEPARTMENT OF AGRONOMY

COLLEGE OF AGRICULTURE

VELLAYANI, TRIVANDRUM

1984

ABSTRACT

An experiment was conducted in the Instructional Farm attached to the College of Agriculture, Vellayani during 1982 - 1983 to study the effect of four levels of phosphorus (0, 30, 60 and 90 kg $P_2O_5$/ha) and three levels each of nitrogen (0, 15 and 30 kg/ha) and potassium (0, 30 and 60 kg $K_2O$/ha) on growth, yield, quality, uptake and chemical composition of the plant parts in winged bean (Psophocarpus tetragonolobus (L.)DC.) The field trial was laid out as a $4 \times 3^2$ confounded factorial experiment confounding $NK^2$ and higher order interactions in both the replications.

The study revealed that application of nitrogen at higher levels only had significant influence on the height of plant, number of leaves and the number of branches.

The yield and yield attributes revealed significant increase with the increase in the levels of nitrogen. Higher levels of nitrogen induced earliness in flowering, increased the number of flowers, pods, yield of green pods, bhusa and total dry matter production. Application of phosphorus at 60 kg $P_2O_5$ per hectare had significant influence on the yield of pods and total dry matter production. The length of pods and the bhusa yield were increased by potassium application. N x P interaction was found to be significantly influencing the production of flowers, pods and the length of pods. Similarly P x K interaction was found to be significant in the yield of green pods and bhusa yield.

The protein content of winged bean tuber which is known to be edible was influenced by the application of nitrogen and phosphorus. Results revealed that the uptake of nitrogen and phosphorus were significantly increased with the higher levels of these elements. So also the application of nitrogen and potassium increased the uptake of potassium.

Higher nitrogen content was obtained in the tuber by the application of nitrogen but it reduced the phosphorus content. The potassium content of pods and leaves were influenced by the application of potassium. The total nitrogen and available phosphorus in the soil after the experiment were not directly influenced by the levels of nitrogen, phosphorus and potassium.

A dose of 16 kg N, 42 kg $P_2O_5$ and 29 kg $K_2O$ was found to be the economic level of nutrients for winged bean grown for the green tender pods. But the optimum requirement was found to be 18 kg N, 48 kg $P_2O_5$ and 36 kg $K_2O$ per hectare.

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