NUTRITIONAL REQUIREMENT OF GREEN GRAM [*Vigna radiata* (L.) Wilczek]

By

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THESIS

submitted in partial fulfilment of the requirement for the degree

MASTER OF SCIENCE IN AGRICULTURE

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DECLARATION

I hereby declare that this thesis, entitled "Nutritional requirement of green gram (*Vigna radiata* (L.) Wilczek)" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

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Vellayani,

28th February, 1980.

DECLARATION

I hereby declare that this thesis, entitled "Nutritional requirement of green gram (*Vigna radiata* (L.) Wilczek)" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship, or other similar title, of any other University or Society.

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28th February, 1980.

CERTIFICATE

Certified that this thesis, entitled "Nutritional requirement of green gram (Vigna radiata (L.) Wilczek)" is a record of research work done independently by Smt. GAVITHRI, K.S., under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship, or associateship to her.

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INTRODUCTION

INTRODUCTION

In India where more than 80 per cent of the population depends on vegetable sources to meet their protein requirements, the grain pulses form the essential protein component in their diet. In addition to this the bhusa is used as fodder and the husk of the pods and small broken pieces are invariably used for incorporation in feed concentrate for cattle, poultry and other animal sources of protein. In the foreseeable future with the present trend of population growth unless immediate steps are taken to boost the currently stagnant pulse production in this country, India will be faced with a protein malnutrition problem, especially for more than 80 per cent of the low income group segment of its population.

An analysis of the per capita availability of pulses reveals that in the last two decades it has decreased from 60 g/day to 40 g/day in the diet compared to the recommended level of 104 g/day. This is mainly because of the stagnancy in pulse production as against the increasing demand entailed by a growing population. During 1977-78, 11 million tonnes of pulse grain was produced from a total cultivated area of 23 million hectares. The prospects of increasing area under pulses are very slender. But however crop improvement programmes, agronomic manipulations for increased yield etc. are being attempted by ICAR, ICRISAT and the various Agricultural Universities.

Kerala accounts for only about 0.15 per cent of the total cultivated area under pulses and about 0.1 per cent of the total production in grain pulses. The average yield of grain pulses in Kerala comes to only 411 kg/ha which is slightly less than the Indian average of 478 kg/ha. Kerala has adopted a two fold strategy of increasing the area under pulse cultivation. These are to utilise the residual moisture in the summer fallow of rice fields (December-April) when many of the pulse crops are also free from disease. The other is to grow the pulses in coconut gardens during the South West Monsoon period.

From among a cafeteria of pulse crops available for cultivation in rice fallows and in coconut gardens, the more promising types of grain pulses that have been found to be suitable are cowpea, green gram and black gram. For cultivation in rice fallows short duration and photoinsensitive varieties of these crops are to be preferred. The Department of Agriculture in Kerala in its pulse development programme especially in summer fallows is faced with a number of problems especially with regard to a proper recommendation of N, P and K for optimum yields. The various nutritional and agronomic aspects for increasing the yield in summer fallows are yet to be accurately assessed. To fill this research gap especially for green gram, an experiment was laid out with a short duration variety, Pusa Baisakhi with the following

Immediate objectives.

1. To assess the effect of different levels of nitrogen, phosphorus and potash on green gram and to determine the optimum levels of each.

2. To find out a suitable combination of N, P and K for maximum crop yields under Kerala condition, in rice fallows.

3. To study the quality of grains as affected by different levels of nutrients.

4. To investigate other agronomic characters as affected by different levels of nutrients.

5. To work out the economics of nitrogen, phosphorus and potash application.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

An experiment was conducted with the object of studying the effects of different levels of nitrogen, phosphorus and potash on green gram and to find out a suitable combination of N, P and K for maximum yield and quality of the crop in rice fallows. The review pertaining to the aspects of study in green gram is given below. Similar works on other leguminous crops are also included in the review wherever the literature is insufficient on green gram.

A. Nitrogen

a. Effect of nitrogen on growth

Application of 50 or 100 kg N/ha was necessary for early growth of mung beans (Phaseolus aureus = Vigna radiata) and it had no effect on later development, presumably because effective N fixing bacteria were present in the soil (Lochaiyukul et al., 1970).

Bhattacharya (1971) observed that on lateritic acid soil, the vegetative growth of horse gram (Dolichos biflorus Roxb.) in respect of vines and number of branches per plant was significantly influenced by application of 22.5 to 45 kg N/ha.

In an experiment conducted in lower uplands of Regional Research Station, Chiplima, Sambalpur (Orissa) during rabi season, plant height and number of branches/plant of green gram variety Pusa Baisakhi was increased from 27.6 to 30.4 cm and 3.5 to 4 respectively with increasing levels of N from 0 to 60 kg N/ha (Panda, 1972). In a trial during the Kharif season with pigeon pea (Cajanus cajan), application of 20 and 40 kg N/ha increased the vegetative growth, height and number of branches per plant over control (Lenka and Satpathy, 1976).

In a field experiment conducted during rabi season at Tirupathi with Pusa Baisakhi green gram on a sandy loam soil, plant height and number of primary branches per plant differed significantly due to N levels (15 - 30 kg/ha) with or without inoculation (Subbaiah, 1978).

b. Effect of nitrogen on nodulation

In pot trials with gram plants given the treatments of N (0.0001 - 0.0003 kg N/pot) and/or P produced higher number of nodules/plant than untreated plants (Pandey, 1969). With 277 mg N/pot, Phaseolus vulgaris fixed the highest amounts of atmospheric N, 563 mg/pot, and developed the highest number of nodules (Kozlov, 1970).

In a pot trial with peas, increase in N to > 600 mg/pot decreased nodulation upto 25 - 42 days after emergence. At maturity, high levels of N (600 and 1200 mg N/pot) did not affect the number of nodules/plant but decreased the total volume of nodules per plant and dry matter yield of nodules (Hubes, 1970). When application of 90 kg N/ha to black beans (Phaseolus vulgaris) was found to reduce nodulation (Sistachs, 1970), application upto 22.5 kg N/ha to chick pea increased the number and dry weight of nodules by 17 per cent and 7 per cent respectively (Singh, 1971). Panfilova (1972) also noted that in peas, application of 20 kg N/ha markedly increased nodule production.

Application of nitrogen especially at higher rate (80 kg N/ha) suppressed the development of root nodules in *Phaseolus vulgaris* (Koinov and Petkov, 1975).

Koslov (1977) observed that in peas, N applied at 20 to 40 kg/ha increased the number of nodules from 49 root nodules per plant with no N to 77 to 86 nodules per plant.

Papanicolaou *et al.* (1977) noted that in beans nodule weight per plant decreased with increasing rate of applied N from 0 to 120 kg/ha.

In peas, a direct correlation was found between N rate (100, 200 or 300 ppm N) and nodulation inhibition (Rubes, 1977).

c. Effect of nitrogen on yield and yield attributes

Moolani and Jana (1965) found that on an acidic lateritic soil with a high fixation capacity for phosphate, application of 25 kg N/ha without P reduced the yield of green gram by about 5 per cent. Pathak *et al.* (1968) observed that the average yields of *Phaseolus aureus*, *Phaseolus mungo* and *Phaseolus aconitifolius* were higher on plots given no N (151.2 kg grain/ha) than on those given N, 45 or 90 kg N/ha (124.8 to 126.8 kg/ha). While Wattribhop and Ferraris (1970) found that application of 75 kg N/ha increased seed yields, hay yields and total dry matter production by about 30 per cent in *mung*.

Choudhary and Bhatia (1971) observed that the yields of *mung* variety Pusa Baisakhi were increased by 42 and 72 per cent with 125 kg ammonium sulphate/ha applied broadcast and in rows 5.6 cm below the seed respectively, over no fertilizer application which gave average seed yield of 470 kg/ha.

In an experiment conducted in lower upland during the *rabi* season with *mung* variety Pusa Baisakhi, length of pod and average weight of seeds per plant were increased with application of 30 and 60 kg N/ha over no nitrogen, from 6.3 to 6.4 and 6.5 cm, 5.1 to 6.3 and 7.3 g respectively. The highest yield of grain (8.61 q/ha) and bhusa (74.4 q/ha) were obtained from 60 kg N/ha level (Panda, 1972).

In a pot trial with black gram (*Phaseolus mungo* = *Vigna mungo*) variety Pusa-1 in a non-calcareous red soil of coimbatore, significant treatment differences for levels of N(0, 30 and 60 kg N/ha) were recorded in seed yield. Application of 30 kg N/ha was superior to control and 60 kg N/ha which were on par (Rajendran *et al*., 1974). Venugopal and Morachan (1974) reported that application of 10 - 30 kg N/ha had no significant effect on yields of 2 green gram cultivars, Rajendran and Pusa Baisakhi. N individually had no significant influence on seed yield and pod number. Application of 20 and 30 kg N/ha increased the 1000 grain weight significantly, while application of 10, 20 and 30 kg N/ha increased the dry matter production.

The results of the experiment carried out during *kharif* season at Punjab Agricultural University, Ludhiana revealed that on light soils application of 17 and 34 kg N/ha increased the yield of black gram significantly over 'no nitrogen' control from 8.1 to 9.0 and 9.3 q/ha respectively (Sawhney *et al.*, 1975).

In a field trial conducted with *moong* on a sandy loam soil of Bihar Agricultural College Farm during summer season, supply of 10 and 20 kg N/ha significantly increased the number of pods per plant, number of grains per pod and 1000 grain weight over no nitrogen from 11.7 to 13.6 and 15.9, 9.6 to 10.4 and 10.9, 23.4 to 24.9 g respectively. The yield of grain increased from 678 - 798 kg/ha with increasing level of N from 10 to 20 kg/ha whereas further increase in N level to 30 kg/ha showed significantly decreasing trend in respect of all characters studied including grain production (655 kg/ha). The plot receiving no nitrogen produced the lowest grain yield of 548 kg/ha (Singh *et al.*, 1975).

Panwar *et al.* (1976) noted that in green gram, there was no response to the application of 15 - 30 kg N/ha. Panwar and Ghalghule (1977) observed that the grain yield of *mung* was increased from 14.85 per cent to 60.84 per cent due to various treatments with rhizobium, azotobacter and nitrogen over control. Maximum grain yield of 826.09 kg/ha was obtained in the case of azotobacter seed inoculation + 25 kg N/ha which was on par with rhizobium seed inoculation + 25 kg N/ha

(750.28 kg/ha). Thousand grain weight was not found to be altered significantly due to various treatments. Significant increase in dry matter weight was recorded in the treatment rhizobium + azotobacter + 25 kg N/ha which may be due to profuse vegetative growth due to this treatment.

Panwar et al. (1977) found that in black gram variety T.9 optimum dose of nitrogen was 15 kg N/ha which increased the grain yield by 13.4 per cent (155 kg/ha) with 10.27 kg/kg N response over no nitrogen. The number of pods/plant was increased by nitrogen application at 15 kg/ha with no further improvement by additional dose. The plant stand, branching and grains per pod were unaffected. Thus pods per plant seems to be the yield component closely associated with the increased grain yield of black gram as a result of nitrogen application.

In a field trial made during kharif at the University of Agricultural Sciences, Bangalore on red sandy loam soil having medium fertility level, under rainfed condition, the response of green gram to 30 kg N/ha was significant for the pod and grain yield. Pod yield increased from 9.5 to 14.9 q/ha and grain yield from 5.2 to 8.8 q/ha with the application of 30 kg N/ha over control (Thime Gowda and Krishna Gowda, 1978).

In a field experiment conducted during rabi season at Tirupathi with green gram variety Pusa Baisakhi on a sandy loam soil low in organic carbon, medium in available phosphorus and potassium, the yield attributes were significantly influenced by nitrogen levels. Among the nitrogen levels of 0, 15 and 30 kg N/ha with or without inoculation tried, maximum grain yield of 1,220 kg/ha was obtained with inoculation + 15 kg N/ha followed by 1,183 kg/ha with inoculation alone, which were on par. But they were significantly superior to the rest of the treatments. The maximum dry matter production was also observed with inoculation + 15 kg N/ha (Subbaiah, 1978).

d. Effect of nitrogen on quality and uptake of nutrients

In field beans, plant N content tended to be decreased at low rates of applied nitrogen but was increased to 3.29 per cent at the highest level of applied nitrogen, compared with 2.54 per cent where none was applied (Bains, 1967).

In an experiment conducted with peas at I.A.R.I., New Delhi, the protein percentage of grains increased progressively with an increase in the level of nitrogen (Singh et al., 1969). Singh (1970) observed that in gram (Cicer arietinum) applications of 22.5 kg N/ha increased protein content to 16.3 per cent compared with 14.73 per cent.

Sinha (1971) noted that in peas, 10 kg N/ha had no effect over unfertilized control in the uptake of total P by the plant.

Protein content in grains of peas was significantly increased due to application of 20 kg N/ha (Garg et al., 1971). Arora and Luthra (1972) observed that in green gram application of N, P and S gave seed protein contents of 19.88 to

24.31 per cent compared with 19.69 per cent with the nutrient solution given no N, P or S. But in a trial with cowpeas on sandy loam soil, application of 20 - 40 kg N/ha had no effect on seed protein content (Malik et al., 1972).

In gram, protein, N and P_2O_5 contents of the grain and straw were considerably increased by the application of 11.25 and 22.5 kg N/ha (Singh, 1971). Rajendran et al. (1974) observed that in black gram seed protein content increased with increasing levels of N from 0 - 60 kg/ha.

B. Phosphorus

a. Effect of phosphorus on growth

Deshpande and Bathkal (1965) found that in mung height of plant increased significantly from 21.5 cm to 26.2 cm with the increase of P_2O_5 from 0 to 60 lb/acre. A significant increase in growth of mash and mung was noted when superphosphate was applied at the rate of 60 kg P_2O_5/ha (Kanwar Singh and Jagjit Singh Virk (1965). In a trial with green gram on an acidic lateritic soil with a high fixation capacity for phosphate, a greater plant height was observed with application of 100 kg P_2O_5/ha (Moolani and Jana, 1965).

In an experiment conducted in lower upland in Orissa during rabi season, plant height of green gram variety Pusa Baisakhi was increased from 28 - 29.2 cm with increasing levels of P from 0 to 90 kg P_2O_5/ha (Panda, 1972).

In pot trials with Urid and mung application rates of 120 kg P_2O_5/ha to Urid and 80 kg P_2O_5/ha to mung were optimum for increasing growth (Ravankar et al., 1972).

In an experiment conducted with _mung_ during _kharif_ at the Punjab Agricultural University, Ludhiana in a loamy sand soil testing low in available P, application of P upto 40 kg P_2O_5/ha resulted in taller plants (21 cm) over control (18.8 cm) (Kaul and Sekhon, 1976).

In a field experiment conducted during _rabi_ season at Tirupathi with Pusa Baisakhi green gram on a sandy loam soil, plant height and number of primary branches per plant differed significantly due to P levels (P_0 - no phosphorus, P_1 - 13 kg P/ha, P_2 - 26 kg P/ha and P_3 - seed soaking in 1 per cent KH_2PO_4 solution for 12 hrs) (Subbaiah, 1978).

Rollin Bhaskar (1979) observed that plant height and L A I of green gram variety M-2 were significantly increased by application of 12.5 - 50 kg P_2O_5/ha over no P application which also resulted in higher dry matter production.

b. Effect of phosphorus on nodulation

Deshpande and Bathkal (1965) reported that in _mung_ cv. Kopargaon application of 40 and 60 lb P_2O_5/ac significantly increased the number of nodules per plant over control.

In pot trials with _urid_ and _mung_ given 0 - 120 kg P_2O_5/ha as single superphosphate, 120 kg P_2O_5/ha to _urid_ and 60 kg P_2O_5/ha to _mung_ were found optimum for increasing nodulation (Ravankar _et al._, 1972). Sahu (1973) noted that in black gram, rhizobium inoculation and application of 22.4 kg P_2O_5/ha increased number of nodules per plant from 5.66 to 16.9 and 5.6 to 15.6 respectively. While Tej Singh _et al._

(1975) suggested that in moong application of 0 to 75 kg P_2O_5/ha may stimulate nodule production.

In a field trial conducted during rabi season at Tirupathi with Pusa Baisakhi green gram on a sandy loam soil low in organic carbon, medium in available phosphorus and potassium, number and weight of nodules increased with increase in phosphorus levels from 0 to 26 kg P/ha (Subbaiah, 1978).

c. Effect of phosphorus on yield and yield attributes

In an experiment to compare the effects of various levels of phosphorus on green gram, the response of the crop to 20, 40 and 60 lb P_2O_5/ac was found to be linear indicating increase in pulse yield (32, 38.6, 56.2, 59.4 kg/ac respectively) and green weight. The number of pods per plant and weight of pods per acre were significantly increased by 40 and 60 lb P_2O_5/ac over control from 3.73 to 4.77 and 5.36, 62.8 to 99.9 and 104.7 kg respectively (Deshpande and Bathkal, 1965).

The application of superphosphate at 60 kg P_2O_5/ha without N produced average response of 50 per cent in case of mash and 46.4 per cent in case of moong over control (Kanwar Singh and Jagjit Singh Virk, 1965).

Moolani and Jana (1965) found that on an acidic lateritic soil with a high fixation capacity for phosphate, 100 kg P_2O_5/ha significantly increased the yield of green gram when applied with (916.4 kg/ha) or without N (880.2 kg/ha) over control

(654.2 kg/ha). Number of branches and number of pods with 100 kg P_2O_5/ha were found to be greater.

It was thought that about 25 per cent increase in grain yield of legumes such as chickpea, peas, Phaseolus mungo, Phaseolus aureus, lentil, lathyrus and Dolichos biflorus can be brought about by applying 33.6 kg P_2O_5/ha and a further 15 per cent yield increase can be obtained by increasing the P_2O_5 rate to 67.2 kg/ha (Prasad et al., 1968).

In trials with green gram grown in the kharif season during 4 years, application of 44.84 kg P_2O_5/ha or 44.84 kg P_2O_5 + 5600 kg f.y.m./ha increased average grain yields by 0.64 and 1.31 h.kg/ha, respectively, yields on unfertilized plots were 6.92 h.kg/ha. From this it was concluded that application of P_2O_5 alone or with f.y.m. should be given to increase the yield of green gram (Sreenivas et al., 1968).

A field experiment conducted during the summer seasons of 1969 and '70 at I.A.R.I., New Delhi to test the response of mung variety Pusa Baisakhi to three phosphate levels revealed that application of 33 kg P_2O_5/ha increased yields from 5.58 to 7.27 q/ha of grain in summer 1969 and from 4.36 to 7.28 q/ha in summer 1970. When phosphorus was applied at the rate of 66 kg P_2O_5/ha the yield increased to 9.7 and 8.47 q/ha in 1969 and 1970 respectively (Bhatia and Chowdhury, 1972).

In an experiment conducted in lower uplands of Orissa during rabi season, length of pod and average weight of seeds per plant increased from 6.2 to 6.6 cm and 5.6 to 6.7 g respectively with increasing levels of P from 0 - 90 kg P_2O_5/ha in green gram variety Pusa Baisakhi. Highest yield of grain (8.39 q/ha) and bhusa (68.1 q/ha) were recorded from 90 kg P_2O_5/ha level while the lowest yield of grain (5.65 q/ha) and bhusa (56.6 q/ha) were obtained from no P control (Panda, 1972).

In trials with 2 green gram cultivars, Pusa Baisakhi and Rajendran, application of 20 kg P_2O_5/ha increased seed yields from 698 kg/ha without P to 781 kg/ha; further increase in P rates decreased them. As the investigation was carried out in a calcareous sandy loam soil, medium in available P, the yield increases to the addition of fertilizer P were meagre (Venugopal and Morachan, 1974). In a field experiment conducted with Pusa Baisakhi mung during pre-kharif season, there was no response to phosphorus due to harmful effects of rice bean on the succeeding crop of mung (Jana et al., 1975). In trials with mung variety Pusa Baisakhi, seed yields were increased from 583 to 632 and 776 kg/ha by increasing P_2O_5 rate from 0 to 20 and 40 kg/ha; further yield increase with 60 kg P_2O_5/ha was not significant (Panwar and Kanwar Singh, 1975).

In a field trial conducted with moong on a sandy loam soil of Bihar Agricultural College Farm during summer season showed that increasing levels of P from 0 to 60 kg/ha significantly increased grain yield from 515 to 781 kg/ha along with favourable effect on other yield attributes. Number of pods per plant, number of grains per pod and 1000 grain weight increased from 10.5 to 15.9, 9.3 to 11.0 and 23.7 to 26.8 g respectively. The difference in number of seeds/pod due to 20 and 40 kg P_2O_5/ha were not significant (Singh et al., 1975).

In field trials with two moong varieties J-781 and H-45 on sandy loam soil revealed that grain yields were not significantly improved by increasing the application rate of P from 0 - 75 kg P_2O_5/ha (Tej Singh et al., 1975).

Agarwal et al. (1976) reported that in summer mung, yields were increased from 0.77 tonne with 25 kg P_2O_5/ha to 0.93 tonne with 50 kg P_2O_5/ha, and decreased thereafter with 75 kg P_2O_5/ha.

An experiment conducted during kharif season at Punjab Agricultural University, Ludhiana on a loamy sand soil testing low in available P, revealed that P application increased the grain yield of mung significantly and the increase being significant upto 40 kg P_2O_5/ha. Beneficial effect of P application on the pods/plant, seeds/pod and 100 grain weight contributed for increased grain yield. P application also increased dry matter production (Kaul and Sekhon, 1976).

In trials with green gram, increasing the P_2O_5 rates from 0 to 30 and 60 kg/ha increased average seed yields from 0.86 to 1.00 and 1.13 t/ha, respectively. The economic optimum P_2O_5 rate was 51 kg/ha with a yield response of 4.79 kg seed/kg P_2O_5 (Panwar et al., 1976).

In three varieties of *mung*, ML-5, Jawahar-45 and Pusa Baisakhi, application of 30 kg P_2O_5/ha gave significantly higher yield over control. While ML-5 has the capacity to produce higher yield with 60 kg P_2O_5/ha over control and 30 kg P_2O_5/ha, higher level of P_2O_5 has not proved its significance with Jawahar-45 and Pusa Baisakhi (Singh, 1976).

Panwar *et al.* (1978) reported that in green gram, application of 30, 60 and 90 kg P_2O_5/ha had a significant effect in increasing grain yield over control. Yields were increased from 10.1 to 11.1, 11.8 and 11.5 q/ha with the application of 30, 60 and 90 kg P_2O_5/ha respectively. There was significant linear increase in yield upto 60 kg P_2O_5/ha application, after which, there was a trend of reduction in yield. Test weight and number of pods/plant also support the response upto 60 kg P_2O_5/ha.

In a field trial made during *kharif* season on red sandy loam soil having medium fertility level, under rainfed condition, revealed that response of green gram to 60 kg P_2O_5/ha alone was significant for the pod and grain yield. Most of the yield contributory factors were significantly affected by P fertilizers (Thime Gowda and Krishna Gowda, 1978).

In a field experiment conducted during *rabi* season at Tirupathi with Pusa Baisakhi green gram on a sandy loam soil, low in organic carbon, medium in available phosphorus and potassium, with increase in levels of P, the grain yield also increased. Highest grain yield of 1,449 kg/ha was obtained at 26 kg P/ha which can be attributed to more number of primary branches, number of pods/plant, number of seeds/pod and highest test weight. Highest harvest index of 0.385 was obtained with 26 kg P/ha (Subbaiah, 1978).

Rollin Bhaskar (1979) observed that in green gram variety M-2 yield components like number of pods and clusters per plant were significantly increased by increasing levels of P from 0 - 50 kg P_2O_5/ha which resulted in higher grain yield. None of the treatments influenced favourably the pod length and number of seeds per pod. Phosphorus application increased the thousand grain weight during summer season alone. The results of the experiment indicated that application of phosphorus above 25 kg P_2O_5/ha did not significantly increase the yield.

d. Effect of phosphorus on quality and uptake of nutrients

The application of phosphatic fertilizers to urd crop (Vigna mungo) resulted in increased concentration of all the nutrients and particularly of phosphate in the plant (Hari Shanker and Kushwaha, 1971).

Sahu and Behera (1972) reported that in cowpea, groundnut and greengram, N content in shoot, root and grains increased significantly by phosphate manuring at the rate of 22.4 kg/ha. The protein content of grains of cowpea, groundnut and green gram were 25.3, 31.2 and 23.7 per cent under control increased to 28.3, 32.2 and 25.2 per cent due to inoculation and application of 22.4 kg P_2O_5/ha.

In pot trials with urd application of 50 kg P_2O_5/ha increased plant uptake of N, P, K and Mo (Kadwe and Badhe, 1973). Radioassay studies of the shoots and seeds of *Phaseolus mungo* cv. Pusa-1 indicated that the uptake of fertilizer P increased with increases in applied P from 0 to 90 kg P_2O_5/ha (Rajendran *et al.*, 1973). In another pot experiment with *Phaseolus mungo* grown from inoculated or uninoculated seeds, P contents increased by increasing levels of P from 0 - 90 kg P_2O_5/ha (Rajendran *et al.*, 1974).

Trials with 2 green gram cultivars, Rajendran and Pusa Baisakhi showed that high levels of P (40 and 60 kg P_2O_5/ha in the absence of applied N did not effect a corresponding increase in P content of the plant. At low levels of N (10 kg N/ha), increased application of P favoured nitrogen uptake. The P removal by green gram ranged between 5 and 10 kg/ha. Green gram with this low uptake capacity when raised in a soil medium in available P (22 kg P_2O_5/ha) naturally cannot be expected to respond well to the additions of fertilizer P. Uptake of N, P and K was lower in Pusa Baisakhi (Venugopal and Morachan, 1974).

Panwar and Kanwar Singh (1975) found that in Pusa Baisakhi *mung*, seed protein content increased from 18.38 to 19.74 per cent with increasing P rates from 0 to 20 and 40 kg P_2O_5/ha.

Rajendran and Krishnamoorthy (1975) reported that in black gram grown in a non-calcareous red soil of Coimbatore, the uptake of N was significantly influenced by the levels of 30, 60 and 90 kg P_2O_5/ha in the shoots, seed and husk samples. With increase in levels of P from 0 - 90 kg P_2O_5/ha, the uptake of P increased in all samples.

A pot culture experiment conducted during the Kharif season using black soil with medium phosphate status at Nagpur revealed that in urid, mung and soyabeans, application of P at the rate of 40, 80 and 120 kg P_2O_5/ha increased seed contents of proteins and N and P uptake by plants (Ravankar and Badhe, 1975).

In trials with black gram (*Vigna mungo*) on red sandy loam soil having pH 5, application of 1 tonne lime + 96 kg P_2O_5/ha increased seed N and P uptake (Badanur *et al.*, 1976). Rollin Bhaskar (1979) observed that in green gram var. M-2 the uptake of nutrients like, N, P and K was found to be higher with increased levels of P from 0 - 90 kg P_2O_5/ha.

C. Potassium

a. Effect of potassium on growth

Reiss and Sherwood (1965) found that plant height of soyabean was not significantly influenced by the application of K. In a three year field trial with soyabeans, K fertilizers had little effect on growth (Groneman, 1974). In a trial with groundnut grown in sandy silt or sandy loam soils showed a decrease in vegetative growth of above ground parts as Ca and K level increases from 0 - 100, 200 or 300 kg K/ha (Son *et al.*, 1974). Sankara Reddi *et al.* (1976)

observed a decrease in plant height of soyabean from 27.6 cm at 0 kg K_2O/ha to 25.3 cm at 40 kg K_2O/ha.

b. Effect of potassium on nodulation

In solution culture experiments with *Vicia faba*, the number of root nodules increased with increase in K from 0.5 to 4.5 meq/l (Haghparast and Mengel, 1973). Chesney (1974) noted that in cowpea, nodulation was increased by the application of 55 or 110 kg K/ha at Kairuni. In soyabeans, nodulation was not affected by K (Groneman, 1974).

c. Effect of potassium on yield and yield attributes

Barrios *et al.* (1970) reported that in one trial on lighter soils, yields of beans (*Phaseolus vulgaris*) were increased by the application of 70 kg K_2O/ha. While trials during 3 years with beans revealed that there was no response to application of 40 or 80 kg K_2O/ha (Braga *et al.*, 1973).

Experiments at Ebini and Kairuni with cowpeas showed that seed yields were significantly increased by the application of 55 to 110 kg K/ha (Chesney, 1974). But in a dry season field trial on an alluvial soil, yield of beans tended to decrease as levels of K increased from 0 - 80 kg K_2O/ha (Eira *et al.*, 1974).

Plant dry matter and seed yields of snap bean (*Phaseolus vulgaris*) were significantly improved by applying 100 kg K_2SO_4/feddan (Mitkees, 1974). Application of 60 kg K_2O/ha gave the highest yield increases in seed yields of peas and

Phaseolus vulgaris grown on light grey soil, intermediate increases on grey soil and lowest increases on dark grey forest soil (Sheveleva, 1974).

Johnson and Evans (1975) observed that application of K increased the yields of cowpea where the soil K content was low. Sawhney *et al.* (1975) reported that application of 17 and 34 kg K_2O/ha increased the grain yield of blackgram significantly over control on light soils from 8.6 to 9.2 and 9 q/ha respectively.

During wet season, application of 40 and 80 kg K_2O/ha decreased the yields of beans and during dry season application of 80 kg K_2O/ha increased the yields by 7 per cent (Krans *et al.*, 1976). In field beans (*Vicia faba*) average seed yield, seed weight and number of seeds/plant increased from 414 to 595 g/m^2, 327 to 342 mg and 38 and 53 respectively, with increasing rate of K from 0 - 300 kg K_2O/ha (Nemeth and Forster, 1976).

In gram there was a significant response to the application of 15 kg K_2O/ha on both medium and high K soils but the magnitude of response was much higher in medium than in high K soils. The response on medium and high K soils to per kg K_2O applied was 18 and 9.8 kg grain respectively (Sharma *et al.*, 1978).

In a field trial made during *kharif* at Bangalore on red sandy loam soil having medium fertility level under rainfed condition, the response of green gram to application of 20 kg K_2O/ha was not significant (Thime Gowda and Krishna Gowda, 1978).

In a field trial conducted at Rice Research Station, Pattambi with cowpea variety Ptb-1 (Kanakamani), application of potash did not show any conclusive yield trend. During 2 seasons a decreasing trend in yield was obtained due to potash application (Viswanathan et al., 1978).

d. Effect of potassium on quality and uptake of nutrients

The percentage of K in bean plants increased in general, with additional increments of potash applications (Bains, 1967). In pot experiments with Southern peas (Vigna sinensis), plant content of K increased with application of 75 lb K/acre (Stewart and Reed, 1969). In glass house experiments with peas in sand culture, plant P content decreased and K increased by applied K (Peck and MacDonald, 1969). An experiment carried out at I.A.R.I., New Delhi with peas revealed that application of potash did not influence protein content in grains (Singh et al., 1969).

In gravel trials with peas, increasing K level in the solution increased the contents of K in plants but did not affect the dynamics of K uptake and accumulation (Potkov and Kalaldzhiev, 1974). Kalyan Singh and Rajendra Prasad (1976) noted that in pigeon pea, application of 25 kg K/ha increased the N and crude protein content in grain.

D. Combination effect of nitrogen, phosphorus and potash on growth, yield, quality and nodulation

Ezedinma (1965) reported that in cowpea (Vigna sinensis Endl.) plant height, number of leaves per plant, shoot dry matter and seed yield were increased by application of 20 lb N + 40 lb P_2O_5/acre.

A significant increase in growth and fruiting attributes of mash and moong was noted when superphosphate was applied. The increase, however, were of much higher order when superphosphate was supplemented with nitrogen. The application of superphosphate at 60 kg P_2O_5/ha both with and without N produced average response of 119.1 and 50 per cent in case of mash and 102.3 and 46.4 per cent in case of moong over control. Application of 60 kg P_2O_5 + 40 kg N and 60 kg P_2O_5 alone were found to be economical in mash. In case of moong the application of fertilizer proved uneconomical (Kanwar Singh and Jagjit Singh Virk, 1965).

In trials with mung variety Pusa Baisakhi at I.A.R.I., New Delhi on a sandy loam soil of low fertility, the yields were increased by 42 and 72 per cent with 125 kg ammonium sulphate/ha applied (a) broadcast and (b) in rows 5.6 cm below the seed respectively, by 77 and 125 per cent with 125 kg ammonium sulphate + 200 kg superphosphate/ha applied as (a) and (b) respectively, and by 100 and 170 per cent with 125 kg ammonium sulphate + 400 kg superphosphate/ha applied as (a) and (b) respectively. The yield from no fertilizer plot was

470 kg/ha (Choudhry and Bhatia, 1971).

Application of 15 - 30 ppm N, 20 - 60 ppm P and 30 - 120 ppm S to Phaseolus aureus grown on sterilised sand gave seed protein contents of 19.88 to 24.31 per cent compared with 19.69 per cent with the nutrient solution given no N, P or S. Application of 30 ppm N + 60 ppm P + 90 ppm S gave the highest protein content (Arora and Luthra, 1972).

In an experiment conducted in lower uplands of Sambalpur, Orissa during rabi season with mung variety Pusa Baisakhi, the combination of 60 kg N + 90 kg P_2O_5/ha level gave significantly highest yield of 10.35 q/ha as against the lowest yield of 3.98 q/ha by no N and P control plots. But the response of grain yield (5.3 kg) per kg N application at 30 kg N/ha level was higher than that (4.8 kg) of 60 kg N level. The response of grain yield (4.7 kg) per kg of P_2O_5 application at 30 kg/ha level was the highest followed by that of 60 kg and 90 kg P_2O_5/ha levels. Therefore it was clearly noticed that application of 30 kg N and 30 kg P_2O_5/ha was the most profitable level of fertilizer if growing Pusa Baisakhi under Sambalpur conditions (Panda, 1972).

In trials with 2 green gram cultivars, viz., Rajendran and Pusa Baisakhi, NP interaction was highly significant. 0:20, 20:60, 30:40 combinations gave more than 800 kg seed yield/ha while 30:60 combination gave only 691 kg/ha which corresponds to the yield of control (0:0). Thus fertilizer nutrient over a certain level tended to reduce the seed yield. 0:20 was the most economical dose (Venugopal and Morachan, 1974).

In a field trial conducted during summer at IARI, New Delhi with 4 varieties of green gram, Pusa Baisakhi, S-9, S-12, G-65, application of 25 kg N and 75 kg P increased the yield by about 71 per cent over control (Chowdhury et al., 1975).

The highest yields of 2.63, 2.87 and 2.75 tonnes of seeds/ha and 600, 690 and 560 kg of protein/ha for mung, cowpea and beans respectively, were obtained from the application of 60 kg N + 60 kg P_2O_5 + 60 kg K_2O/ha (Niklyaev, 1975).

In a field trial at IARI, New Delhi during kharif season, the yield of black gram increased with increase in fertility level, but the differences were not significant. The root studies revealed that the length, dry weight and number of nodules/plant increased significantly with the increase in fertility level. Nodulation was more under the treatment 25 kg N + 100 kg P_2O_5 and more than 32 nodules over control were formed. The other treatments were at par (Sewa Ram and Gajendra Giri, 1975).

Tej Singh et al. (1975) reported that grain yield of two varieties of moong, J-781 and H-45 was significantly increased over the untreated control with 25 kg N and 50 kg P_2O_5/ha but was not significantly improved by increasing the application rate of P; protein content was also significantly increased.

Seed yields in green gram given 15 kg N/ha increased from 0.75 t/ha without P to 1.11 t/ha with 40 kg P_2O_5/ha and were not further increased with 60 - 80 kg P_2O_5/ha (Kaul and Sekhon, 1976).

In fertilizer trials with green gram variety CO.2 in the wet seasons, highest seed yields were obtained by applying 50 kg N + 50 kg P_2O_5/ha (Ramakrishnan et al., 1977).

In a field trial made during kharif season at Bangalore on red sandy loam soil having medium fertility level, under rainfed condition, application of 30 kg N + 60 kg P + 20 kg K/ha to green gram gave the highest pod (20.5 q/ha) and grain yield (12.7 q/ha) over control (9.5 and 5.2 q/ha respectively) (Thimma Gowda and Krishna Gowda,,1978).

In a field experiment conducted during rabi season at Tirupathi with Pusa Baisakhi green gram on a sandy loam soil low in organic carbon, medium in available phosphorus and potassium, the yield attributes were significantly influenced by N and P interactions(Subbaiah, 1978).

E. Effect of nitrogen, phosphorus and potash on soil fertility status

An experiment under glass house conditions with field beans revealed that soil test values for available P_2O_5 and available K_2O were affected by the application of respective fertilizer elements particularly at higher levels of phosphate and potash which indicated build up of available nutrients in the soil (Bains, 1967).

Garg et al. (1970) observed that nitrogen and available phosphorus contents of soil had improved by phosphorus fertilization of cowpea at the rate of 37, 74 or 111 kg P_2O_5/ha.

Chatterjee et al. (1972) reported that application of 40 - 80 kg P_2O_5/ha to soyabeans grown on well drained alluvial soil increased the soil N content. Sahu and Behera (1972) also observed that inoculation and application of phosphate (22.4 kg/ha) increased the soil nitrogen by 58, 29 and 26 per cent over control in crops of cowpea, groundnut and green gram respectively.

An experiment conducted on sandy loam soil with black gram and horse gram revealed that inoculation and application of 22.4 kg P_2O_5/ha alone or in combination increased nitrogen content of soil from 20 to 38 per cent in the case of black gram and from 7 to 19 per cent in the case of horse gram (Sahu, 1973).

Sharma and Yadav (1976) reported that in a field experiment conducted with gram, the available phosphorus content of soil in general increased with the addition of P upto 34.8 kg P in 1972-'73 and upto 52.2 kg P/ha in 1973-'74.

MATERIALS AND METHODS

MATERIALS AND METHODS

An investigation was undertaken with a view to find out the effect of nitrogen, phosphorus and potash on growth, yield and quality and to assess the nutrient uptake of green gram grown in rice fallows during third crop season 1978-79.

Experimental site

The experiment was conducted in the rice fallows of the Instructional Farm, College of Agriculture, Vellayani, Kerala State.

Soil

The soil of the experimental site was sandy clay loam with the following chemical composition.

Total nitrogen	-	0.112 per cent (Micro kjeldahl method)
Available P_2O_5	-	0.002 per cent (Bray's method)
Available K_2O	-	0.001 per cent (Ammonium acetate method)
pH	-	5.6 (1:2 soil solution ratio using pH meter)

Season

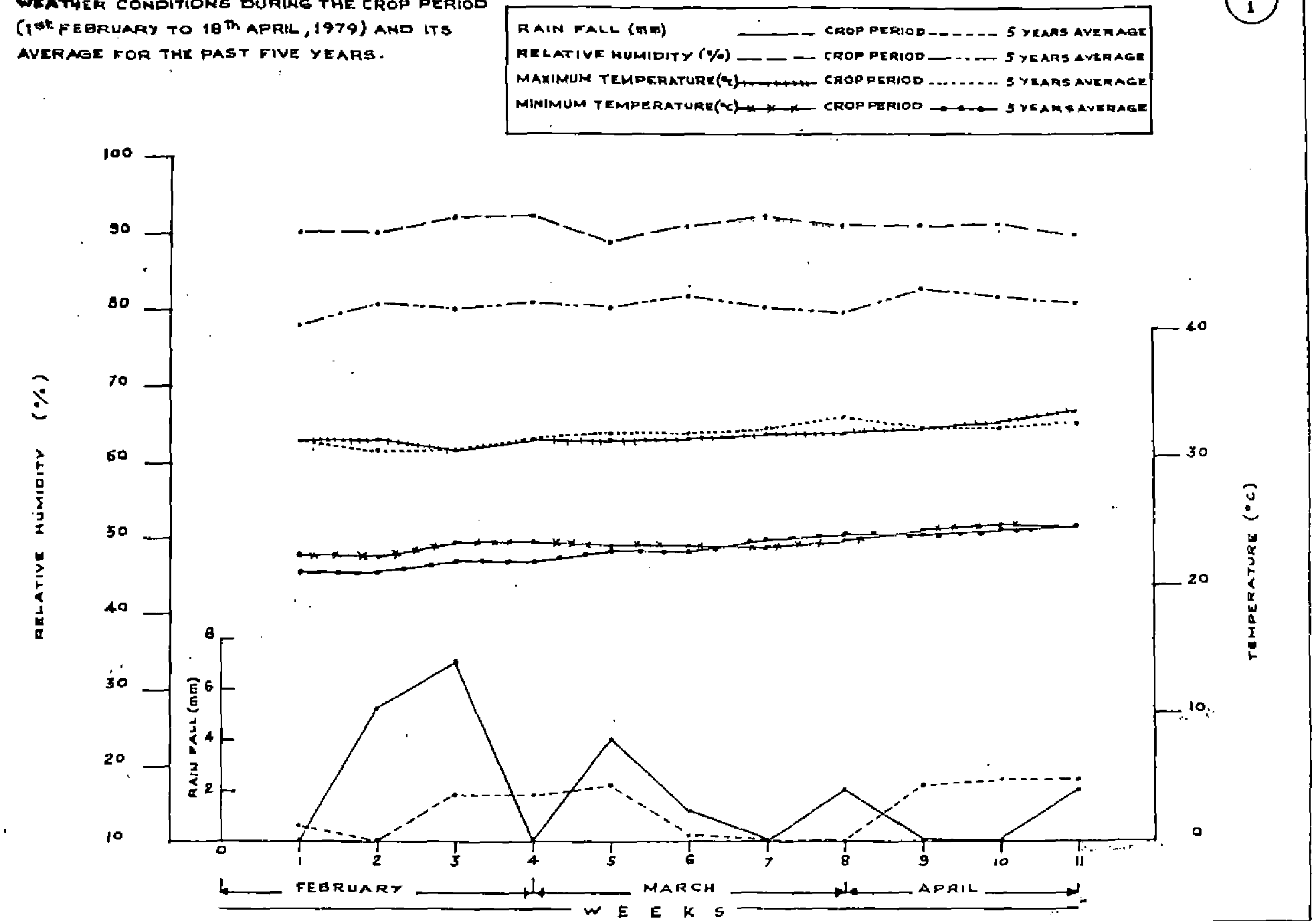
The experiment was conducted during the third crop season from January to April 1979.

Weather conditions

The meteorological parameters recorded are rainfall, maximum and minimum temperature and relative humidity. The average weekly values and their variation from that of the past five years from sowing to harvest were worked out and

FIG 1

WEATHER CONDITIONS DURING THE CROP PERIOD (1st FEBRUARY TO 18th APRIL, 1979) AND ITS AVERAGE FOR THE PAST FIVE YEARS.



presented in Appendix I and Fig. 1.

Cropping history of the field

A bulk crop of rice was raised in the experimental field during the second crop season of 1978.

MATERIALS

Variety

The green gram variety Pusa Baisakhi, developed at I.A.R.I., New Delhi was used for the present investigation. This variety is having a yield potential of 10 quintals/ha. It is a dwarf plant and possesses synchronous fruiting branches with clustered pods around fruiting axils which bring up uniform maturity. Seventy-five per cent of the crop is harvested during the first picking and remaining 25 per cent in second picking after about 10 days. This variety is of 60 - 65 days duration and suitable for summer season.

The seeds for the experiment were obtained from Rice Research Station, Pattambi, Kerala State.

Fertilisers

Ammonium sulphate, superphosphate, muriate of potash and dolomite analysing 20.5 per cent N, 16 per cent P_2O_5, 60 per cent K_2O and 45 per cent CaO respectively were used for the experiment.

METHODS

The experiment was laid out as a partially confounded factorial experiment with 27 treatments and two replications, confounding NPK in replication I and NPK^2 in replication II. The lay out plan of the experiment is given in Fig. 2.

Treatments

Factorial combinations of three levels each of nitrogen, phosphorus and potash constituted the treatments.

i. Levels of nitrogen

n_1	-	20 kg N/ha
n_2	-	30 ,,
n_3	-	40 ,,

ii. Levels of phosphorus

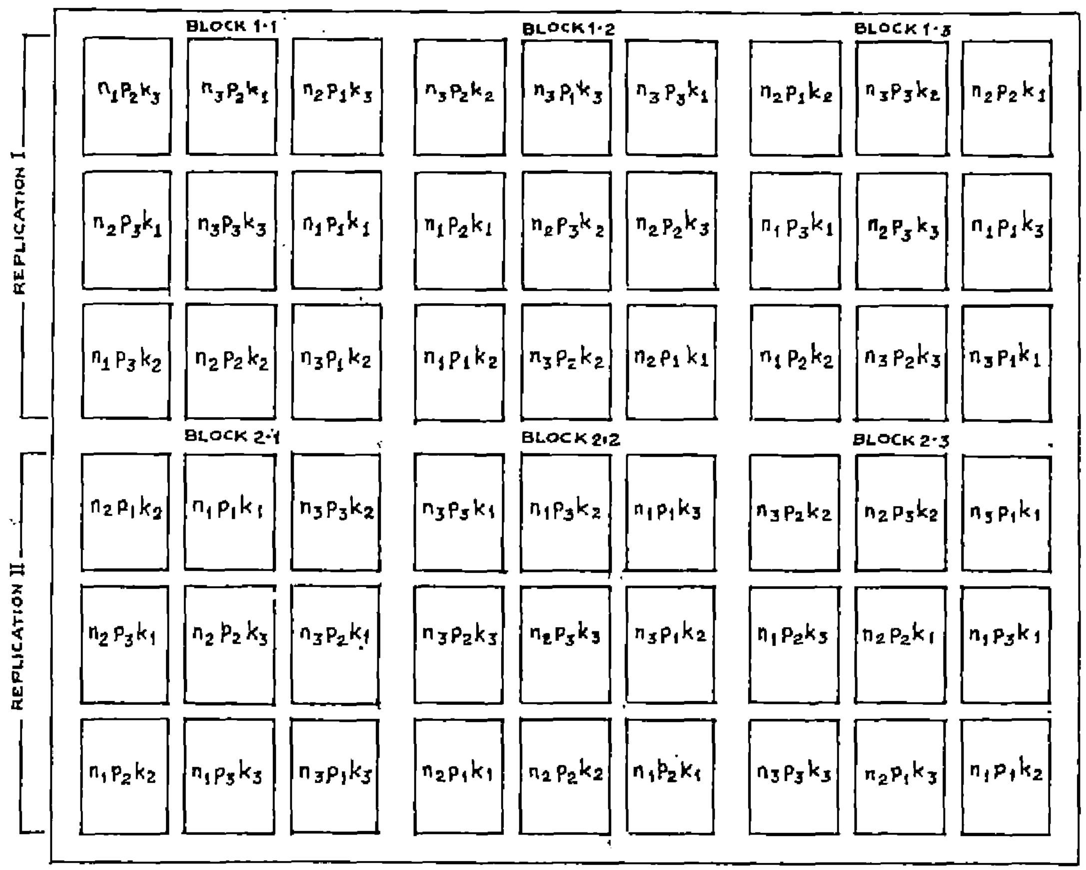
p_1	-	30 kg P_2O_5/ha
p_2	-	45 ,,
p_3	-	60 ,,

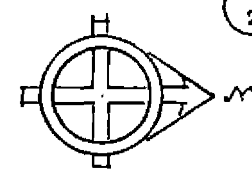
iii. Levels of potash

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

FIG 2

LAY OUT PLAN - CONFOUNDED FACTORIAL EXPERIMENT





LEVELS OF NITROGEN

- n_1 - 20 kg N/ha
- n_2 - 30 kg N/ha
- n_3 - 40 kg N/ha

LEVELS OF PHOSPHORUS

- p_1 - 30 kg P_2O_5/ha
- p_2 - 45 kg P_2O_5/ha
- p_3 - 60 kg P_2O_5/ha

LEVELS OF POTASH

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

GROSS PLOT SIZE
5 X 4 M.

Treatment combinations

1. n_1 p_1 k_1	10. n_2 p_1 k_1	19. n_3 p_1 k_1
2. n_1 p_1 k_2	11. n_2 p_1 k_2	20. n_3 p_1 k_2
3. n_1 p_1 k_3	12. n_2 p_1 k_3	21. n_3 p_1 k_3
4. n_1 p_2 k_1	13. n_2 p_2 k_1	22. n_3 p_2 k_1
5. n_1 p_2 k_2	14. n_2 p_2 k_2	23. n_3 p_2 k_2
6. n_1 p_2 k_3	15. n_2 p_2 k_3	24. n_3 p_2 k_3
7. n_1 p_3 k_1	16. n_2 p_3 k_1	25. n_3 p_3 k_1
8. n_1 p_3 k_2	17. n_2 p_3 k_2	26. n_3 p_3 k_2
9. n_1 p_3 k_3	18. n_2 p_3 k_3	27. n_3 p_3 k_3

1. Number of treatments	- 27
2. Replications	- 2
3. Number of blocks	- 6
4. Total number of plots	- 54
5. Gross plot size	- 5.0 m x 4.0 m
6. Net plot size	- 4.6 m x 2.8 m
7. Number of plants per hill	- 1
8. Spacing	- 20 x 10 cm
9. Number of border rows	- 2 rows all around the plot and one row after the destructive row
10. Number of destructive row	- 1

Details of cultivation

The experimental site was dug twice, stubbles removed, clods broken and laid out into plots and blocks. The beds were levelled in each plot.

Lime application

Lime was applied to plots, as dolomite at the rate of 400 kg/ha, two weeks before sowing, and incorporated into the soil.

Fertilizer application

The full dose of fertilizers were applied as basal dressing and thoroughly mixed with the soil.

Sowing

Sowing was done on 6th February 1979. Seeds were treated with rhizobium culture specific for the crop (*Rhizobium phaseoli*) and were dibbled at the rate of 2 seeds per hole at 10 cm spacing in shallow furrows taken at 20 cm apart and were covered with a thin layer of soil.

After cultivation

Germination of seeds was satisfactory. Thinning was done one week after emergence, retaining one healthy seedling per hill.

Weeding was done twice. One life irrigation was given after sowing and one irrigation at the time of flowering.

Plant protection

Sevin 0.2 per cent was sprayed thrice to protect the crop against pod boring caterpillars.

General condition of the crop

The general condition of the crop was satisfactory throughout the period of growth.

Harvest

The matured pods from the net area of each plot were picked thrice, sun dried and threshed plotwise and recorded separately. The plants were then pulled out from the net area of each plot and sun dried.

OBSERVATIONS

I. Growth characters

For recording periodical growth observations, ten plants were selected randomly from each net plot, and the following observations were recorded.

a. Height

Height of plants were recorded at 15 days interval after the emergence of the seedlings and at harvest and the average worked out. The height was measured from the base of the plant to the tip of the growing point and expressed in cm.

b. Number of leaves per plant

Number of leaves were recorded at 15 days interval after emergence and at harvest and the average worked out.

c. Number of nodules per plant

At flowering 5 plants from the destructive row were dug out with least disturbance to the roots, washed carefully and the nodules separated, counted and the average worked out.

d. Dry weight of nodules per plant

The nodules used for nodule count were oven dried, weighed and the average worked out.

II. Yield characters

a. Number of flowers per plant

Number of flowers were noted daily after flowering from the observation plants and the average worked out.

b. Number of pods per plant

Pods collected from the observation plants were counted separately and the average worked out.

c. Length of pod

Length of 10 pods selected randomly from the observation plants were measured in cm and the average worked out.

d. Number of seeds per pod

Pods used for measuring the length were threshed separately and the number of seeds in each pod was counted and the average worked out.

e. Weight of seeds per plant

Dry weight of seeds from the observation plants was recorded and the average worked out and expressed in grammes.

f. 100 seed weight

This was obtained by weighing 100 randomly selected seeds from the bulk in each plot and recorded in grammes.

g. Grain yield

Yield of grain obtained from each net plot was recorded separately and expressed in kg/ha.

h. Bhusa yield

After the pods were picked from net plot, the plants were uprooted, sundried uniformly and weighed and expressed in kg/ha.

i. Harvest index

Harvest index was computed using the formula

$\frac{\text{Economic yield}}{\text{Biological yield}}$ and expressed in per cent.

j. Dry matter yield

The samples were sundried and then dried to a constant weight in an air oven. Dry matter content was computed for each treatment and the dry matter yield worked out.

III. Chemical studies

A. Plant analysis

The oven dried samples were powdered in a grinder and used for chemical analysis. The plant, grain and husk samples were separately analysed for total N, ~~available~~ P_2O_5 and ~~available~~ K_2O.

a. Nitrogen

Total nitrogen content of the samples was determined by modified micro Kjeldahl method (Jackson, 1967) and crude protein percentage worked out by multiplying the nitrogen content by the factor 6.25 (Simpson et al., 1965). Grain protein yield and fodder protein yield per hectare were also worked out.

b. Phosphorus

Phosphorus was determined by Vanado-molybdo-phosphoric yellow colour method (Jackson, 1967).

c. Potassium

Potassium was determined by using 'EEL' Flame photometer.

The N, P_2O_5 and K_2O uptake by the crop were also worked out and expressed in kg/ha.

B. Soil analysis

The composite soil sample collected prior to the experiment and soil samples collected from individual plots after the experiment were analysed for total nitrogen, available P_2O_5 and available K_2O.

Total nitrogen was determined by modified micro-Kjeldahl method (Jackson, 1967).

Available phosphorus was determined by Bray's method.

Available potassium was determined by ammonium acetate method.

IV. Statistical analysis

Data relating to different characters were analysed statistically by applying the technique of analysis of variance for partially confounded 3^3 factorial experiment and significance was tested by 'F' test (Snedecor and Cochran, 1967). Important correlations were also worked out.

RESULTS

RESULTS

The observations recorded were analysed statistically and the results are given below. The mean values are presented in Tables 1 to 24. The analysis of variance tables are given in Appendix II to VIII and the correlation studies are presented in Table 25. Economics of nitrogen, phosphorus and potash application are also presented in Table 26.

I. Growth characters.

a. Height

The mean plant height taken on 15th day, 30th day, 45th day after sowing and at harvest are presented in Tables 1 a to 1 d and the analysis of variance table in Appendix II.

Higher levels of nitrogen (30 and 40 kg N/ha) significantly increased the height of plants over the lowest level of 20 kg N/ha upto 45th day after sowing and at harvest the treatment differences were not significant. The highest level of 40 kg N depressed the plant height in all stages of crop growth than that of 30 kg N treated plot, though the difference was not significant.

Highest level of 60 kg P_2O_5/ha was found to significantly increase the height of plants compared to 45 and 30 kg P_2O_5/ha in all stages of crop growth. There was no significant difference between 45 and 30 kg P_2O_5/ha application.

As in the case of nitrogen the higher levels of potash (30 and 20 kg K_2O/ha) influenced the plant height significantly

Table 1 a

Plant Height (cm) on 15th day

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	11.15	13.28	12.08	12.17
45	11.67	12.90	12.55	12.37
60	13.91	13.93	14.91	14.25
K_2O kg/ha				
10	11.05	11.75	11.76	11.52
20	12.83	13.76	13.38	13.32
30	12.85	14.60	14.41	13.95
Mean	12.24	13.37	13.18	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	10.95	11.20	12.41	11.52
20	11.79	12.36	15.81	13.32
30	13.77	13.55	14.54	13.95
Mean	12.17	12.37	14.25	

C.D.(0.05) for marginal means = 0.852
C.D.(0.05) for combinations = 1.475

Table 1 b

Plant Height (cm) on 30th day

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	15.85	19.84	16.74	17.48
45	16.87	19.33	17.17	17.79
60	20.13	22.48	23.52	22.04
K_2O kg/ha				
10	16.95	18.84	16.99	17.59
20	18.09	22.33	19.62	20.01
30	17.81	20.48	20.83	19.71
Mean	17.62	20.55	19.15	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	16.65	16.92	19.20	17.59
20	18.15	18.49	23.39	20.01
30	17.64	17.95	23.53	19.71
Mean	17.48	17.79	22.04	

C.D.(0.05) for marginal means = 1.882
C.D.(0.05) for combinations = 3.259

Table 1 c

Plant Height (cm) on 45th day

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	18.52	21.63	20.53	20.23
45	19.74	21.44	20.54	20.57
60	23.13	24.82	26.36	24.77
K_2O kg/ha				
10	19.51	20.30	20.00	19.94
20	20.96	24.20	22.91	22.69
30	20.92	23.39	24.52	22.94
Mean	20.46	22.63	22.48	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	19.29	19.04	21.47	19.94
20	20.61	21.18	26.28	22.69
30	20.78	21.50	26.56	22.94
Mean	20.23	20.57	24.77	

C.D.(0.05) for marginal means = 1.868
C.D.(0.05) for combinations = 3.235

Table 1 d

Plant Height (cm) at harvest

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	19.56	21.96	20.83	20.78
45	20.23	21.85	21.21	21.10
60	23.51	26.41	27.33	25.75
K_2O kg/ha				
10	20.17	21.00	20.65	20.61
20	21.33	25.05	23.23	23.20
30	21.80	24.17	25.50	23.82
Mean	21.10	23.40	23.12	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	19.72	19.67	22.44	20.61
20	21.05	21.37	27.18	23.20
30	21.58	22.25	27.63	23.82
Mean	20.78	21.10	25.75	

C.D.(0.05) for marginal means = 2.036
C.D.(0.05) for combinations = 3.527

over the lowest level of 10 kg, while the difference between higher levels was not significant.

The interaction between P and K during the early stages of growth (15th day after sowing) alone was found to be significant. The maximum height of 15.81 cm was recorded by p_3k_2 combination and the minimum height of 10.95 cm by p_1k_1 combination.

b. Number of leaves per plant

The mean number of leaves per plant recorded are presented in Tables 2 a to 2 d and the analysis of variance table in Appendix II.

Higher levels of nitrogen significantly influenced the number of leaves in the early stages of plant growth (15th day after sowing) only.

In the case of phosphorus, 60 kg P_2O_5/ha significantly increased the number of leaves over 30 kg P_2O_5/ha upto flowering stage only, after which the differences were not significant.

Potash had influenced the number of leaves only during the early stages of plant growth. Higher doses of potash (20 and 30 kg K_2O) increased the number of leaves significantly over the lowest level of 10 kg K_2O.

As in the case of plant height, the mean number of leaves were significantly influenced by the interaction between P and K in the early stages of plant growth (15th day after sowing). Among the treatment combinations, p_3k_2 recorded the maximum number of leaves and p_3k_1 the minimum number of leaves.

Table 2 a

Number of leaves per plant on 15th day

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	2.07	2.27	2.28	2.21
45	2.22	2.30	2.30	2.27
60	2.23	2.40	2.45	2.36
K_2O kg/ha				
10	2.08	2.22	2.10	2.13
20	2.22	2.33	2.43	2.33
30	2.22	2.42	2.50	2.38
Mean	2.17	2.32	2.34	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	2.13	2.17	2.10	2.13
20	2.13	2.28	2.57	2.33
30	2.35	2.37	2.42	2.38
Mean	2.21	2.27	2.36	

C.D.(0.05) for marginal means = 0.114
C.D.(0.05) for combinations = 0.198

Table 2 b

Number of leaves per plant on 30th day

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	3.40	3.65	3.72	3.59
45	3.67	3.65	3.65	3.66
60	3.68	3.90	3.95	3.84
K_2O kg/ha				
10	3.52	3.67	3.70	3.63
20	3.55	3.75	3.77	3.69
30	3.68	3.78	3.85	3.77
Mean	3.58	3.73	3.77	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	3.57	3.60	3.72	3.63
20	3.55	3.60	3.92	3.69
30	3.65	3.77	3.90	3.77
Mean	3.59	3.66	3.84	

C.D.(0.05) for marginal means = 0.208
C.D.(0.05) for combinations = 0.361

Table 2 c

Number of leaves per plant on 45th day

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	3.53	3.60	3.65	3.59
45	3.72	3.62	3.78	3.71
60	3.58	3.72	3.65	3.72
K_2O kg/ha				
10	3.57	3.58	3.78	3.64
20	3.63	3.68	3.72	3.68
30	3.63	3.67	3.78	3.69
Mean	3.61	3.64	3.76	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	3.58	3.70	3.65	3.64
20	3.55	3.72	3.77	3.68
30	3.65	3.70	3.73	3.69
Mean	3.59	3.71	3.72	

C.D.(0.05) for marginal means = 0.199
C.D.(0.05) for combinations = 0.345

Table 2 d

Number of leaves per plant at harvest

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	2.97	2.98	3.17	3.04
45	3.02	3.06	3.24	3.10
60	3.10	3.32	3.17	3.19
K_2O kg/ha				
10	3.02	2.98	3.13	3.04
20	3.10	3.17	3.13	3.13
30	2.97	3.19	3.32	3.16
Mean	3.03	3.12	3.19	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	2.98	3.07	3.08	3.04
20	3.21	2.90	3.30	3.13
30	2.93	3.35	3.20	3.16
Mean	3.04	3.10	3.19	

C.D.(0.05) for marginal means = 0.297
C.D.(0.05) for combinations = 0.515

c. Number of nodules per plant

The mean number of nodules taken are presented in Table 3 and the analysis of variance table in Appendix III.

The table shows that the number of nodules per plant was decreased with increasing levels of nitrogen, though the differences were not significant.

Number of nodules showed an increasing trend with increasing levels of phosphorus as well as potash, though the differences were not significant.

It was observed from the table that the number of nodules per plant was significantly influenced by P x K interaction. The maximum number of 21.75 was recorded with p_3k_2 combination and the minimum number of 8.92 with p_2k_2 combination.

d. Dry weight of nodules per plant

The mean dry weight of nodules are given in Table 4 and the analysis of variance table in Appendix III.

Dry weight of nodules showed a decreasing trend with increasing levels of N, though the differences were not significant.

In the case of phosphorus, there was an increasing trend in dry weight of nodules with increasing levels of phosphorus. But the differences were not significant. Levels of potash also showed no significant difference in the dry weight of nodules per plant. But the lowest level of 10 kg K_2O/ha had shown an increase in the dry weight of

Table 3

Number of nodules per plant

	N kg/ha			
P_2O_5 kg/ha	20	30	40	Mean
30	13.50	16.07	14.11	14.56
45	16.43	13.17	15.93	15.18
60	16.83	15.75	15.08	15.89
K_2O kg/ha				
10	16.58	15.43	10.93	14.32
20	16.08	13.47	14.25	14.60
30	14.10	16.08	19.95	16.71
Mean	15.59	15.00	15.04	

	P_2O_5 kg/ha			
K_2O kg/ha	30	45	60	Mean
10	12.02	17.35	13.58	14.32
20	13.14	8.92	21.75	14.60
30	18.53	19.27	12.33	16.71
Mean	14.56	15.18	15.89	

C.D.(0.05) for marginal means = 5.548
C.D.(0.05) for combinations = 9.609

Table 4

Dry weight of nodules per plant (mg)

	N kg/ha			
P_2O_5 kg/ha	20	30	40	Mean
30	21.25	29.83	22.75	24.61
45	34.17	26.67	30.67	30.50
60	42.08	27.08	30.00	33.06
K_2O kg/ha				
10	38.33	25.83	33.17	32.44
20	27.50	30.25	20.83	26.19
30	31.67	27.50	29.42	29.53
Mean	32.50	27.86	27.81	

	P_2O_5 kg/ha			
K_2O kg/ha	30	45	60	Mean
10	26.67	36.50	34.17	32.44
20	19.83	25.83	32.92	26.19
30	27.33	29.17	32.08	29.53
Mean	24.61	30.50	33.06	

C.D.(0.05) for marginal means = 10.189
C.D.(0.05) for combinations = 17.649

nodules per plant over the higher levels.

II. Yield and yield attributes.

a. Number of flowers per plant

The mean number of flowers per plant are presented in Table 5 and the analysis of variance table in Appendix IV.

Though the levels of nitrogen did not significantly affect the flowers per plant, the number increased with the increase of N from 20 to 30 kg after which it was reduced to the level of 20 kg N/ha.

In the case of phosphorus and potash, different levels had no significant effect on the number of flowers per plant. But an increasing trend was noted with an increase in the levels of P_2O_5 as well as K_2O.

b. Number of pods per plant

The mean number of pods are presented in Table 6 and the analysis of variance table in Appendix IV.

It was observed that levels of nitrogen had no significant influence on number of pods. However there was an increasing trend in number of pods with increasing the nitrogen level upto 30 kg after which it decreased.

Levels of phosphorus and potash had no significant effect on number of pods. But an increasing trend was noticed in both cases by increasing their levels.

c. Length of pod

The mean length of pod recorded are presented in

Table 5

Number of flowers per plant

	N kg/ha			
P_2O_5 kg/ha	20	30	40	Mean
30	6.30	6.73	6.37	6.47
45	7.07	7.33	6.52	6.97
60	7.13	6.93	7.60	7.22
K_2O kg/ha				
10	6.60	6.35	6.18	6.38
20	6.52	7.65	6.57	6.91
30	7.38	7.00	7.73	7.37
Mean	6.83	7.00	6.83	

	P_2O_5 kg/ha			
K_2O kg/ha	30	45	60	Mean
10	6.03	6.53	6.57	6.38
20	6.27	7.10	7.36	6.91
30	7.10	7.28	7.73	7.37
Mean	6.47	6.97	7.22	

C.D.(0.05) for marginal means = 0.813
C.D.(0.05) for combinations = 1.409

Table 6

Number of pods per plant

	N kg/ha			
P_2O_5 kg/ha	20	30	40	Mean
30	3.72	3.73	3.65	3.70
45	4.02	3.77	3.60	3.79
60	3.65	4.03	3.82	3.83
K_2O kg/ha				
10	3.78	3.53	3.33	3.55
20	3.87	4.08	3.40	3.78
30	3.73	3.92	4.33	3.99
Mean	3.79	3.84	3.69	

	P_2O_5 kg/ha			
K_2O kg/ha	30	45	60	Mean
10	3.40	3.60	3.65	3.55
20	3.47	4.03	3.85	3.78
30	4.23	3.75	4.00	3.99
Mean	3.70	3.79	3.83	

C.D.(0.05) for marginal means = 0.671
C.D.(0.05) for combinations = 1.162

Table 7 and the analysis of variance table in Appendix IV.

There was no significant difference in length of pod with increasing levels of nitrogen. The highest level of 40 kg N showed a decreasing trend in length of pod over that of 30 and 20 kg N, though the differences were not significant. The length of pod showed an increasing trend with increasing levels of phosphorus and potash, eventhough the treatment differences were not significant.

d. Number of seeds per pod

The mean number of seeds per pod taken are given in Table 8 and the analysis of variance table in Appendix IV.

Nitrogen levels did not significantly affect the number of seeds per pod. But there was an increasing trend seen upto 30 kg N after which it decreased.

As in the case of length of pod, increasing levels of phosphorus and potash increased the number of seeds per pod, though the treatment differences were not significant.

e. Weight of seeds per plant

The mean weight of seeds per plant taken are presented in Table 9 and the analysis of variance table in Appendix IV.

The weight of seeds per plant was increased with increasing levels of nitrogen from 20 to 30 kg/ha after which it got reduced. But the differences were not significant.

In the case of phosphorus, the weight of seeds per plant was increased with increasing the levels from 30 to 40 and to 60 kg P_2O_5/ha, though the differences were not

Table 7

Length of pod (cm)

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	7.30	7.32	7.13	7.25
45	7.23	7.36	7.20	7.26
60	7.33	7.42	7.39	7.38
K_2O kg/ha				
10	7.32	7.24	7.13	7.23
20	7.29	7.52	7.15	7.32
30	7.26	7.34	7.42	7.34
Mean	7.29	7.36	7.24	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	7.13	7.15	7.42	7.23
20	7.34	7.32	7.30	7.32
30	7.28	7.31	7.42	7.34
Mean	7.25	7.26	7.38	

C.D.(0.05) for marginal means = 0.164
C.D.(0.05) for combinations = 0.284

Table 8

Number of seeds per pod

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	11.15	11.18	11.03	11.12
45	11.30	11.40	11.03	11.24
60	11.37	11.48	11.58	11.48
K_2O kg/ha				
10	11.15	11.20	11.18	11.18
20	11.42	11.48	11.02	11.31
30	11.25	11.38	11.45	11.36
Mean	11.27	11.36	11.22	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	10.87	11.23	11.43	11.18
20	11.18	11.33	11.40	11.31
30	11.32	11.17	11.60	11.36
Mean	11.12	11.24	11.48	

C.D.(0.05) for marginal means = 0.330
C.D.(0.05) for combinations = 0.572

significant.

The highest level of 30 kg K_2O increased the weight of seeds per plant significantly only over 10 kg which in turn was on par with 20 kg K_2O.

f. 100 seed weight

The mean values are given in Table 10 and the analysis of variance table in Appendix IV.

The highest level of 40 kg N significantly decreased the 100 seed weight over the lower levels (20 and 30 kg N), which were on par.

In the case of phosphorus the higher levels of 45 and 60 kg P_2O_5 increased the 100 seed weight significantly over 30 kg P_2O_5/ha.

With regard to potash, an increasing trend in 100 seed weight was observed with increasing the levels, though the differences were not significant.

g. Grain yield

The mean grain yield recorded are given in Table 11 and the analysis of variance table in Appendix V.

The data showed that there was no significant difference in grain yield due to levels of nitrogen. Still an increasing trend was noted upto 30 kg N/ha after which the yield considerably got reduced.

With increasing levels of phosphorus grain yield also increased but the differences were not significant.

Table 9

Weight of seeds per plant (g)

	N kg/ha			
P_2O_5 kg/ha	20	30	40	Mean
30	0.86	0.87	0.89	0.87
45	0.93	1.04	0.76	0.91
60	0.81	1.06	0.91	0.93
K_2O kg/ha				
10	0.80	0.76	0.65	0.74
20	0.90	0.96	0.88	0.91
30	0.90	1.25	1.03	1.06
Mean	0.87	0.99	0.85	

	P_2O_5 kg/ha			
K_2O kg/ha	30	45	60	Mean
10	0.65	0.92	0.63	0.74
20	0.90	0.86	0.98	0.91
30	1.07	0.94	1.17	1.06
Mean	0.87	0.91	0.93	

C.D.(0.05) for marginal means = 0.211
C.D.(0.05) for combinations = 0.365

Table 10

Weight of 100 Seeds (g)

	N kg/ha			
P_2O_5 kg/ha	20	30	40	Mean
30	3.31	3.28	2.93	3.17
45	3.20	3.54	3.46	3.40
60	3.63	3.64	3.22	3.49
K_2O kg/ha				
10	3.44	3.40	3.07	3.30
20	3.32	3.59	3.15	3.35
30	3.37	3.47	3.39	3.41
Mean	3.38	3.49	3.20	

	P_2O_5 kg/ha			
K_2O kg/ha	30	45	60	Mean
10	3.10	3.57	3.24	3.30
20	3.22	3.35	3.49	3.35
30	3.20	3.27	3.75	3.41
Mean	3.17	3.40	3.49	

C.D.(0.05) for marginal means = 0.222
C.D.(0.05) for combinations = 0.384

In the case of potash, the highest level of 30 kg K_2O increased the grain yield significantly over 10 kg K_2O. While the yields due to 10 and 20 kg K_2O and 20 and 30 kg K_2O were on par.

h. Bhusa yield

The mean bhusa yield are presented in Table 12 and the analysis of variance table in Appendix V.

It was observed that the highest level of 40 kg N significantly increased the bhusa yield over 30 and 20 kg N which were on par.

With regard to phosphorus and potash increasing their levels increased the bhusa yield, though the differences were not significant.

i. Harvest index

The mean values are presented in Table 13 and the analysis of variance table in Appendix V.

From the table it was observed that levels of N, P_2O_5 or K_2O had no significant influence on harvest index. But increasing levels of N and P_2O_5 showed a decreasing trend whereas levels of K_2O showed an increasing trend in harvest index.

j. Dry matter yield

The mean values are presented in Table 14 and the analysis of variance table in Appendix V.

Both nitrogen and phosphorus levels had no significant influence on dry matter yield of the crop. But an increase

Table 11

Yield of grain (kg/ha)

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	428.05	434.52	453.42	438.66
45	463.90	521.09	394.93	459.97
60	407.22	526.79	472.57	468.86
K_2O kg/ha				
10	400.62	374.22	334.11	369.65
20	444.75	480.20	453.29	459.41
30	453.80	627.97	533.51	538.43
Mean	433.06	494.13	440.30	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	325.18	466.23	317.55	369.65
20	447.46	436.47	494.31	459.41
30	543.35	477.23	594.72	538.43
Mean	438.66	459.97	468.86	

C.D.(0.05) for marginal means = 103.693
C.D.(0.05) for combinations = 179.601

Table 12

Yield of bhusa (kg/ha)

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	786.10	850.01	957.56	864.82
45	847.57	944.62	996.38	929.52
60	847.57	938.15	1208.36	997.03
K_2O kg/ha				
10	815.22	782.87	946.56	848.22
20	747.28	918.74	1106.37	924.13
30	918.74	1031.97	1106.37	1019.03
Mean	827.08	811.19	1053.10	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	860.51	821.69	862.45	848.22
20	818.45	866.98	1086.96	924.13
30	915.51	1099.90	1041.67	1019.03
Mean	864.82	929.52	997.03	

C.D.(0.05) for marginal means = 178.218
C.D.(0.05) for combinations = 308.683

Table 13

Harvest index (per cent)

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	33.40	32.00	31.49	32.30
45	33.54	33.12	30.13	32.26
60	30.84	31.52	29.93	30.76
K_2O kg/ha				
10	32.10	29.91	29.16	30.39
20	33.16	32.47	30.53	32.05
30	32.52	34.27	31.86	32.88
Mean	32.59	32.22	30.52	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	29.12	33.09	28.96	30.39
20	33.58	32.31	30.27	32.05
30	34.19	31.39	33.06	32.88
Mean	32.30	32.26	30.76	

C.D.(0.05) for marginal means = 2.732
C.D.(0.05) for combinations = 4.732

Table 14

Dry matter yield (kg/ha)

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	1417.45	1517.86	1626.69	1520.67
45	1540.12	1709.37	1571.95	1607.15
60	1439.19	1717.66	1896.10	1684.31
K_2O kg/ha				
10	1417.71	1353.66	1437.63	1403.00
20	1395.84	1624.88	1771.88	1597.53
30	1583.21	1966.36	1885.23	1811.60
Mean	1465.58	1648.30	1698.25	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	1361.16	1513.33	1334.51	1403.00
20	1481.50	1505.44	1805.65	1597.53
30	1719.54	1802.67	1912.79	1811.60
Mean	1520.67	1607.15	1684.31	

C.D.(0.05) for marginal means = 264.099
C.D.(0.05) for combinations = 457.432

in their levels resulted in an increase in the dry matter yield.

In the case of potash, highest level of 30 kg K_2O significantly increased the dry matter yield only over the lowest level of 10 kg which was on par with 20 kg K_2O.

III. Plant analysis.

A. Nutrient uptake

The mean values of the uptake of N, P_2O_5 and K_2O by the crop at harvest are presented in Tables 15, 16 and 17 and the analysis of variance tables in Appendix VI.

a. Nitrogen uptake

The mean values are given in Table 15 and the analysis of variance table in Appendix VI.

The table shows that an increase in the N level increased the N uptake by plants, though the differences were not significant.

Different levels of phosphorus and potash also had no significant influence on the nitrogen uptake.

b. P_2O_5 uptake

The mean values are given in Table 16 and the analysis of variance table in Appendix VI.

The highest level of 40 kg N significantly increased the P_2O_5 uptake by plants only over 20 kg which was on par with 30 kg N.

As in the case of nitrogen, highest level of 60 kg P_2O_5 also increased the P_2O_5 uptake by plants significantly

Table 15

Nitrogen uptake (kg/ha)

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	24.98	26.66	28.42	26.69
45	27.34	30.70	28.36	28.80
60	25.36	32.64	33.91	30.64
K_2O kg/ha				
10	26.25	25.45	24.95	25.55
20	24.52	28.92	30.96	28.13
30	26.91	35.63	34.79	32.44
Mean	25.89	30.00	30.23	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	23.82	29.05	23.78	25.55
20	25.13	26.20	33.06	28.13
30	31.11	31.16	35.07	32.44
Mean	26.69	28.80	30.64	

C.D.(0.05) for marginal means = 5.637
C.D.(0.05) for combinations = 9.764

Table 16

P_2O_5 uptake (kg/ha)

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	1.93	2.17	2.33	2.14
45	2.40	2.72	2.49	2.53
60	2.18	2.72	3.15	2.69
K_2O kg/ha				
10	2.19	2.18	2.34	2.24
20	2.10	2.46	2.84	2.47
30	2.22	2.97	2.80	2.66
Mean	2.17	2.54	2.66	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	1.94	2.48	2.29	2.24
20	2.11	2.33	2.96	2.47
30	2.38	2.80	2.81	2.66
Mean	2.14	2.53	2.69	

C.D.(0.05) for marginal means = 0.395
C.D.(0.05) for combinations = 0.684

only over 30 kg which was on par with 45 kg P_2O_5.

Potash had no significant influence on P_2O_5 uptake by plants. But an increasing trend was noticed with increasing levels of potash.

c. K_2O uptake

The mean values are presented in Table 17 and the analysis of variance table in Appendix VI.

Though the levels of nitrogen had no significant influence on K_2O uptake by plants, an increasing trend was noted upto 30 kg N after which it declined.

Increasing levels of P_2O_5 showed an increasing trend in K_2O uptake, though the differences were not significant.

Increasing levels of K_2O significantly increased the K_2O uptake by plants.

B. Protein

a. Protein content of grain

The results on mean protein content of grains are presented in Table 18 and the analysis of variance table in Appendix VII.

It was observed that protein content of grains showed an increasing trend with increasing levels of N as well as P_2O_5, but the differences were not significant.

Potash also had no significant influence on protein content of grains. The lowest level of 10 kg K_2O had given higher protein content over the higher levels of 20 and 30 kg K_2O.

Table 17

K_2O uptake (kg/ha)

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	12.31	13.12	13.05	12.83
45	14.59	15.91	13.24	14.58
60	12.37	16.10	15.76	14.75
K_2O kg/ha				
10	11.11	10.24	9.83	10.39
20	13.01	14.90	14.90	14.27
30	15.16	19.99	17.32	17.49
Mean	13.09	15.05	14.02	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	9.25	12.10	9.84	10.39
20	13.26	13.79	15.77	14.27
30	15.97	17.86	18.65	17.49
Mean	12.83	14.58	14.75	

C.D.(0.05) for marginal means = 2.689

C.D.(0.05) for combinations = 4.658

b. Protein content of bhusa

The mean protein content of bhusa are given in Table 19 and the analysis of variance table in Appendix VII.

As in the case of grain, the protein content of bhusa also showed an increasing trend with increasing levels of nitrogen and phosphorus, though the differences were not significant.

The lowest level of 10 kg K_2O had given significantly higher protein content over the higher levels of 20 and 30 kg K_2O.

c. Grain protein yield

The mean values are presented in Table 20 and the analysis of variance table in Appendix VII.

Increasing levels of N upto 30 kg increased the grain protein yield whereas a further increase in N level showed a reduction. The differences between N levels were not significant.

In the case of phosphorus, increasing levels had no significant influence on grain protein yield, though it showed an increasing trend.

Potash at 30 kg K_2O/ha significantly increased the grain protein yield only over 10 kg which was on par with 20 kg K_2O/ha.

d. Fodder protein yield

The mean values are presented in Table 21 and the analysis of variance table in Appendix VII.

Table 18

Protein content of grain (per cent)

P_2O_5 kg/ha	N Kg/ha 20	30	40	Mean
30	18.011	18.375	18.375	18.254
45	18.250	18.271	18.959	18.493
60	18.705	18.834	18.511	18.683
K_2O kg/ha				
10	18.490	18.730	19.053	18.757
20	18.121	18.480	17.959	18.186
30	18.354	18.271	18.834	18.486
Mean	18.322	18.493	18.615	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	18.542	19.261	18.469	18.757
20	18.011	18.094	18.455	18.186
30	18.209	18.125	19.125	18.486
Mean	18.254	18.493	18.683	

C.D.(0.05) for marginal means = 0.623
C.D.(0.05) for combinations = 1.079

Table 19

Protein content of bhusa (per cent)

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	8.677	8.761	8.719	8.719
45	8.646	8.584	9.125	8.785
60	8.282	9.313	9.125	8.906
K_2O kg/ha				
10	9.532	9.542	8.771	9.282
20	8.000	8.448	9.063	8.504
30	8.073	8.667	9.136	8.625
Mean	8.535	8.886	8.990	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	9.157	9.344	9.344	9.282
20	8.063	8.396	9.052	8.504
30	8.938	8.615	8.323	8.625
Mean	8.719	8.785	8.906	

C.D.(0.05) for marginal means = 0.644
C.D.(0.05) for combinations = 1.116

Table 20

Grain protein yield (kg/ha)

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	77.11	79.43	82.95	79.83
45	84.68	97.13	74.29	85.37
60	78.62	102.82	88.93	90.12
K_2O kg/ha				
10	74.21	72.91	63.95	70.36
20	82.54	90.24	80.33	84.37
30	83.66	116.23	101.89	100.59
Mean	80.14	93.13	82.05	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	60.19	90.90	59.98	70.36
20	80.18	78.33	94.59	84.37
30	99.11	86.86	115.80	100.59
Mean	79.83	85.37	90.12	

C.D.(0.05) for marginal means = 19.541
C.D.(0.05) for combinations = 33.845

Table 21

Fodder protein yield (kg/ha)

P_2O_5 kg/ha	N kg/ha 20	30	40	Mean
30	136.28	152.72	162.16	150.39
45	152.42	166.53	176.81	165.26
60	143.45	176.35	212.98	177.59
K_2O kg/ha				
10	155.92	149.55	164.29	156.59
20	125.67	156.10	190.57	157.44
30	150.57	189.95	197.10	179.21
Mean	144.05	165.20	183.99	

K_2O kg/ha	P_2O_5 kg/ha 30	45	60	Mean
10	153.21	161.98	154.58	156.59
20	133.25	149.65	189.43	157.44
30	164.70	184.15	188.77	179.21
Mean	150.39	165.26	177.59	

C.D.(0.05) for marginal means = 33.277
C.D.(0.05) for combinations = 57.639

The table shows that increasing levels of nitrogen, phosphorus as well as potash showed an increasing trend in fodder protein yield, though the differences were not significant.

IV. Soil analysis

The soil sample taken from each plot after the experiment were analysed for total N, available P_2O_5 and available K_2O.

a. Total nitrogen content

The mean values are given in Table 22 and the analysis of variance table in Appendix VIII.

The table shows that increasing levels of nitrogen resulted in a decrease in total N content of the soil, though the differences were not significant.

The N content of soil showed an increase upto 45 kg P_2O_5 after which there was a reduction. The differences were not significant.

As in the case of phosphorus, potash also showed an increasing trend upto 20 kg K_2O/ha after which it got reduced.

The table shows that the total nitrogen content of the soil was significantly influenced by N x K interaction. The maximum nitrogen content was observed at N_1K_3 combination and the minimum nitrogen content at N_3K_3 combination.

b. Available P_2O_5 content

Data on mean phosphorus content of soil are presented in Table 23 and the analysis of variance table in Appendix VIII.

Table 22

Total nitrogen content of soil (kg/ha)

	N kg/ha			
P_2O_5 kg/ha	20	30	60	Mean
30	2426.67	2356.67	2426.67	2403.33
45	2450.00	2426.67	2403.33	2426.67
60	2496.67	2496.67	2170.00	2387.78
K_2O kg/ha				
10	2380.00	2310.00	2403.33	2364.44
20	2473.33	2473.33	2450.00	2465.56
30	2520.00	2496.67	2146.67	2387.78
Mean	2457.78	2426.67	2333.33	

	P_2O_5 kg/ha			
K_2O kg/ha	30	45	60	Mean
10	2356.67	2380.00	2356.67	2364.44
20	2473.33	2473.33	2450.00	2465.56
30	2380.00	2426.67	2356.67	2387.78
Mean	2403.33	2426.67	2387.78	

C.D.(0.05) for marginal means = 122.078
C.D.(0.05) for combinations = 211.446

Table 23

Available phosphorus content of soil (kg/ha)

	N kg/ha			
P_2O_5 kg/ha	20	30	40	Mean
30	44.13	57.88	50.38	50.79
45	63.50	59.13	60.38	61.00
60	69.75	61.63	83.50	71.63
K_2O kg/ha				
10	65.63	61.25	53.75	60.21
20	58.63	56.13	67.38	60.71
30	53.13	61.25	73.13	62.50
Mean	59.13	59.54	64.75	

	P_2O_5 kg/ha			
K_2O kg/ha	30	45	60	Mean
10	43.75	63.13	73.75	60.21
20	53.63	61.75	66.75	60.71
30	55.00	58.13	74.38	62.50
Mean	50.80	61.00	71.63	

C.D.(0.05) for marginal means = 9.818
C.D.(0.05) for combinations = 17.005

It was observed that P_2O_5 content of the soil increased with increasing levels of N, though the differences were not significant.

Increasing levels of P_2O_5 had given a corresponding significant increase in soil P_2O_5 content.

As in the case of nitrogen, levels of potash also showed a similar trend. The differences were not significant.

c. Available K_2O content

The mean K_2O content of the soil are given in Table 24 and the analysis of variance table in Appendix VIII.

The data shows that N levels had no significant influence on K_2O content of soil. But increasing levels of N showed a decreasing trend in K_2O content.

Eventhough the levels of phosphorus had no significant effect on K_2O content of soil, it was increased with increasing the level upto 45 kg after which it showed a reduction.

K_2O content of the soil was also not significantly influenced by potash levels. With increasing levels of potash upto 20 kg, soil K_2O content increased, after which it showed a reduction.

V. Correlation studies

The values of simple correlation coefficients are presented in Table 25.

Grain yield of the crop was positively and significantly correlated with number of flowers per plant, number of pods per plant, number of seeds per pod, length of pod and 100 seed

Table 24

Available potassium content of soil (kg/ha)

	N kg/ha			
P_2O_5 kg/ha	20	30	40	Mean
30	96.50	63.33	60.50	73.44
45	63.67	87.83	69.00	73.50
60	63.83	65.67	80.00	69.83
K_2O kg/ha				
10	79.00	68.33	63.50	70.28
20	69.50	76.00	84.00	76.50
30	75.50	72.50	62.00	70.00
Mean	74.67	72.28	69.83	

	P_2O_5 kg/ha			
K_2O kg/ha	30	45	60	Mean
10	72.33	67.33	71.17	70.28
20	65.67	85.33	78.50	76.50
30	82.33	67.83	59.83	70.00
Mean	73.44	73.50	69.83	

C.D.(0.05) for marginal means = 2.07

C.D.(0.05) for combinations = 2.07

weight. The 'r' values were 0.2815, 0.4686, 0.4505, 0.3402 and 0.4442 respectively.

N, P_2O_5 and K_2O uptake by the crop were positively and significantly correlated with grain yield and total dry matter production of the crop and the correlation coefficients were; 0.8866, 0.5235, 0.8217, 0.9460, 0.8722 and 0.8780 respectively.

Protein of the grain was positively and significantly correlated with protein of the total crop and N uptake and the correlation coefficients were 0.8571 and 0.5092 respectively.

Total N and K_2O uptake by the crop were negatively correlated with total N and available K_2O content of the soil respectively. While P_2O_5 uptake was positively and significantly correlated with available P_2O_5 content of the soil. The 'r' values of N, K_2O and P_2O_5 were -0.1368, -0.0460 and 0.3365 respectively. The 'r' values of N and K_2O were not significant.

Table 25

Values of Simple Correlation Coefficients

Sl.No.	Characters correlated	Correlation coefficients
1.	Grain yield x No. of flowers per plant	0.2815*
2.	,, x No. of pods per plant	0.4686**
3.	,, x No. of seeds per pod	0.4505**
4.	,, x length of pod	0.3402*
5.	,, x 100 seed weight	0.4442**
6.	,, x N uptake by crop	0.8866**
7.	,, x P_2O_5 uptake by crop	0.5235**
8.	,, x K_2O uptake by crop	0.8217**
9.	Total dry matter production of the crop x N uptake by crop	0.9460**
10.	,, ,, x P_2O_5 uptake by crop	0.6722**
11.	,, ,, x K_2O uptake by crop	0.8217**
12.	Protein content of the grain x Protein content of the total crop	0.8571**
13.	,, ,, x Total N uptake	0.3092*
14.	Total N uptake by crop x Total N content of soil	-.1568
15.	P_2O_5 uptake by crop x available P_2O_5 content of soil	0.3365*
16.	K_2O uptake by crop x available K_2O content of soil	-.0460

*Significant at 0.05 level
**Significant at 0.01 level

DISCUSSION

DISCUSSION

An experiment was conducted in the Instructional Farm attached to the College of Agriculture, Vellayani during the third crop season of 1978-79 to find out a suitable combination of nitrogen, phosphorus and potash for maximum yield of green gram in rice fallows and to study the effect of levels of nutrients on yield, quality and uptake of nutrients by the crop. The results of the experiment are discussed below.

I. Growth characters

a. Height

(Tables 1a to 1d, Fig. 3, Appendix II)

The plant height is a factor influenced by nutritional supply. In the case of green gram, 30 and 40 kg N increased the plant height over the lowest level of 10 kg upto 45th day after sowing, after which the height was not further increased. Russel (1961) opined that nitrogen supply was beneficial for rapid establishment of leguminous crops particularly if the seed was small and the land was worn out. The symbiotic association with rhizobium and the effective fixation of N commences only after the formation of root nodules. In the early stages the response obtained in growth is indicative of the insufficiency of the available nitrogen from the soil and the fixed nitrogen by the symbiosis. Similar results have been recorded by Panda (1972) in green gram, Lenka and Satpathy (1976) in pigeon pea and Subbaiah (1978) in green gram.

Phosphorus at the highest level of 60 kg P_2O_5/ha increased the plant height even upto the later stages of growth. This may be due to the influence of phosphorus on meristematic activity (Black, 1968). Similar increase in plant height with increasing levels of phosphorus was also reported by Deshpande and Bathkal (1965), Moolani and Jana (1965), Panda (1972), Kaul and Sekhon (1976) and Rollin Baskar (1979) in green gram.

Higher levels of potash (20 and 30 kg K_2O/ha) increased the height of plants throughout the growth period. Potassium is reported to be essential for the promotion of growth of meristematic tissue (Tisdale and Nelson, 1975). Potash as an element hastens metabolic processes in plants and response to this nutrient is well exhibited as an increase in the height of plants. Increased height of plants by potash application has been reported in lucerne (<u>Medicago sativa</u> L.) by Cooper <u>et al</u>. (1967).

Phosphorus in combination with potash was found to influence the height of green gram at higher levels. It was found that a combination of 60 kg P_2O_5 and 20 kg K_2O significantly increased the plant height in the early stages of crop growth compared to application of P and K alone. The significant interactional effect is to be mainly attributed to the enhanced root growth due to phosphorus and consequent effective utilisation of applied potash. Further, phosphorus and potassium through their role as essential macronutrients, may have exerted a direct influence on nitrogen gains as well in the early stages which in turn has resulted in increased height.

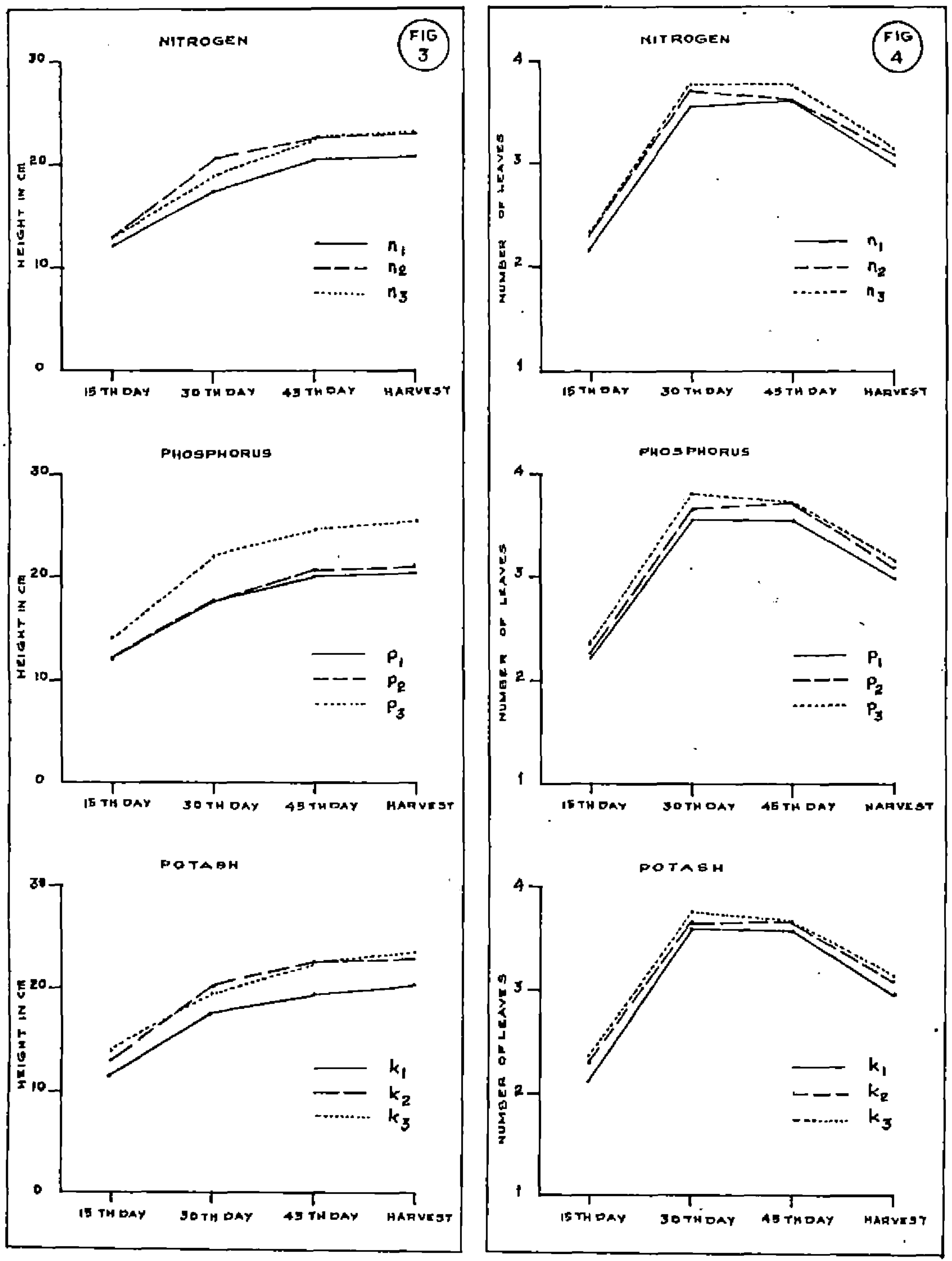
b. Number of leaves per plant

(Tables 2a to 2d, Fig.4, Appendix II)

Number of leaves per plant was found to increase significantly by higher levels of nitrogen in early stages of plant growth only. Nitrogen being the most important nutrient element for the growth and development of plants, its supply and availability, when the nodule bacteria was not well established or the symbiotic mechanism had not become effectively operative, would have helped the plant to produce more number of leaves in the initial stages of growth. Lochaiyukul *et al*. (1970) also reported that application of nitrogen was necessary for the early growth of *mung*. Increase in growth of foliage with increasing levels of nitrogen was also observed by Singh (1971) in gram, Loong and Lenz (1974) in soybean and Jayadevan and Sreedharan (1975) in groundnut.

Highest level of 60 kg P_2O_5/ha significantly increased the number of leaves over the lowest level of 30 kg P_2O_5/ha upto flowering stage. Increasing levels of phosphorus has increased the number of leaves similar to increased general growth effects. These effects of phosphorus appear to be

EFFECT OF NITROGEN, PHOSPHORUS AND POTASH ON HEIGHT AND NUMBER OF LEAVES AT DIFFERENT GROWTH STAGES.



mainly due to NP interactional effects. The enhanced root growth in leguminous crops by the application of phosphorus and the subsequent interactional effects with nitrogen has been well documented (Garg et al., 1970 and Tarila et al., 1977).

Potash had no significant effect on the number of leaves at all stages of growth except on the 15th day. Groneman (1974) reported that potash fertilizers had little effect on growth of soybeans.

As in the case of plant height, the combination of phosphorus and potash was found to affect the number of leaves of green gram only during the early stages of growth. A combination of 60 kg P_2O_5 and 30 kg K_2O was found to be most effective in increasing the number of leaves. This may be due to the enhanced uptake of nitrogen due to the phosphorus and potash application.

c. Nodulation

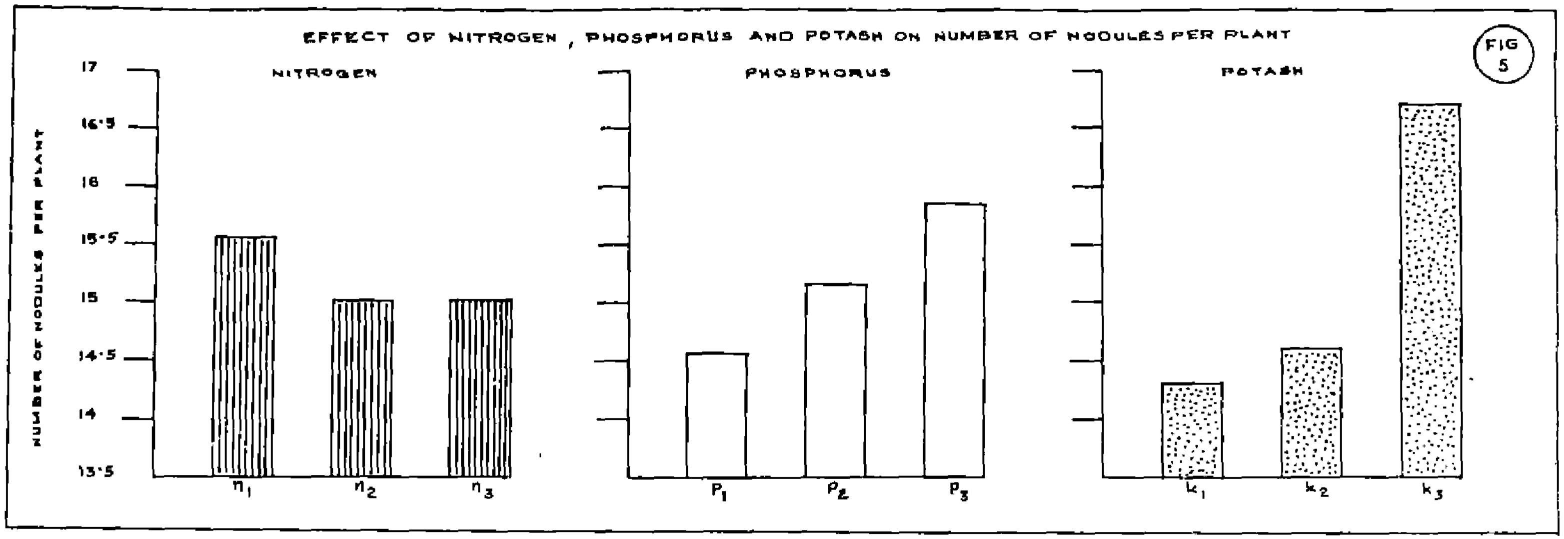
(Tables 3 and 4, Fig. 5 and 6, Appendix III)

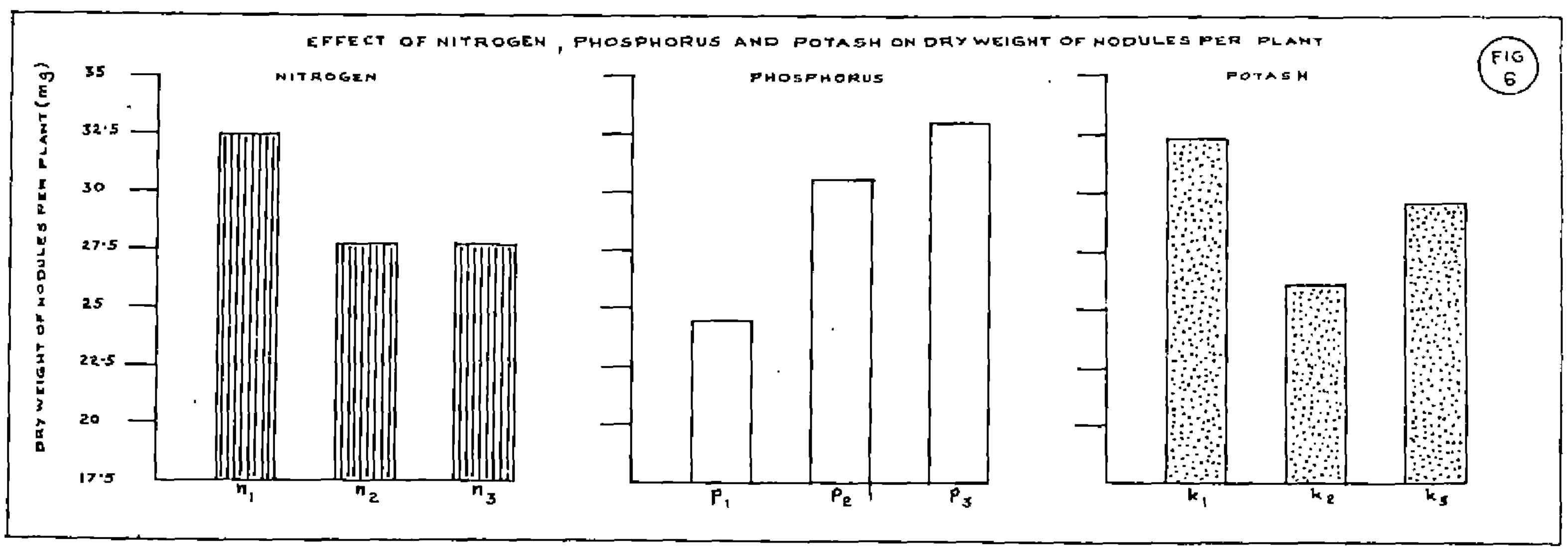
The levels of nitrogen, phosphorus and potash do not appear to influence the number and dry weight of nodules. Smith et al. (1968) reported that number of nodules were not significantly affected by nitrogen levels in soybean. Badawy and El-Sayed (1976) reported that nodulation was not affected by phosphorus application in broad beans.

As the level of nitrogen was increased, the nodule number and weight were reduced. It is a known fact that application of higher levels of nitrogen sometimes inhibit nodule production in legumes. Similar reduction in number of nodules at higher levels of nitrogen was also reported by Sistachs (1970) and Koinov and Petkov (1975) in *Phaseolus vulgaris* and Rubes (1977) in peas. Singh (1971) in chick pea, Koinov and Petkov (1975) in *Phaseolus vulgaris* and Papanicolaou *et al.* (1977) in beans reported the reduction in dry weight of nodules at higher levels of nitrogen.

Though phosphorus levels did not affect the number and weight of nodules, the highest level of 60 kg P_2O_5 was seen to increase these factors over the lower levels. Phosphorus is well known to have an influence on nodulation in legumes. But the effect was not pronounced here. The medium available phosphorus status of the soil might have contributed enough quantity for nodulation and so there was no response to the applied phosphorus. Favourable effects of phosphorus on nodulation was also reported by Deshpande and Bathkal (1965) and Ravankar *et al.* (1972) in green gram, Sahu (1973) in black gram, Tej Singh *et al.* (1975) and Subbaiah (1978) in green gram.

Though potash levels did not significantly affect the number and weight of nodules, an increasing trend was noted with regard to number and decreasing trend with regard to dry weight as the potash levels were increased. Results showing


EFFECT OF NITROGEN, PHOSPHORUS AND POTASH ON NUMBER OF NODULES PER PLANT
FIG 5
NITROGEN
PHOSPHORUS
POTASH
NUMBER OF NODULES PER PLANT
17
16·5
16
15·5
15
14·5
14
13·5
n1
n2
n3
P1
P2
P3
k1
k2
k3


EFFECT OF NITROGEN, PHOSPHORUS AND POTASH ON DRY WEIGHT OF NODULES PER PLANT
FIG 6
NITROGEN
PHOSPHORUS
POTASH
DRY WEIGHT OF NODULES PER PLANT (mg)
35
32·5
30
27·5
25
22·5
20
17·5
n1
n2
n3
P1
P2
P3
k1
k2
k3

the effect of potash in increasing the number of nodules were also reported by Van Schreven (1965) in peas and groundnut, Haghparast and Mengel (1973) in *Vicia faba*, Chesney (1974) in cowpea and Greneman (1974) in soybean.

Combined application of 60 kg P_2O_5 and 20 kg K_2O gave the maximum number of nodules (21.75). This may be due to the favourable influence of P and K together on microbial activity. Van Schreven (1958) observed a stimulation in nitrogen fixation in soybean by K, when P was also applied. Debin and Ignatenko (1969) in soybean and Muthuswamy (1973) in groundnut, also reported the increase in nodule number by the application of P and K.

II. Yield characters

a. Number of flowers per plant

(Table 5, Fig. 7, Appendix IV)

Though the levels of nitrogen did not affect the number of flowers/plant, a depressing effect was noted beyond 30 kg/ha which shows that the lowest level of nitrogen was more than sufficient for the flower production and the higher levels affect the flower production adversely in legumes.

In the case of phosphorus, though the levels did not affect the number of flowers per plant, a linear increasing trend has been noted from the lowest level to the highest level (11.59 per cent). This shows that the lowest level of applied phosphorus was sufficient for flower production in green gram when the soil was considered as medium for available phosphorus. Tanaki and Naka (1971) reported that absence of phosphorus caused a decline in the number of flowers in broad bean. Tarila et al. (1977) found that increasing levels of applied phosphorus enhanced flower number in cowpea.

As in the case of phosphorus, potash also did not significantly influence the flower production. However, a linear increase from 6.38 to 7.37 flowers per plant was found by increasing potash levels from 10 to 30 kg K_2O/ha. The increase of flowers by the highest level over the lowest was equivalent to 15.52 per cent, though not significant. Thus both phosphorus and potash application were found to definitely enhance flower production to the extent of 10 to 15 per cent while highest level of nitrogen had a suppressing effect. Such a suppression of flowering is only to be expected from the physiological role of higher levels of nitrogen in enhancing the vegetative growth.

b. Number of pods per plant

(Table 6, Fig. 8, Appendix IV)

The levels of nitrogen, phosphorus and potash had no effect in significantly enhancing the number of pods per plant. It may be noted from the table that in the case of number of pods, the difference between the highest and lowest levels of nitrogen was only 4.06 per cent. In the case of phosphorus it was still less (3.51 per cent). Since the levels of nitrogen and phosphorus had not affected the number of flowers/plant, the number of pods were also remained unaffected by these nutrients.

Green gram with low uptake capacity when raised in a soil medium in available phosphorus (45 kg P_2O_5/ha) naturally cannot be expected to respond well to the addition of fertiliserP. This is in agreement with the findings of Venugopal and Moracham (1974) in green gram.

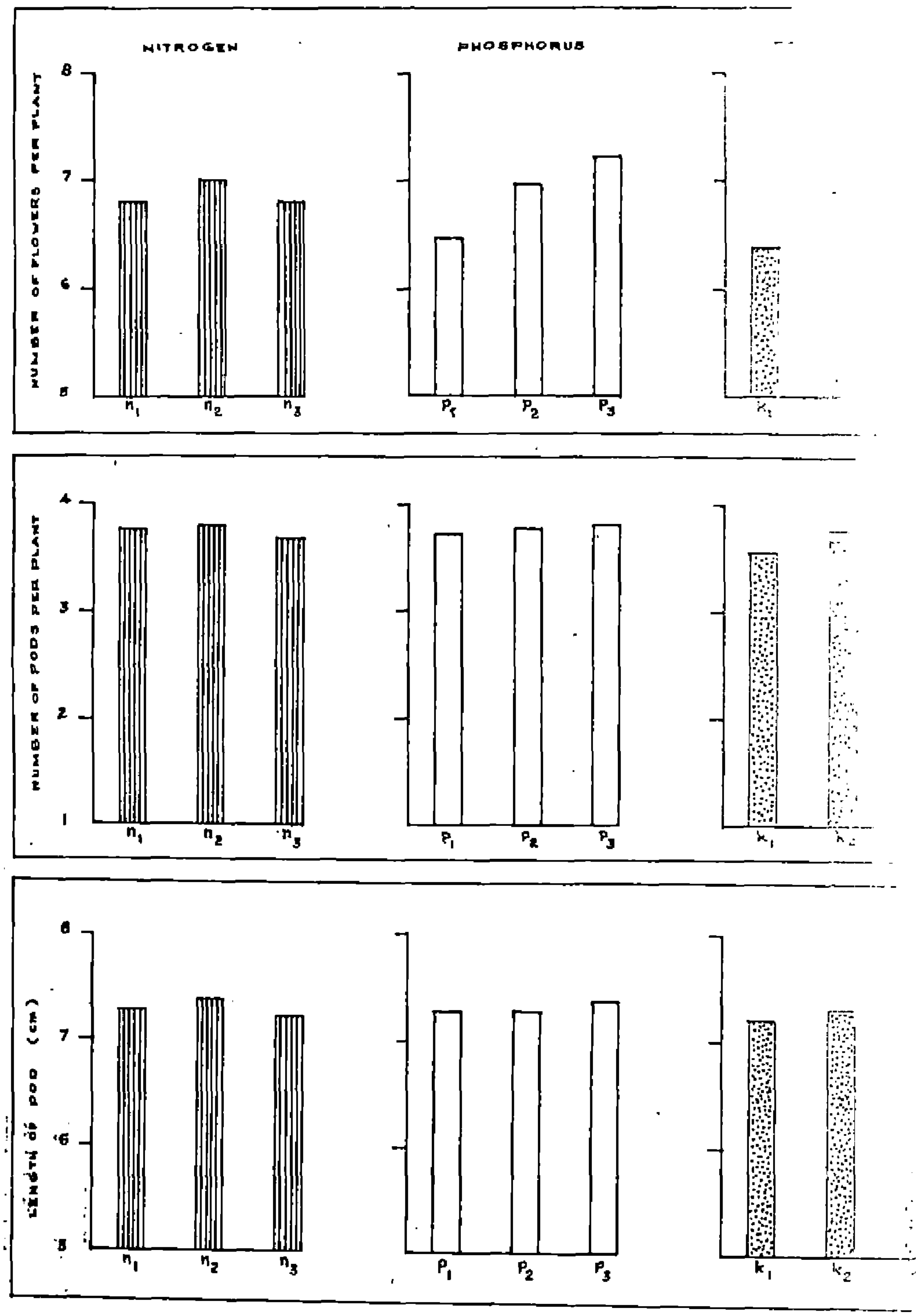
But in the case of potash, though the difference between the levels were not significant, there was a linear increase in the number of pods seen from the lowest to the highest level of potash and the variation between them were found to be 12.39 per cent which can be considered much higher as compared to the effect of nitrogen and phosphorus. This observation more or less synchronises with the enhanced flower production due to graded levels of potash. Increase in pod yield with potash application was also reported by Shekhawat et.al. (1967) in peas and Pande et al. (1971) in groundnut.

c. Length of pod

(Table 7, Fig. 9, Appendix IV)

Different levels of nitrogen, phosphorus and potash did not significantly affect the length of pod. Length of pod is a character which mainly depends on the genetical make up of the variety. This may be one of the reasons for the

EFFECT OF NITROGEN, PHOSPHORUS AND POTASH ...



lack of response observed with respect to this character. Similar observations have been made by Vijayakumar (1967) in cowpea.

d. Number of seeds per pod

(Table 8, Fig. 10, Appendix IV)

Since the levels of nutrients did not affect the length of pod (Table 7), the number of seeds per pod was also not influenced. Similar results in green gram were reported by Panwar *et al.* (1977) for different levels of nitrogen and phosphorus and Rollin Baskar (1979) for different levels of phosphorus. Ahmad and Shafi (1975) reported that in peas, number of seeds per pod was not significantly altered by nitrogen, phosphorus or potash application. The results obtained in the present investigation are thus in conformity with similar observations made in other pulse crops.

e. Weight of seeds per plant

(Table 9, Fig. 11, Appendix IV)

Though the levels of nitrogen and phosphorus did not significantly influence the weight of seeds per plant, the highest level of 30 kg K_2O increased the seed weight significantly over the lowest level of 10 kg. This may be due to the influence of potash on photosynthesis and carbohydrate metabolism. Increase in seed weight per plant with increasing levels of potash was also reported by Nemeth and Forster (1976) in field beans.

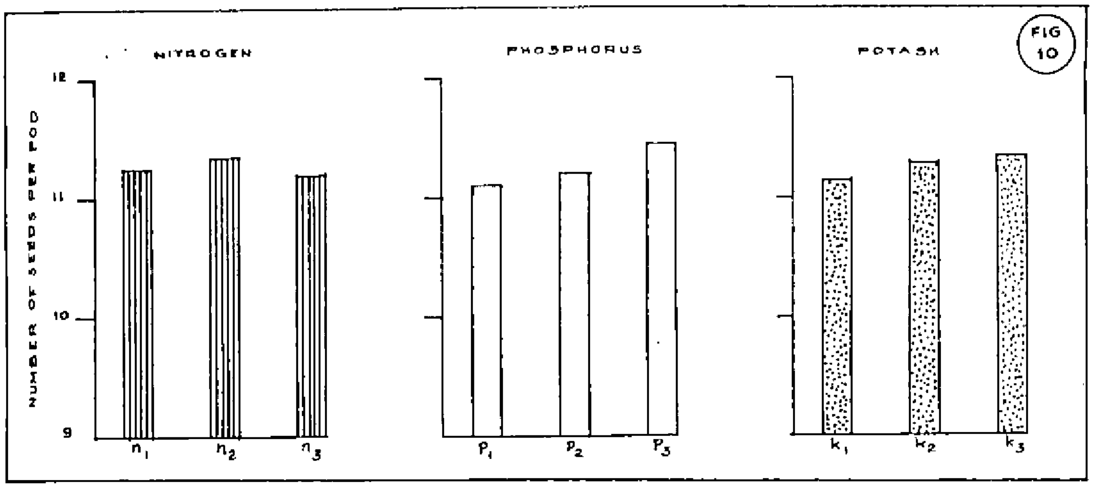
f. 100 seed weight

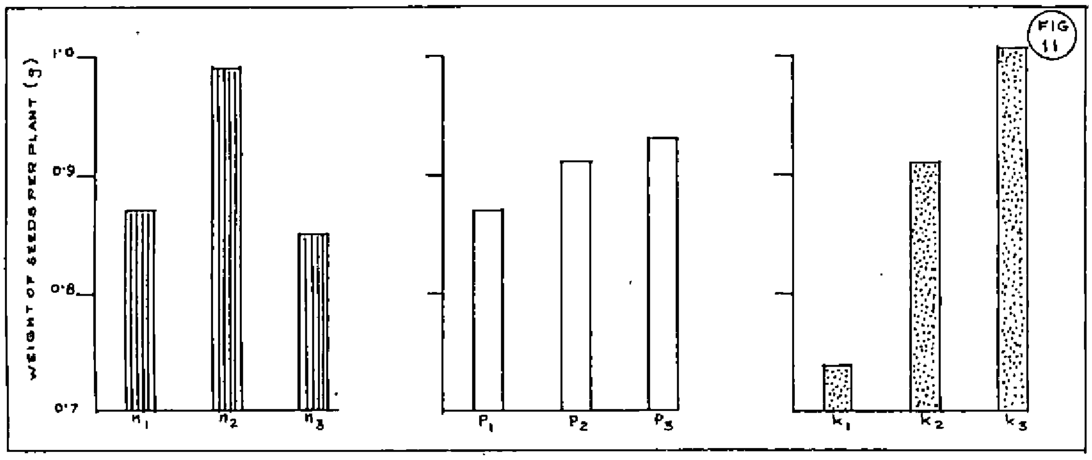
(Table 10, Fig. 12, Appendix IV)

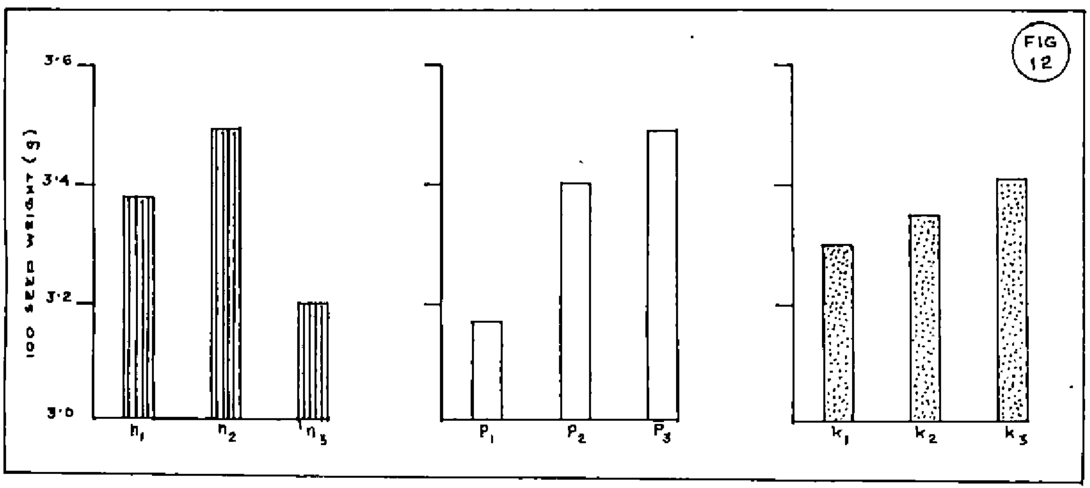
Increase in the level of nitrogen did not affect the 100 seed weight upto 30 kg/ha after which the weight was significantly reduced. Similar trend was also noticed in the case of height of plants in all stages of growth, number of flowers and number of pods per plant, length of pod, number of seeds per pod and weight of seeds per plant. This shows that beyond 30 kg N the aforementioned characters as well as growth and yield were adversely affected. Application of higher levels of nitrogen is well known to reduce nitrogen fixation by the symbiotic association (Sistachs, 1970; Singh, 1971; Koinov and Petkov, 1975; Rubesa 1977 and Papanicolaou et al., 1977). Further the possibility of leaching losses of soil and applied nitrogen also cannot be excluded. Similar decrease in 100 seed weight at higher levels of nitrogen has been recorded by Borcean et al. (1977) in peas and Chee and Karim (1977) in groundnut.

In the case of phosphorus, significant increase in 100 seed weight was obtained by application of 45 and 60 kg P_2O_5/ha over 30 kg. This may be due to its effect on efficient seed production and grain filling. Similar results showing an increase in 100 seed weight with increasing levels of phosphorus was also reported by Singh et al. (1975), Kaul and Sekhon (1976), Panwar et al. (1978), Subbaiah (1978) and Rollin Baskar (1979) in green gram.

EFFECT OF NITROGEN, PHOSPHORUS AND POTASH ON YIELD ATTRIBUTES







Levels of potash had no significant influence on 100 seed weight. But a linear increase was seen from the lowest to the highest level. Sankara Reddi et al. (1976) also reported that test weight of soybean was not significantly influenced by levels of potash.

g. Grain yield

(Table 11, Fig. 13, Appendix V)

Levels of nitrogen did not affect the grain yield significantly. Similar results were also noted by Garg et al. (1971) in peas, Malik et al. (1972) in cowpea, Venugopal and Morachan (1974) in green gram. As in the case of height and yield contributing factors, the results showed a reduction in grain yield at 40 kg N which again points out that the addition of nitrogen beyond 30 kg will adversely affect the crop yield. The Table 11 shows that 30 kg N could produce an additional grain yield of 61.7 kg over 20 kg N, which is not very remunerative. So it may be concluded that green gram requires only the lowest level of 20 kg N/ha. Reduction in grain yield at higher levels of nitrogen was also reported by Singh et al. (1975) in green gram and Lenka and Satpathy (1976) in red gram.

The grain yield was not significantly influenced by levels of phosphorus also. This may possibly be due to the comparative medium status of the soil with respect to available phosphorus and so the crop need be applied with 30 kg P_2O_5/ha. Similar results were also reported by

Venugopal and Morachan (1974) and Tej Singh et al. (1975) in green gram.

Highest level of 30 kg K_2O significantly increased the grain yield over 10 kg. When 10 kg K_2O was applied the yield of grain recorded was 369.65 kg/ha and addition of 20 kg K_2O gave an extra yield of 168.78 kg which works out to a production of 8.44 kg of grain/kg of potash added and in terms of money value it is Rs.27.78 for every one rupee spend on additional 20 kg of potash. Eventhough all the yield contributing factors except weight of seeds per plant were not significantly influenced by levels of potash, all of them showed an upward trend with increasing levels of potash. The cumulative effect of all these factors together might have contributed for the significant increase in grain yield. A significant positive correlation was also observed between grain yield and yield contributing factors. Similar correlation was also reported by Verma and Dubey (1970) in black gram. Results showing increased grain yield with increasing levels of potash were also reported by Chesney (1974) in cowpea, Sawhney et al. (1975) in black gram and Nemeth and Forster (1976) in field beans.

h. Bhusa yield

(Table 12, Fig. 13, Appendix V)

Highest level of 40 kg N significantly increased the bhusa yield over the lower levels. Height of plants and number of leaves per plant which contribute towards the bhusa yield were maximum at higher levels of nitrogen. This might be the reason for increased bhusa yield. Similar results were also reported by Shukla (1964) in gram, Rubes (1971) in peas, Panda (1972) in green gram and Lenka and Satpathy (1976) in pigeon pea.

Though the levels of phosphorus and potash had no significant influence on bhusa yield, an increase in their levels showed a linear increase as in the case of height and number of leaves.

i. Harvest index

(Table 13, Appendix V)

None of the nutrient levels had any influence in significantly affecting the harvest index. In the case of nitrogen, the harvest index was decreasing with increasing the level, but the reduction was much higher beyond 30 kg. Similar reduction at the highest level of N was noted in grain yield and yield attributing characters. The nitrogen application helped to increase the yield of bhusa which reduced the harvest index at the highest level. This may be due to the excessive vegetative growth and comparatively reduced translocation of nitrogen from the vegetative parts to grains.

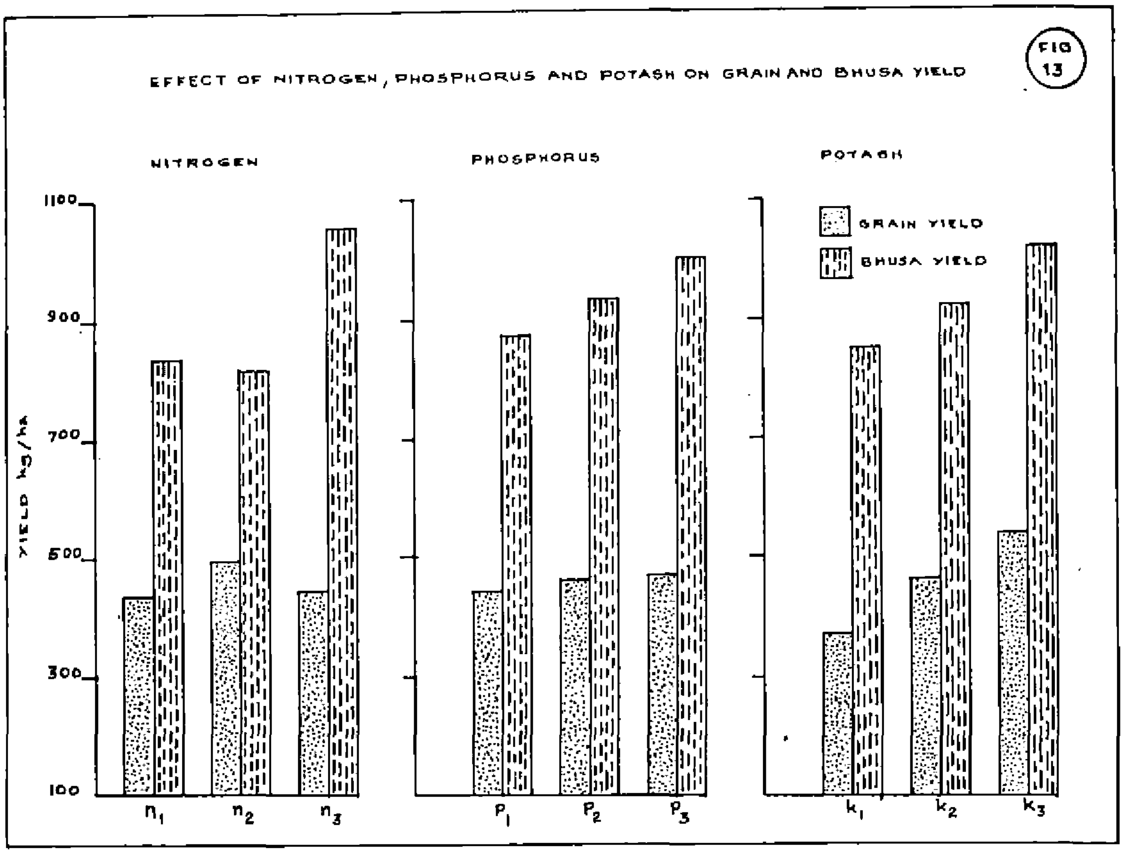
In the case of phosphorus, the grain and bhusa yield were increased with increasing the level though the differences were not significant. The highest level of 60 kg P_2O_5 reduced the harvest index over the other two levels. This reduction is mainly due to excessive vegetative production. But this finding is not in conformity with the results of Kalyan Singh and Rajendra Prasad (1975) in pigeon pea and Kaul and Sekhon (1976) in mung. The possible reason for this may be that the soil was having sufficient available P_2O_5 and the applied phosphorus was not able to exert its influence much.

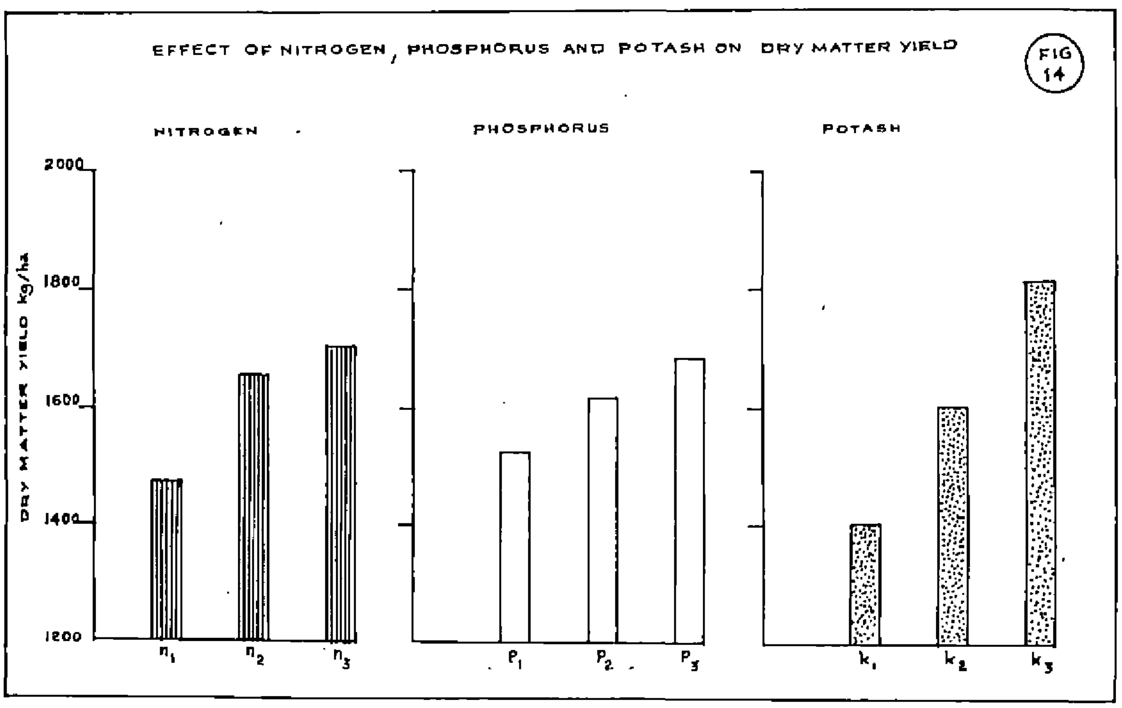
In contrast to nitrogen and phosphorus, potash application showed an increasing trend in harvest index. The grain yield was increased more with the increase in the potash application when compared to the increase in bhusa, so the harvest index also showed an increasing trend. Similar results were reported by Gutstein (1978) in groundnut.

j. Dry matter yield

(Table 14, Fig.14, Appendix V)

Eventhough application of nitrogen and phosphorus did not significantly influence the total dry matter production, a general increase was noted in both cases. Sundaram et al. (1974) in cowpea and Parodi et al. (1977) in bean also reported that there was no difference in dry matter yield between phosphorus levels. In the case of nitrogen the increase was steep upto 30 kg beyond which it levelled off. However at 40 kg a definite declining trend in grain yield was exhibited. Nattribhop and Ferraris (1970) reported an increase in total dry matter production of green gram by about 30 per cent with an increase in the N level. Similar results


EFFECT OF NITROGEN, PHOSPHORUS AND POTASH ON GRAIN AND BHUSA YIELD
FIG 13
NITROGEN
PHOSPHORUS
POTASH
GRAIN YIELD
BHUSA YIELD
YIELD kg/ha
1100
900
700
500
300
100
n1
n2
n3
P1
P2
P3
k1
k2
k3


EFFECT OF NITROGEN, PHOSPHORUS AND POTASH ON DRY MATTER YIELD
FIG 14
NITROGEN
PHOSPHORUS
POTASH
DRY MATTER YIELD kg/ha
2000
1800
1600
1400
1200
n1
n2
n3
P1
P2
P3
k1
k2
k3

were also reported by Venugopal and Morachan (1974) in green gram, Ahmad and Shafi (1975) in peas and Kang (1975) in soyabean.

As in the case of grain and bhusa yield, applied phosphorus did not play a significant role in the total accumulation of dry matter, though an increasing trend was noted. Venugopal and Morachan (1974) reported that in green gram dry matter production increased with increasing levels of phosphorus. Similar results were also reported by Rajendran and Krishnamoorthy (1975) in black gram and Kaul and Sekhon (1976) in green gram.

In the case of potash, 30 kg K_2O significantly increased the dry matter production over 10 kg. This was due to the significant increase in grain production and increasing trend in bhusa yield. This is in agreement with the findings of Mitkees (1974) in snap bean and Chevalier (1978) in soybean.

III. <u>Plant analysis</u>

A. <u>Nutrient uptake</u>

a. Nitrogen uptake

(Table 15, Fig. 15, Appendix VI)

Increasing levels of nitrogen, phosphorus as well as potash increased the nitrogen uptake by plants, though the differences between the levels were not significant. Dalal and Quilt (1977) reported that fertilizer N did not significantly affect the uptake of N in pigeon pea.

The increase in nitrogen uptake with increasing levels of applied nitrogen may be due to comparatively higher availability of nitrogen in the soil. This is in agreement with the findings of Kushizaki et al. (1964) in soybean, Dart and Mercer (1965) in cowpea and Kang (1975) in soybean.

The influence of phosphorus on nitrogen uptake may be due to its effect on root development and thereby increasing dry matter production. Similar results were also reported by Kadwe and Badhe (1973) in black gram, Venugopal and Morachan (1974) in green gram, Rajendran and Krishnamoorthy (1975) in black gram, Ravankar and Badhe (1975) in urid, mung and soybean and Rollin Baskar (1979) in green gram.

The increase in nitrogen uptake with increasing levels of potash may be due to the increased dry matter production. Similar results were also reported by Chevalier (1976) in soybean.

A significant and positive correlation was also observed between N uptake and total dry matter production.

b. P_2O_5 uptake

(Table 16, Fig. 16, Appendix VI)

The highest level of 40 kg N significantly increased the P_2O_5 uptake by plants over the lowest level of 20 kg. Higher levels of nitrogen applied at the time of planting might have hastened the growth of plants and resulted in higher dry matter production. This may be the reason for the increased uptake of P_2O_5 at higher levels of nitrogen.

Brenscale (1928) concluded that the absorption of phosphate was stimulated by the presence of nitrogen. There was also a significant positive correlation observed between P_2O_5 uptake by the crop and total dry matter production.

Application of 60 kg P_2O_5 significantly increased the P_2O_5 uptake by plants over 30 kg. The increase in root growth leading to greater uptake of P by root interception may be the reason for the observed increase in the uptake of P_2O_5. Increased dry matter production at higher levels of P_2O_5 might have also influenced the P_2O_5 uptake. Similar results were also reported by Kadwe and Badhe (1973), Rajendran et al. (1973) and Rajendran and Krishnamoorthy (1975) in black gram, Ravankar and Badhe (1975) in black gram, green gram and soybean, Badanur et al. (1976) in black gram and Rollin Baskar (1979) in green gram.

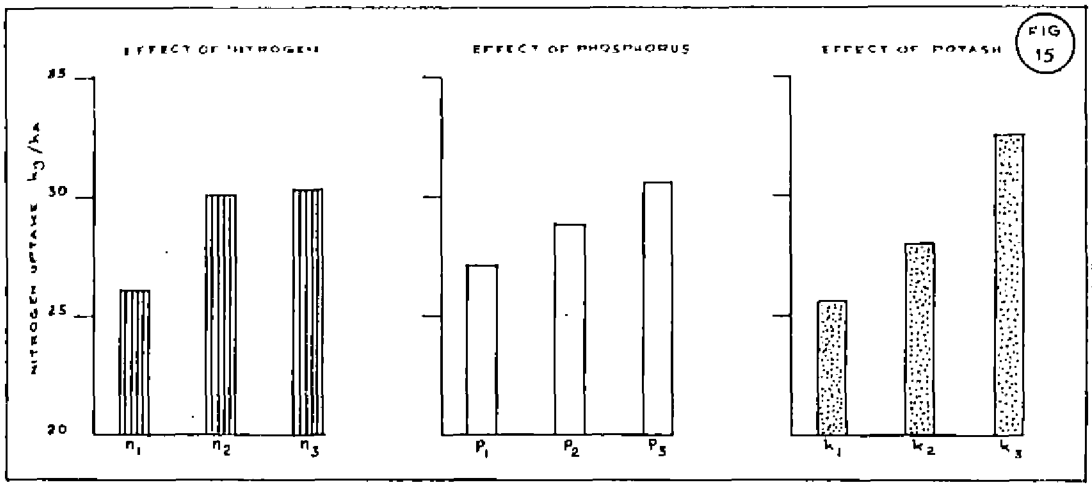
Though potash had no significant influence on P_2O_5 uptake by plants, an increase in the levels of potash showed an increasing trend. Sasidhar and George (1972) reported that increasing rates of K_2O increased the phosphorus contents in lab lab.

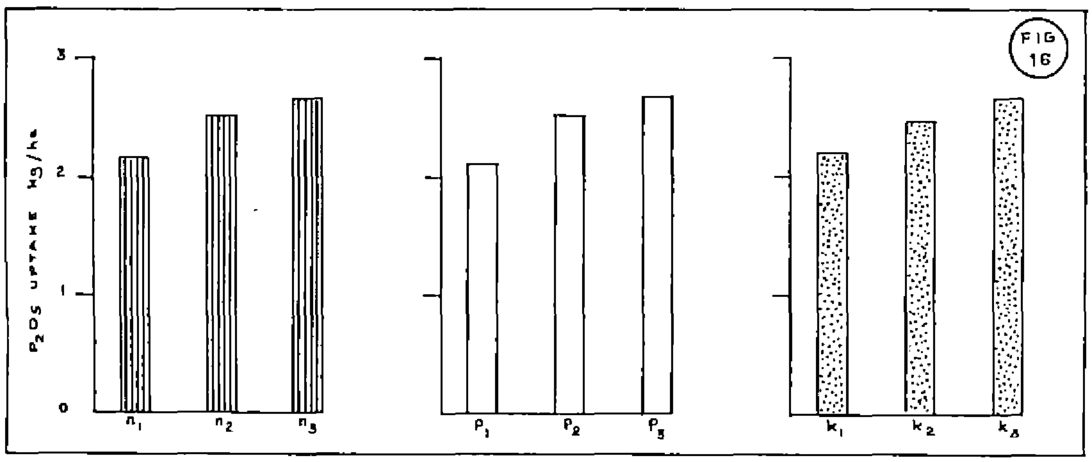
c. K_2O uptake

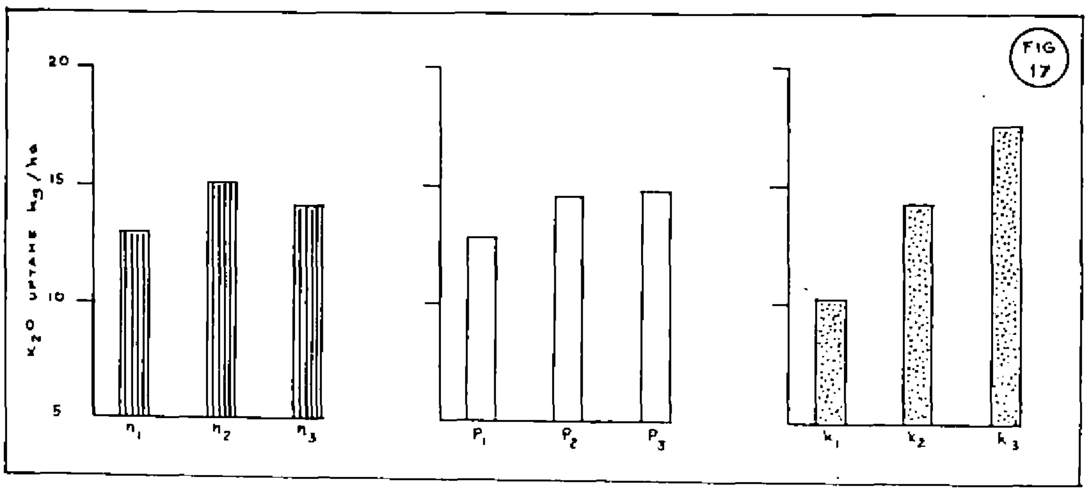
(Table 17, Fig. 17, Appendix VI)

Levels of nitrogen had no significant influence on K_2O

NITROGEN, PHOSPHORUS AND POTASH UPTAKE BY PLANTS







uptake by plants. But it showed an increasing trend upto 30 kg after which there was a reduction. Yield and all the yield contributing factors showed a similar trend. Identical results have been obtained by Dalal and Quilt (1977) in pigeon pea.

Though the levels of phosphorus had no significant influence on K_2O uptake by plants, an increasing trend was noticed with increasing levels of phosphorus. The uptake of K depends to a large extent on the degree of development of the root system (Kanwar, 1976). Increase in K_2O uptake with increasing levels of phosphorus was also reported by Kadwe and Badhe (1975) in black gram and Rollin Baskar (1979) in green gram.

Regarding the effect of potash, increasing levels of K_2O significantly increased its uptake by plants. This may be due to the luxury consumption of potash which is a characteristic of many plants. Puntamkar and Bathkal (1967) in groundnut and Groneman (1974) in soybean had reported the effect of potash application on K_2O uptake. Moreover a significant positive correlation was observed between K_2O uptake and total dry matter production.

B. Protein

a. Protein content of grain

(Table 18, Fig.18, Appendix VII)

From the table it can be seen that the protein content was increased with increase in the level of nitrogen application in green gram though the differences were not significant. The rains during the early stages of crop growth might have removed some of the applied nitrogen beyond the root zone and the translocation of nitrogen from the leaves to the grains by destructive senescence might not have taken place effectively. Still a slight variation was noted. Increase in the grain protein content by nitrogen application was also reported by Bains (1967) in field beans, Singh et al. (1969) and Garg et al. (1971) in peas, Singh (1971) in gram, Rajendran et al. (1974) in black gram and Borceen et al. (1977) in peas. Correlation studies showed that there was a significant positive correlation between protein content of grain and N uptake by the crop.

In the case of phosphorus also a similar trend like nitrogen was noted in the protein content. Increase in seed protein content with increasing levels of phosphorus was also reported by Garg et al. (1971) in pea, Singh (1971) in gram, Kesavan and Morachan (1973) in soybean, Panwar and Kanwar Singh (1976) in green gram and Bavankar and Badhe (1975) in urid, mung and soybeans.

Potash, like nitrogen and phosphorus though not significant in effect, showed a decrease in the protein content as the level was raised from 10 to 30 kg. The findings of Singh et al. (1969) in peas, Augustinussen (1972) in field beans and Bhuiya and Chowdhury (1974) in groundnut also indicated that potash had no influence on the protein content.

while Belojova (1968) and Chevalier (1976) found a reduction in protein content of soybean when the applied potash was increased.

b. Protein content of bhusa

(Table 19, Fig.19, Appendix VII)

Similar to grain protein, the protein content of bhusa was also increased with increasing levels of nitrogen and phosphorus, though the differences were not significant. Increase in protein content of straw with increasing levels of N and P was also reported by Singh (1971) in gram.

Potash has helped in increasing the total production of bhusa of green gram. From the data in Table 12 it can be noted that the yield of bhusa was increased from 848 kg to 1019 kg when potash level was increased from 10 to 30 kg/ha. It is a well known fact that increase in yield has a dilution effect on protein content. In this study also such an observation could be made.

c. Grain protein yield

(Table 20, Fig. 20, Appendix VII)

The grain protein production was increased with the increase in nitrogen level upto 30 kg/ha. This also showed the same pattern as in the case of yield and yield attributing characters. The differences between the levels though not significant indicate that 30 kg N is the maximum that can be given to green gram for higher grain protein yield. Increase in protein yield with nitrogen application was also reported by Costache (1970) and Markus (1976) in soybean. Reduction in crude protein yield at higher levels of nitrogen was in agreement with the findings of Ratner (1977) in soybean, peas, broad beans, clover and vetches.

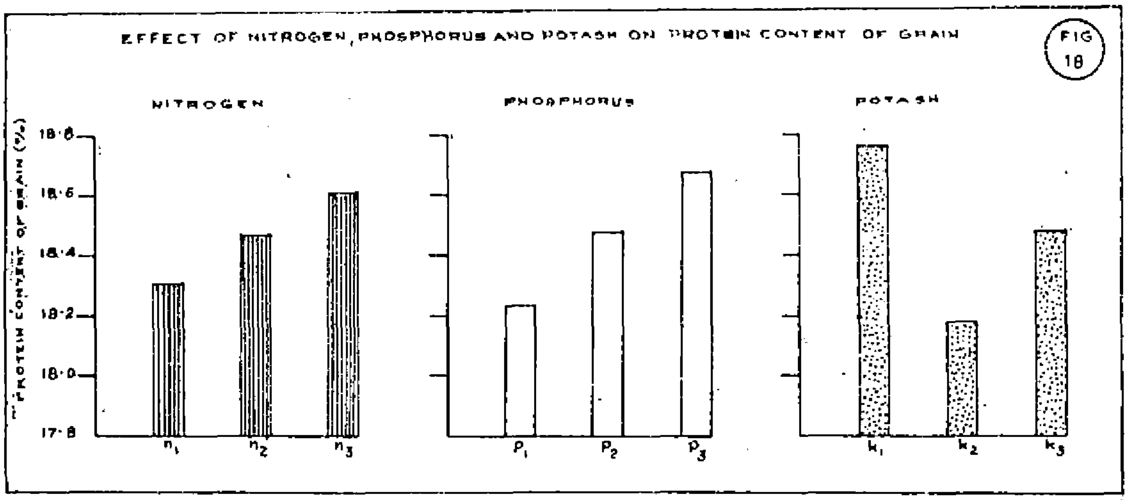
Highest level of phosphorus produced 13 per cent more protein than the lowest level per hectare, though it was not significant. Increase in protein yield at higher levels of phosphorus was also reported by Kesavan and Morachan (1973) in soybean.

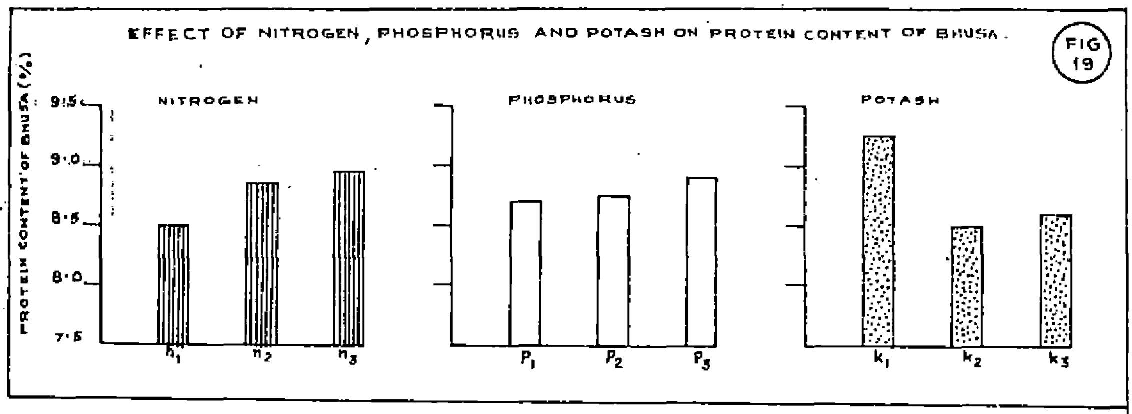
The grain protein yield due to potash application was found to be significant since the grain yield was also influenced by potash. The highest level of 30 kg K_2O/ha increased the protein yield by 43 per cent over the lowest level of 10 kg. This is in agreement with the findings of Markus (1976) in soybean.

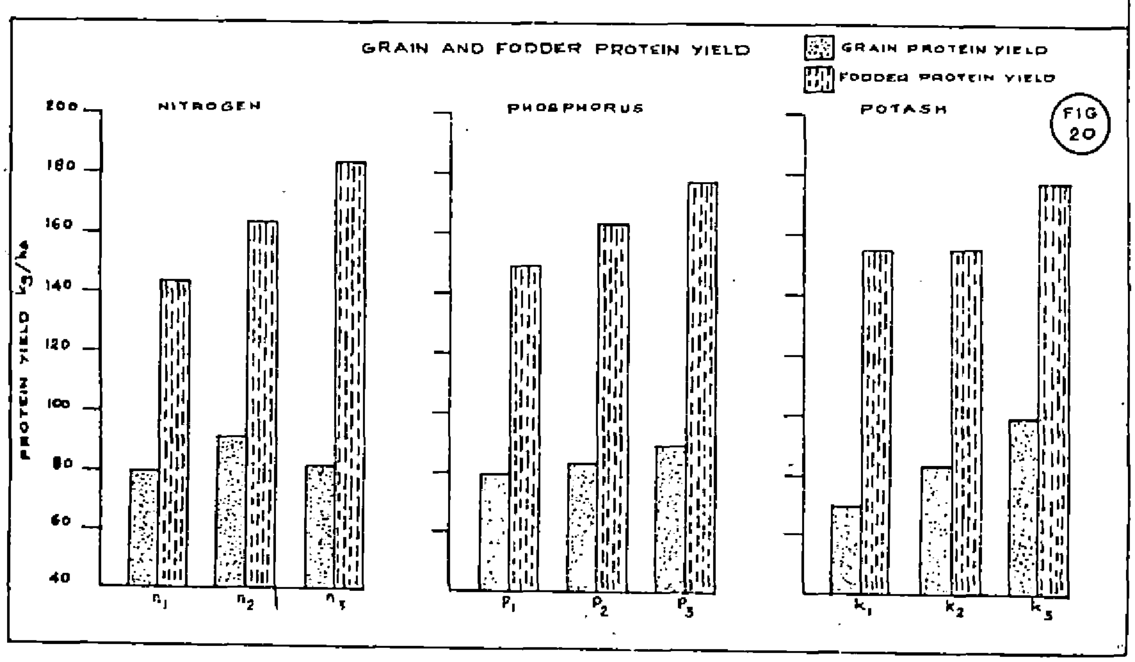
d. Fodder protein yield

(Table 21, Fig. 20, Appendix VII)

Eventhough the levels of nitrogen had no significant influence on fodder protein yield, the highest level of 40 kg N increased the protein yield by 27 per cent over the lowest level of 20 kg, while 60 kg P_2O_5 increased the fodder protein production by 18 per cent and 30 kg K_2O by 14 per cent over the lowest levels.


EFFECT OF NITROGEN, PHOSPHORUS AND POTASH ON PROTEIN CONTENT OF GRAIN
FIG 18
NITROGEN
PHOSPHORUS
POTASH
PROTEIN CONTENT OF GRAIN (%)
18·8
18·6
18·4
18·2
18·0
17·8
n1
n2
n3
P1
P2
P3
k1
k2
k3


EFFECT OF NITROGEN, PHOSPHORUS AND POTASH ON PROTEIN CONTENT OF BHUSA.
FIG 19
NITROGEN
PHOSPHORUS
POTASH
PROTEIN CONTENT OF BHUSA (%)
9·5
9·0
8·5
8·0
7·5
n1
n2
n3
P1
P2
P3
k1
k2
k3


GRAIN AND FODDER PROTEIN YIELD
GRAIN PROTEIN YIELD
FODDER PROTEIN YIELD
FIG 20
NITROGEN
PHOSPHORUS
POTASH
PROTEIN YIELD kg/ha
200
180
160
140
120
100
80
60
40
n1
n2
n3
P1
P2
P3
k1
k2
k3

IV. Soil analysis

a. Total nitrogen content

(Table 22, Appendix VIII)

There was no significant difference in total N content in the soils under various treatments. Maximum dose of 30 kg N/ha cannot be expected to register itself as an increase in N content of the soil as determined by the Kjeldahl's method. The plant analysis as per the Table 15 indicated that the uptake was however higher at higher levels of applied nitrogen, thereby depleting the soil of the fixed nitrogen, part of the soil nitrogen and of the applied nitrogen. Correlation studies showed a negative correlation between N uptake and total N content of the soil after the experiment.

In the case of phosphorus and potash, medium levels (45 kg P_2O_5 and 20 kg K_2O) helped in getting maximum total nitrogen content than the other levels. Increase in nitrogen content of soil with phosphorus application was also reported by Garg et al. (1970) in cowpea, Chatterjee et al. (1972) in soybeans, Sahu and Behera (1972) in cowpea, groundnut and green gram and Sahu (1973) in black gram.

Significant increase in the nitrogen content of soil at 20 and 30 kg N in the presence of the highest dose of K_2O might be due to enhanced symbiotic fixation and excretion of the fixed N into the soil by the leguminous crop.

b. Available P_2O_5 content

(Table 23, Appendix VIII)

Nitrogen and potash had no significant influence on P_2O_5 content of soil. But increasing levels of phosphorus had a significant influence on it. This may be due to the fact that the proportion of fertiliser P taken up by a single crop is often quite low and the P fertilisers have residual value. Moreover the fixation reactions of phosphate with soil are not entirely irreversible and hence, reserves of excess P from fertilisers are not irreversibly lost. Increase in P_2O_5 content of soil with phosphorus application was also reported by Bains (1967) in field beans, Garg et al. (1970) in cowpea and Sharma and Yadav (1976) in gram.

c. Available K_2O content

(Table 24, Appendix VIII)

K_2O content of the soil was not significantly influenced by levels of nitrogen, phosphorus and potash. As a mobile cation K^+ is easily susceptible to loss through leaching. Moreover the crop also removed sufficient quantities of potash. So the small quantity of applied K_2O could not produce any significant effect on its content in the soil.

Response curve and economics of nitrogen, phosphorus and potash application

The results showed that there was no significant response to nitrogen as well as to phosphorus. Hence it is not possible to estimate the optimum and economic dose and so the lower levels of 20 kg N and 30 kg P_2O_5/ha can be considered as the optimum levels. In the case of potash, a significant linear response was observed, viz., $\hat{y} = 84.39\ x + 4\ 55.83$, where $x = \frac{K-20}{10}$, showing increasing returns in the range of levels tried. Hence it is not possible to estimate the optimum dose of potash from the levels tried. So with the available information, 30 kg K_2O/ha may be considered as the optimum requirement till further investigations are carried out and levels fixed.

The economics of nitrogen, phosphorus and potash application presented in Table 26 reveal that nitrogen application beyond 30 kg was not economical. In the case of phosphorus there was only a slight variation in the net profit between different levels. But in the case of potash, the lowest level resulted in a net loss of Rs.54.12, whereas the highest level of 30 kg K_2O gave a net profit of Rs.695.14/ha.

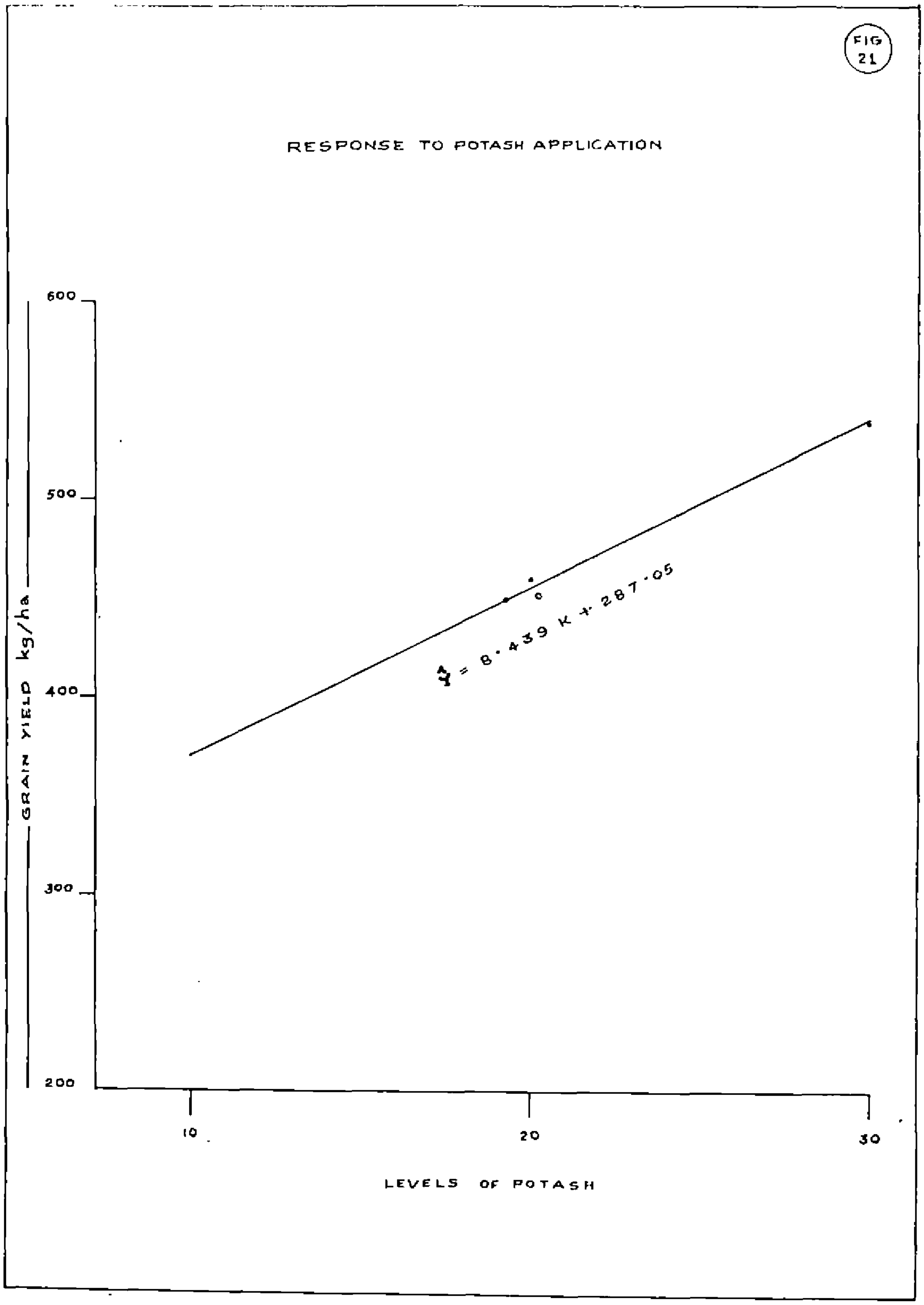


FIG 21
RESPONSE TO POTASH APPLICATION
GRAIN YIELD kg/ha
600
500
400
300
200
10
20
30
LEVELS OF POTASH
Ŷ = 8·439 K + 287·05

Table 26

Economics of nitrogen, phosphorus and potash application (Rs./ha)

Treatment	Cost of production (excluding the treatment) Rs	Additional cost for the treatment Rs	Total cost of production Rs.	Yield kg/ha		Value Rs			Additional profit from the treatment over the lowest level Rs. ±	Net profit Rs. ±
				Grain	Bhusa	Grain	Bhusa	Total		
N kg/ha										
20	1677.00	92.68	1769.68	433.06	827.08	1948.77	82.71	2031.48	..	261.80
30	1677.00	139.02	1816.02	494.13	811.19	2223.59	81.12	2304.71	+273.23	488.69
40	1677.00	185.37	1862.37	440.30	1053.10	1981.35	105.31	2086.66	+ 55.18	224.29
P_2O_5 kg/ha										
30	1661.35	103.13	1764.48	438.66	864.82	1973.97	86.48	2060.45	..	295.97
45	1661.35	154.69	1816.04	459.97	929.52	2069.87	92.95	2162.82	+102.37	346.78
60	1661.35	206.25	1867.60	468.86	997.03	2109.87	99.70	2209.57	+149.12	341.97
K_2O kg/ha										
10	1788.70	13.67	1802.37	369.65	848.22	1663.43	84.82	1748.25	..	-54.12
20	1788.70	27.33	1816.03	459.41	924.13	2067.35	92.41	2159.76	+411.51	343.73
30	1788.70	41.00	1829.70	538.43	1019.03	2422.94	101.90	2524.84	+776.59	695.14
Mean	1709.02	107.02	1816.03	455.83	919.35	2051.24	91.93	2143.17	..	327.14

Price of 1 kg nitrogen = Rs. 4.63
Price of 1 kg P_2O_5 = Rs. 3.44
Price of 1 kg K_2O = Rs. 1.37

Price of 1 kg grain = Rs. 4.50
Price of 1 kg bhusa = Rs. 0.10

SUMMARY

SUMMARY

An investigation was conducted to study the effect of three levels in each of nitrogen (20, 30 and 40 kg/ha), phosphorus (30, 45 and 60 kg/ha) and potash (10, 20 and 30 kg/ha) on growth, yield and quality of green gram in rice fallows. The experiment was laid out as 3^3 factorial experiment, confounding NPK in first replication and NPK^2 in second replication. The results of the investigation are summarised below.

1. Higher levels of nitrogen significantly increased the plant height upto 45th day after sowing whereas highest level of phosphorus and higher levels of potash significantly influenced the plant height in all stages of crop growth.

2. Higher levels of nitrogen and potash and highest level of phosphorus had a significant influence on number of leaves per plant, only in the early stages of crop growth.

3. Number and dry weight of nodules per plant were not significantly affected by levels of nitrogen, phosphorus and potash.

4. Levels of nutrients had no significant influence on yield contributing factors namely number of flowers and number of pods per plant, length of pod and number of seeds per pod.

5. Weight of seeds per plant was significantly increased by highest level of potash.

6. Highest level of nitrogen significantly decreased the 100 seed weight whereas it showed a significant increase at higher levels of phosphorus.

7. Grain yield was not significantly influenced by levels of nitrogen as well as phosphorus. Maximum grain yield of 538 kg/ha was obtained with the highest level of potash (30 kg/ha).

8. Maximum bhusa yield of 1053 kg/ha was recorded at the highest level of nitrogen. But it did not differ significantly by levels of phosphorus and potash.

9. Harvest index was not significantly influenced by nitrogen, phosphorus and potash levels.

10. Maximum dry matter yield of 1812 kg/ha was recorded at the highest level of potash.

11. Nitrogen uptake by the crop was not significantly influenced by levels of nitrogen, phosphorus and potash whereas P_2O_5 uptake was significantly increased by highest level of nitrogen and phosphorus and K_2O uptake by increasing levels of potash.

12. Protein content of grain was not significantly influenced by levels of nutrients. But maximum protein content of bhusa was observed at the lowest level of potash.

13. Maximum grain protein yield of 101 kg/ha was recorded at highest level of potash whereas fodder protein yield was not significantly affected by levels of nitrogen, phosphorus and potash.

14. Total nitrogen and available potassium content of the soil were not significantly affected by nutrient levels. But available phosphorus content was significantly increased with increasing levels of phosphorus.

15. A significant positive correlation was observed between grain yield and yield contributing factors, grain yield and uptake of nutrients, total dry matter production and uptake of nutrients.

A significant positive correlation was also observed between protein content of the grain and protein content of the total crop, protein content of the grain and nitrogen uptake, phosphorus uptake by crop and available phosphorus content of the soil.

16. Maximum net profit of Rs.695/- was obtained by applying 30 kg K_2O/ha.

The present investigation indicates that green gram requires a fertilizer dose of 20 kg N, 30 kg P_2O_5 and 30 kg K_2O/ha for giving higher yields in rice fallows under Kerala condition.

Future line of work

From the investigation it was noted that green gram responded to potash application upto 30 kg/ha and so further trials in rice fallows with higher levels of potash is necessary.

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*Original not seen

APPENDICES

Appendix - I

Weather data during the crop period (1st February to 18th April, 1979) and its variation from the past 5 years'

Weeks	Periods	Rainfall (mm)		Temperature °C Maximum	
		1979	Variation	1979	Variation
1.	1-2-1979 - 7-2-1979	-	-0.74	31.82	-0.10
2.	8-2-1979 - 14-2-1979	5.29	+5.29	31.64	+0.64
3.	15-2-1979 - 21-2-1979	7.14	+5.28	30.89	-0.03
4.	22-2-1979 - 28-2-1979	0.00	-1.80	31.71	+0.11
5.	1-3-1979 - 7-3-1979	4.00	+1.85	31.57	-0.49
6.	8-3-1979 - 14-3-1979	1.29	+1.12	31.68	-0.57
7.	15-3-1979 - 21-3-1979	-	-	31.96	-0.66
8.	22-3-1979-28-3-1979	2.14	+2.14	32.21	-1.06
9.	29-3-1979 - 4-4-1979	0.00	-2.26	32.54	+0.13
10.	5-4-1979 - 11-4-1979	0.00	-2.52	33.11	+0.52
11.	12-4-1979 - 18-4-1979	2.00	-0.48	33.75	+0.96

+ more than 5 years' data
- less than 5 years' data

continued.....2

Appendix - I

Weather data during the crop period (1st February to 18th April, 1979) and its variation from the past 5 years'

Weeks	Periods	Temperature °C Minimum		Relative humidity (%)	
		1979	Variation	1979	Variation
1.	1-2-1979 - 7-2-1979	22.46	+0.99	90.29	+11.91
2.	8-2-1979 - 14-2-1979	22.60	+1.35	90.45	+9.38
3.	15-2-1979 - 21-2-1979	23.36	+1.36	92.43	+12.10
4.	22-2-1979 - 28-2-1979	23.69	+1.45	92.29	+11.39
5.	1-3-1979 - 7-3-1979	23.30	+0.20	89.00	+ 9.10
6.	8-3-1979 - 14-3-1979	23.19	+0.38	91.00	+ 9.52
7.	15-3-1979 - 21-3-1979	23.21	-0.44	92.00	+10.95
8.	22-3-1979 - 28-3-1979	23.67	-0.36	90.86	+11.43
9.	29-3-1979 - 4-4-1979	24.65	+0.42	90.57	+ 7.57
10.	5-4-1979 - 11-4-1979	24.99	+0.47	90.57	+ 9.38
11.	12-4-1979 - 18-4-1979	24.96	+0.14	86.29	+ 5.67

+ more than 5 years' data

− less than 5 years' data

Appendix II

Abstract of analysis of variance table for height and number of leaves

Source	df	Mean square							
		Height (cm)				Number of leaves			
		15th day	30th day	45th day	Harvest	15th day	30th day	45th day	Harvest
Block	5	12.205**	6.510	11.840	14.348	0.081*	0.343*	0.243*	0.409
N	2	6.538*	38.715*	26.338*	28.473	0.158**	0.179	0.112	0.125
P	2	23.718**	116.987**	115.038**	139.308**	0.110*	0.316*	0.082	0.110
N x P	4	2.335	8.257	4.320	4.011	0.010	0.055	0.029	0.059
K	2	28.727**	31.271*	50.055**	52.254**	0.300**	0.095	0.012	0.065
N x K	4	0.640	6.192	5.487	7.178	0.036	0.004	0.012	0.055
P x K	4	4.974*	6.204	6.804	6.603	0.097*	0.026	0.013	0.226
N P K ∓	2	0.674	0.042	1.672	2.365	0.007	0.013	0.113	0.009
N P K^2 ∓	2	0.991	1.685	5.155	3.589	0.014	0.189	0.425*	0.307
N P^2 K	2	2.681	10.255	17.410	16.845	0.029	0.150	0.151	0.293
N P^2 K^2	2	4.022	18.118	9.901	9.283	0.118*	0.211	0.271	0.486
Error	22	1.518	7.410	7.299	8.676	0.027	0.091	0.083	0.185

∓ Partially estimable

*Significant at 0.05 level
**Significant at 0.01 level

Appendix III

Abstract of analysis of variance table for number of nodules per plant and dry weight of nodules per plant

Source	df	Mean square	
		Number of nodules per plant	Dry weight of nodules per plant (mg)
Block	5	54.851	34.800
N	2	1.955	130.681
P	2	7.947	337.556
N x P	4	16.065	229.715
K	2	30.748	176.042
N x K	4	57.669	136.410
P x K	4	190.406*	56.306
N P K ∓	2	36.525	91.750
N P K^2 ∓	2	53.781	155.264
N P^2 K	2	156.592	885.083*
N P^2 K^2	2	305.069*	2316.097**
Error	22	64.395	217.235

∓ Partially estimable

* Significant at 0.05 level
** Significant at 0.01 level

Appendix IV

Abstract of analysis of variance table for number of flowers per plant, number of pods per plant, length of pod, number of seeds per pod, weight of seeds per plant and 100 seed weight

Source	df	Mean square					
		Number of flowers per plant	Number of pods per plant	Length of pod (cm)	Number of seeds per pod	Weight of seeds per plant (g)	100 seed weight (g)
Block	5	4.188*	3.196*	0.227**	0.830*	0.245	1.206**
N	2	0.172	0.114	0.074	0.088	0.102	0.373*
P	2	2.667	0.085	0.092	0.587	0.013	0.484*
N x P	4	0.949	0.192	0.024	0.118	0.059	0.215
K	2	4.458	0.890	0.060	0.159	0.478*	0.049
N x K	4	1.680	0.745	0.111	0.180	0.062	0.097
P x K	4	0.241	0.436	0.050	0.136	0.122	0.252
N P K ∓	2	4.321	1.317	0.112	0.283	0.020	0.205
N P K^2 ∓	2	3.487	4.228*	0.019	0.190	0.039	0.497*
N P^2 K	2	1.494	0.934	0.077	0.023	0.206	0.180
N P^2 K^2	2	3.132	0.378	0.036	0.078	0.040	0.487*
Error	22	1.384	0.942	0.056	0.228	0.093	0.103

∓ Partially estimable

*Significant at 0.05 level
**Significant at 0.01 level

Appendix V

Abstract of analysis of variance table for grain yield, bhusa yield, harvest index and dry matter yield

Source	df	Mean square			
		Grain yield (kg/ha)	Bhusa yield (kg/ha)	Harvest index (per cent)	Dry matter yield (kg/ha)
Block	5	61491.137*	165099.547	85.449**	347653.072
N	2	20041.805	234891.296*	22.017	270030.648
P	2	4333.757	78662.190	13.797	120642.785
N x P	4	13225.737	25975.424	4.215	81188.207
K	2	123362.964*	131830.019	28.896	751867.483*
N x K	4	17177.549	28653.249	6.220	100800.290
P x K	4	32100.542	50350.834	23.772	93733.251
N P K †	2	7208.982	2790.488	3.460	21828.213
N P K^2 †	2	49479.549	7573.907	0.751	139773.385
N P^2 K	2	9534.535	41358.569	67.123*	107382.468
N P^2 K^2	2	12228.750	1570.911	4.182	33913.485
Error	22	22496.856	66455.126	15.682	146488.505

† Partially estimable

*Significant at 0.05 level

**Significant at 0.01 level

Appendix VI

Abstract of analysis of variance table for uptake of nitrogen, phosphorus and potash by the crop

Source	df	Mean square		
		Uptake of nitrogen (kg/ha)	Uptake of P_2O_5 (kg/ha)	Uptake of K_2O (kg/ha)
Block	5	178.265*	1.153*	36.160
N	2	107.334	1.161*	17.179
P	2	70.375	1.413*	20.391
N x P	4	28.051	0.335	10.117
K	2	218.428	0.828	227.149**
N x K	4	49.603	0.319	13.828
P x K	4	65.456	0.275	7.431
N P K ∓	2	6.024	0.069	0.158
N P K^2 ∓	2	51.344	0.041	9.493
N P^2 K	2	48.027	0.370	15.457
N P^2 K^2	2	16.440	0.012	1.521
Error	22	66.469	0.326	15.134

∓ Partially estimable

*Significant at 0.05 level
**Significant at 0.01 level

Appendix VII

Abstract of analysis of variance table for protein content of grains, protein content of bhusa, grain protein yield and fodder protein yield

Source	df	Mean square			
		Protein content of grains (per cent)	Protein content of bhusa (per cent)	Grain protein yield (kg/ha)	Fodder protein yield (kg/ha)
Block	5	16.005**	0.542	3530.899**	5105.021
N	2	0.390	1.022	884.033	7183.457
P	2	0.833	0.163	477.842	3540.063
N x P	4	0.504	0.665	418.230	1001.433
K	2	1.468	3.151*	4121.484*	2958.155
N x K	4	0.534	1.779	531.798	1618.481
P x K	4	1.248	0.998	1581.408	1389.688
N P K ∓	2	5.048*	0.177	230.038	117.440
N P K^2 ∓	2	0.798	0.323	424.949	1971.774
N P^2 K	2	0.089	0.007	1847.433	91.471
N P^2 K^2	2	1.030	0.865	743.933	92.913
Error	22	0.812	0.869	801.987	2326.070

∓ Partially estimable

*Significant at 0.05 level

**Significant at 0.01 level

Appendix VIII

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

Source	df	Mean square		
		Total nitrogen content (kg/ha)	Available phosphorus content (kg/ha)	Available potassium content (kg/ha)
Block	5	91176.296*	851.667**	413.852
N	2	75496.296	176.823	105.130
P	2	6896.296	1953.385**	79.463
N x P	4	75496.297	435.807	1868.130
K	2	50451.852	26.135	243.130
N x K	4	101085.185*	427.995	445.130
P x K	4	1451.852	173.698	670.130
N P K ∓	2	55170.371	29.688	223.593
N P K^2 ∓	2	57385.185	783.073*	70.130
N P^2 K	2	5081.482	378.646	28.778
N P^2 K^2	2	137562.965*	150.260	786.074
Error	22	31181.818	201.681	756.771

∓ Partially estimable

*Significant at 0.05 level
**Significant at 0.01 level

NUTRITIONAL REQUIREMENT OF GREEN GRAM [*Vigna radiata* (L.) Wilczek]

By

SAVITHRI. K. E.

ABSTRACT OF A THESIS

submitted in partial fulfilment of the
requirement for the degree

MASTER OF SCIENCE IN AGRICULTURE

Faculty of Agriculture
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ABSTRACT

An experiment was conducted in the Instructional Farm, College of Agriculture, Vellayani during 1979 to study the effect of three levels in each of nitrogen (20, 30 and 40 kg/ha), phosphorus (30, 45 and 60 kg/ha) and potash (10, 20 and 30 kg/ha) on growth, yield and quality of green gram (Vigna radiata) grown in rice fallows.

The experiment was laid out as 3^3 partially confounded factorial experiment with two replications, confounding NPK in replication I and NPK^2 in replication II.

The study revealed that nitrogen, phosphorus and potash had an influence on height and number of leaves, but not on nodulation.

The yield contributing factors namely number of flowers and number of pods per plant, length of pod and number of seeds per pod were not influenced by the treatments. Weight of seeds per plant was significantly increased by the highest level of potash and 100 seed weight by higher levels of phosphorus, while highest level of nitrogen significantly decreased the 100 seed weight. Maximum grain yield of 538 kg/ha was obtained with the highest level of potash. Dry matter yield was also influenced by potash and bhusa yield by nitrogen.

None of the treatments had any influence on N uptake by the crop, whereas P_2O_5 uptake was increased by nitrogen

and phosphorus application and K_2O uptake by the application of potash.

Protein content of grain was not affected by nutrient levels, whereas protein content of bhusa was decreased by potash application. Potash application considerably increased the grain protein yield but fodder protein yield was not influenced by the treatments.

A significant positive correlation was observed between grain yield and yield contributing factors, protein content of the grain and nitrogen uptake and total dry matter production and uptake of nutrients.