# EFFECT OF DIFFERENT LEVELS OF NITROGEN, PHOSPHORUS AND POTASSIUM ON GROWTH AND YIELD OF COWPEA, (*Vigna sinensis* SAVI) VARIETY P. 118

By

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**THESIS**

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# DECLARATION

I hereby declare that this thesis entitled "Effect of different levels of nitrogen, phosphorus and potassium on the growth and yield of cowpea, variety P.118" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title of any other University or Society.

Vellanikkara,
7th August, 1978.

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## CERTIFICATE

Certified that this thesis is a record of research work done by Shri B.Mohankumar under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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# INTRODUCTION

# INTRODUCTION

Pulses make an important contribution to human dietary needs. The Indian sub-continent is apparently the area of greatest dependence on pulses. This arises from high population pressure on the land and the religious prohibition on the slaughter of cattle for beef amongst a section of the population.

In India pulses are cultivated in an area of 22.5 million hectares out of the total cropped area of 164 million hectares. The annual production of pulses today is only 9.48 million tonnes against the requirement of 22.8 million tonnes.

Due to the intrusion of high yielding varieties of cereals into the areas traditionally planted to grain legumes, the production of pulses has dropped from 11.8 million tonnes in 1970-71 to 9.48 million tonnes in 1976-77. The situation is alarming especially because of the fact that the grain legumes are expected to play increasing roles in providing adequate protein to the undernourished people of the country. The per capita consumption of pulses in India is only 45 g per day as against the 104 g recommended by the WHO (Lal, 1977).

In Kerala, the area under pulses recorded a steady fall during the last decade from 43,310 hectares in 1965-66 to 38,560 hectares in 1975-76. The present production is only 13,350 tonnes. The average yield of pulses in this State is only 372 kg/ha against the all India average of 500 kg/ha. These figures indicate that pulses have not been given the due importance they deserve.

The area under agricultural crops being difficult to enlarge, one of the vital steps to augment production is to raise high yielding varieties under adequate management. Unfortunately little attention is paid on the agronomic requirements for increasing and stabilizing production of pulses.

Cowpea (Vigna sinensis Savi) has good quality protein and is an important part of the diet of many people. In the preliminary varietal trial conducted at the Rice Research Station, Pattambi, the variety P.118 showed prominence. No systematic trials have been conducted in Kerala to study the requirements of nitrogen, phosphorus and potassium for the cowpea, variety P.118. Therefore it was felt necessary to take up a manurial study on cowpea with the following objectives.

1. To study the performance of cowpea variety P.118 under varying levels of nitrogen, phosphorus and potassium.

2. To find out the optimum dose of nitrogen, phosphorus and potassium under the agro-climatic conditions of Vellanikkara.

3. To study the rate of removal of nitrogen, phosphorus and potassium by plants as a function of nitrogen, phosphorus and potassium supplies at varying levels.

4. To assess the influence of nitrogen, phosphorus and potassium on the quality of produce.

# REVIEW OF LITERATURE

# REVIEW OF LITERATURE

Though cowpea is one of the oldest cultivated food crops, only very little research has been done in our country on its nutritional aspects. The present study was mainly oriented towards the impact of fertilisation of the three major nutrients ie. nitrogen, phosphorus and potassium on growth and yield of cowpea.

## 1.0. Physiological role of nitrogen, phosphorus and potassium in plants

Nitrogen, the 'key element' in plant nutrition, is essential for protein synthesis in plants. Nitrogen is thus an essential constituent of all living matter (Tisdale and Nelson, 1971). It is also an important component of chlorophyll which gives plants their green colour (Black, 1957).

Phosphorus is essential for root development, flower primordia initiation, stimulation of growth, seed formation and early maturity (Tisdale and Nelson, 1971). Black (1957) reported that phosphorus is involved in metabolism and reproduction in plants. He also observed that phosphorus is a constituent of nucleic acid, phytin and phosphoric acid.

Potassium is essential for carbohydrate metabolism, nitrogen metabolism, and protein synthesis, activation of various enzymes and promotion of growth of meristematic tissues (Tisdale and Nelson, 1971).

2.0. Effect of nitrogen on growth components

It seems reasonable to assume that the major contribution to pod yield is a result of photosynthesis and translocation from leaves and that the leaves alone play a substantial role in total yields produced by the plants. Battacharya (1971) reported that vegetative growth of the crop in respect of length of vines and number of branches per plant was significantly influenced by nitrogen application in horsegram.

Increased vegetative growth and consequent increase in haulm yield due to additions of nitrogen to peas was reported by Sharma (1968). Though there was a definite trend of response to higher doses of nitrogen in gram, the number of branches did not show any significant increase (Prabhanjan Rao *et al*. 1973).

Chowdhury *et al*. (1974) observed no significant change in root length due to the application of nitrogen and nodulation. Likewise, Satyanarayana and Rao (1975) indicated that nitrogen, in general, failed to establish a significant advantage in increasing root and shoot weight of cowpea. Adepetu and Akapa (1977) reported that varying efficiencies of cowpea varieties to absorb nutrients from soil depend not so much on the total surface area of the root system but probably more on the concentration of the specific absorption sites per unit root length and on the inherent nutrient requirement. However, for a given cultivar, there should be greater uptake of nutrients if the plant could be induced by a favourable soil physical environment to produce more extensive roots, thereby providing more surface area for nutrient absorption. Slabko (1970) found that application of nitrogen at low rates before sowing increased the growth of roots and shoots, dry matter accumulation and nodulation in soybean. High rates of nitrogen increased plant growth but decreased nodulation. Top dressing with nitrogen at flowering stage decreased nodulation and seed yields.

Sinha (1970) observed that dry matter production of peas was not affected by application of nitrogen at 10 kg/ha. Panwar and Jain (1974) reported that nitrogen application significantly depressed dry matter accumulation of berseem plants at the first two cuttings. Aathook (1975) reported no significant difference between the nitrogen treatments for fresh weight, dry weight, plant height and root nodules per plant in soybeans. Unlike the above findings, Gill et al. (1972) observed that dry matter production in cowpea favourably responded upto 10 kg N/ha.

Pate and Dart (1961) reported that in summer-sowing of cowpea, primary root nodulation was stimulated by low concentration of ammonium nitrate but higher levels progressively decreased the nodule number. Dart and Mercer (1965) also found that in cowpeas ammonium nitrate had the greatest influence on the size of both primary and secondary nodules. The size of the nodules increased with increasing levels of ammonium nitrate. Increasing ammonium nitrate stimulated root growth. Pandey (1969) held the view that neither heavier applications of nitrogen nor very light applications were beneficial to nodulation. Within certain limits, nodule formation gradually increased with the extra application of nitrogen, phosphorus and molybdenum fertilizers. Non-significant increase in number of nodules due to additional supply of inorganic nitrogen (20 kg/ha) to inoculated cowpea plants was reported by Sharma and Ghonsikar (1976). It was explained that additional supply of 20 kg N/ha perhaps was short of the total nitrogen requirements of cowpea and therefore did not appear to affect nodulation. Additional supply of 20 kg N/ha to inoculated plants further raised the nodule mass weight. Although additional inorganic nitrogen did not cause increase in nodule numbers, it enhanced nodule mass weight per plant. Summerfield et al. (1976) while studying the effect of environmental stress on seed yield of cowpea observed that plants receiving no combined nitrogen in the nutrient solution nodulated poorly.

Trials with soybean, grown hydroponically, indicated (Vigue et al. 1977) that urea allowed effective nodule development and function, as evidenced by nodule mass, acetylene reduction and difference between total Kjeldahl nitrogen gain per plant and urea uptake measurements. Plants grown in solutions with as high as 18 millimoles of urea-nitrogen produced nodules capable of nitrogen fixation, while nitrate concentrations as low as two millimoles inhibited nodulation.

Contrary to the earlier observations, a number of reports reflect the inhibitory effect of applied nitrogen on root nodulation. Ljunggren & Fahreus (1961) reported that a pre-requisite for infection of roots by the nodule bacteria and the formation of polygalacturonase is a certain nitrogen deficiency. At higher nitrate ion concentration polygalacturonase formation stops. Thanner and Anderson (1963) indicated that the effect of combined nitrogen in reducing indole acetic acid would result in reduced infection as nitrites catalytically destroy indole acetic acid. Dart and Mercer (1965) found that primary root nodulation was significantly affected by the amount of ammonium nitrate. More primary root nodules were formed when no ammonium nitrate was added. Pal and Saxena (1975) also observed that in soybean application of nitrogen fertilizers reduced number and weight of nodules and the inhibitory effect increased with increasing rates of nitrogen. Antony Joseph (1977) reported that nitrogen either as ammonium or nitrate ions suppressed nodulation and nitrogen fixation.

## 2.1. Effect of nitrogen application on yield and yield components

Horner and Mojtehedi (1970) reported that applied nitrogen had no significant effect on the yield of cowpea indicating that the nitrogen requirement of the crop is adequately met by symbiotic fixation. Singh *et al*. (1971) observed that no applied nitrogen was required for inoculated soybeans. Hinson and Kuell (1975) found that response to nitrogen was infrequent, unprofitable and unpredictable. Summerfield *et al*.(1976) concluded that seed yields of nodulated cowpea plants were unaffected by combined nitrogen supply and were almost double those of non-nodulated plants, due mainly to increases in pod number per plant and mean seed weight. Reducing nitrogen from 25 to 0 ppm especially between midpodfill and maturity, reduced seed yields of non-nodulated plants considerably. Dart *et al*. (1977) observed that large amounts of applied nitrogen given daily in solution either before or after flowering were completely ineffective as a substitute for prolonged symbiotic fixation. Applying nitrogen to nodulated plants during vegetative growth had an adverse effect on subsequent seed production, probably because nodulation was delayed. Summerfield *et al*. (1977) reported that effectively nodulated oowpea plants were not only vegetatively equal to the non-nodulated plants supplied with 60 ppm nitrogen throughout the growing season but also produced greater seed yields.

Sharma (1968) found that higher levels of nitrogen tended to depress the grain yield of peas. Godfrey-Sam-Aggrey (1975) reported that in cowpea nitrogen application decreased the number of days between sowing and appearance of first flower and first pod; but increased the number of days from flowering and pod formation to harvest, without affecting the harvest date. Dry whole pod yield and hull yield but not the seed yield increased with increased nitrogen rates. Lack of response to nitrogen application had also been reported by Sharma (1968) and Singh et al. (1969) in peas, Welch (1974) and Panwar et al. (1976) in soybeans and Terman (1977) in cowpea.

Contrary to the above observations, there are a number of reports which indicate the superiority of nitrogen application on cowpea and other legumes. According to Erskine and Khan (1977), environmental effects account for 82% of the variation in grain yield in cowpea. Among these, the most important is soil structure and consequent nutrition. Importance of application of nutrients is quite evident from this.

Rama Rao and Patel (1975) observed that addition of nitrogen increased the yield of cowpea grains. The response to added nitrogen was explained as addition of readily available nitrogen components beneficial for the seedlings to make a good start before nitrogen fixation took place. There was a small non-significant effect on final seed yield by the combined nitrogen supply to nodulated plants. Summerfield *et al*. (1976) proved that cowpea plants which received 60 ppm of nitrogen from emergence to first flower had the greatest yield. The number of seeds per pod was much less affected by the application of nitrogen. Kumar *et al*.(1976) reported that pod yield in cowpea was significantly associted with branches per plant, pods per plant, pod length, seeds per pod, thickness of pod and 100 seed weight. All these yield components were influenced by applied nitrogen. Summerfield *et al*.(1977) found that although nodulated cowpea plants receiving no applied nitrogen had the most rapid rate of fixation, they were smaller vegetatively and in seed yield, compared with nodulated ones receiving a low level of applied nitrogen throughout the growth.

Singh (1970) reported that in gram, application of nitrogen at 22.5 kg/ha produced maximum yields. Experimenting with horsegram, Battacharya (1971) observed that application of nitrogen in the lime dressed soil caused significantly proportional increase in the number of pods per plant. Kurdikeri *et al*.(1973) showed that flowering was earlier in cowpea plants receiving nitrogen and phosphorus fertilisers. Inclusion of nitrogen resulted in an increased retention of flowers. The grain yield was also maximum in treatments receiving nitrogen and phosphorus. The increase in yield was attributed to the difference in the number of pods per plant and seeds per pod. The 1000 grain weight was also considerably increased by the application of fertilizers. Significant increase in number of pods by the application of 30 kg N/ha over 10 and 20 kg N/ha has been reported by Prabhanjan Rao _et al_. (1973). Mclean _et al_.(1974) observed that application of nitrogen delayed the maturity by seven days and each increment of nitrogen fertilizer markedly increased the plant and seed yields in fieldpeas. Seed yields were doubled due to the development of greater number of pods per plant, whereas seeds per pod and seed weight remained nearly constant. Likewise, Godfrey-Sam-Aggrey (1975) reported that in cowpea as a consequence of the positive linear relationship between the hull weight and nitrogen levels, there was significant dry pod weight response to nitrogen levels. In pot experiments with soybeans, Stanilova (1975 a) observed that by increasing nitrogen rates, the yield also increased. Sharma _et al_. (1975) reported that application of 20 kg N/ha increased seed yields in gram by 31.7 and 16% respectively, over those obtained without nitrogen and with nitrogen at 10 kg/ha. In trials with black gram, Jej Singh *et al*. (1975) also observed increased grain yields with application of nitrogen. Chowdary *et al*. (1977) working on groundnut found that nitrogen had significant effect on number of pods per plant, number of filled pods per plant and pod yield. The increase was attributed to the high dry matter accumulation and higher number of pods per plant. Significant yield increase due to application of nitrogen has also been reported by Parr and Bose (1945), Faroda and Tomer (1976) and Maloth and Prasad (1976), in cowpea; Puntamkar and Bathkal (1967), and Jayadevan and Sreedharan (1975) in groundnut; Panda (1972) in black gram; Shekhawat *et al*. (1972) in moth beans; Rathi and Singh (1976), Chundawat *et al*. (1976), Goud Reddy *et al*. (1977), in gram and Sable and Khuspe (1977) in soybeans.

Yadav and Saxena (1974) indicated that fertilizer application for pulses should be based on soil test values. In most cases, residual fertility of previous *rabi* crops would be sufficient.

El Baradi (1975) reviewed the experimental findings on the fertilization of cowpea and reported that the general trend of the results favoured the application of small amounts of readily available nitrogen at planting to stimulate nitrogen fixation. A fertilizer trial at the International Institute of Tropical Agriculture, Trinidad, indicated that cowpeas did not gain significantly in seed yield by nitrogen and phosphorus fertilization. Lack of response was attributed to the excellent root nodulation (Anon.1974). Sellschop (1962) observed that even though cowpea is a legume, readily available nitrogenous compounds might be beneficial as they allowed seedlings to make a good start before nitrogen fixation took place. It was also concluded that when given, legumes tended to use the available nitrogen rather than that fixed by symbiotic fixation.

## 2.2. Effect of nitrogen on quality, chemical composition and uptake of nutrients

It was shown by Black (1957) that in a plant that contained 1.6 per cent nitrogen, about 10 per cent of the weight was contributed by nitrogenous compounds.

$N^{15}$ analyses showed that major source of nitrogen for cowpeas was symbiotic fixation which contributed to 83 and 89 per cent, at first flower and maturity respectively. The symbiotic contribution to total nitrogen content of green leaves, stem plus branches and roots was slightly lower at first flower (79-83%) than during later reproductive development. The very high contents of fixed nitrogen in nodules largely satisfied their own requirements, once fixation was started. Maximum rates of accumulation of both nutrient nitrogen and fixed nitrogen occurred during the 19 days from first flower to midpodfill, when plants accumulated fixed nitrogen at the rate of 111 mg/plant per day compared with 23 and 28 mg/day during vegetative growth and midpodfill to maturity. The maximum rate of nitrogen assimilation occurred after flowering. The remobilization of nitrogenous compounds from vegetative structure during fruit maturation was proportionately greater for nutrient nitrogen than for fixed nitrogen. Of the total nitrogen content of mature seeds 56% was accounted by translocation from vegetative components. The remaining 44% must have originated from direct uptake (largely symbiotic) and/or rapid flux of nitrogenous compounds through the vegetative structures particularly leaves. (Eaglesham, 1977). Janet and Alison (1977) have shown that in fieldpeas, total plant nitrogen uptake continued to increase upto seed maturation.

In experiments with groundnut, Puntamkar and Bathkal (1967) observed that maximum concentration of nitrogen was observed in 30 day old plants as compared to other stages. There was marked decrease in concentration of nitrogen in 60 days but there was subsequent improvement in nitrogen concentration at 90 and 120 days. In the first stage, little difference was observed in the nitrogen concentration of the plant as affected by the application of fertilizers. But in the later stages application of nitrogen and phosphorus were found to increase the nitrogen concentration in plants. At harvest, nitrogen concentration was found to be more in seeds followed by leaf and shoots. Non-significant decrease in nitrogen concentration was reported by Bains (1967) with low levels of applied nitrogen, but a significant increase occurred with subsequent additions of nitrogen in fieldpeas. Similarly Panwar and Jain (1974) observed that nitrogen content and uptake increased with increasing levels of nitrogen. On the other hand phosphorus uptake did not show any response to the application of nitrogen in berseem. Enikov and Velchev (1976) reported that increasing nitrogen rates increased the seed nitrogen content and decreased phosphorus and potassium contents in chickpea. Brevedan (1977) found that increasing the nitrogen supply to the plant resulted in an increase in the concentration of nitrogen and nitrate in the vegetative tissue at the end of bloom. The concentration of total available carbohydrates, on the other hand, tended to decrease when the nitrogen supply to the plant increased.

Sinha (1970) reported that nitrogen applied at 10 kg/ha had no effect on the total phosphorus content of the plant sample, in peas. Faroda and Tomer (1975) observed that application of nitrogen had no significant effect on the chemical composition of cowpea plants. But Singh and Saxena (1977) found that in soybeans although phosphorus concentration in plant parts was reduced owing to nitrogen fertilization and inoculation, the phosphorus uptake was considerably increased.

Moula and Krishnamurthy (1972) reported that total dry matter of green gram increased till maturity. Total dry matter accumulation was nearly sigmoid in nature. The accumulation of nitrogen in the grains at time of harvest was almost two and a half times that of total of the shoot and root.

There are a number of reports showing the beneficial effect of nitrogen application on crude protein content of legumes. Sayad Nazeer Peeran et al. (1969) studied the effect of urea wholly as foliar spray in three equal instalments and as soil plus foliar spray in two equal instalments and reported 1.5 and 1 per cent increase in protein content, respectively, as compared to the application of urea wholly as basal dressing. Gill *et al.*(1972) found that nitrogen application increased the crude protein content slightly in cowpeas. Sharma and Singh (1973) noticed that nitrogen application from 0 to 40 kg/ha enhanced the production of crude protein, crude fibre, mineral matter, ether extract and nitrogen free extract of fodder cowpea in the increasing order. No additional advantage could be secured by applying more than 40 kg N/ha. Mclean *et al.* (1974) was of opinion that protein content of grains increased substantially with each increment of nitrogen in fieldpeas. Stanilova (1975 b) noticed that seed inoculation with nitrogen increased seed protein content and decreased fat, ash and phosphorus contents in soybeans.

In sharp contrast to the above findings, Bishop *et al.* (1976) found that applied nitrogen, phosphorus and potassium had little effect on seed protein content and leaf nitrogen, phosphorus, potassium, calcium and magnesium contents in soybeans and fieldpeas.

## 2.5. Effect of legumes on soil fertility

Root nodules on legumes contain the symbiotic bacteria which supply nitrogen to the host plants and receive carbon and energy from the host. In essence, through infection by a beneficial bacterium, the host plant acquires a new set of genetic traits (Nif genes) (Keelnatham and Raymond, 1976).

The growth of legumes, well nodulated with efficient symbiotic nitrogen fixing bacteria, may contribute to nitrogen and organic matter supply of nitrogen depleted soils. Therefore, legumes have special significance in the soil improvement process. The amount of nitrogen thus made available, varies from 50-150 kg/ha (Chhonkar, 1970). Besides, legumes add appreciable quantity of organic matter. Schroder and Kuell (1975) studied the contribution of soybeans to soil nitrogen using yields of subsequent companion crops to measure responses. All evidences indicated that nodulated soybeans contributed to, rather than depleted soil nitrogen. Nnadi and Balasubramonian (1978) observed that in cowpeas about 37% of nitrogen fixed had been retained in the roots; hence these might be useful in improving the soil nitrogen status, even when the tops are not returned to the soil. Therefore, any agronomic technique which improves their nitrogen fixing ability will be a contributory factor to soil fertility.

3.0. Effect of phosphorus on growth attributes

Positive responses of legumes to phosphorus application were reported by Donald and William (1954). Kurup and Kaliappan (1969) noticed that in sannhemp, application of phosphorus markedly increased the plant height at 34 kg level. This trend was maintained till flowering. The dry weight of shoot was markedly influenced by phosphorus. Phosphorus did not influence the root length, but gave appreciable increase in the dry weight of roots. Phosphorus also had a significant effect on the production of nodules. Olsen and Moe (1971) observed that phosphorus accelerated the rate of establishment of legumes and significantly increased dry matter production. In pot experiments with peas, Tyagim *et al.*(1972) observed that increasing phosphate rates from 0 to 40 kg/ha increased fresh weight and dry weight and dry matter content of roots and nodules and number of nodules per plant. These characters were adversely affected at 60 kg $P_2O_5$/ha. Panda (1972) found that both straw and grain yields, plant height, number of branches per plant, length of pod and average weight of seeds per pod increased with increasing levels of phosphorus. According to Alagarswamy (1973), concentration of phosphorus in the nutrient solution exerted a marked direct effect on the growth of groundnut plants. Kesavan and Morachan (1973) experimenting with soybean, indicated that levels of phosphoric acid had significant negative influence on plant height. Successive additions of phosphorus gradually reduced the plant height, but the differences were not significant. They also showed that application of phosphorus significantly influenced the total dry matter production. The maximum dry matter was obtained at 100 kg $P_2O_5$/ha. Roy and Mishra (1975) reported that in soybean, the effect of phosphorus fertilisation on the leaf area index was appreciable. The highest leaf area index was recorded at 39.3 kg $P_2O_5$/ha. A further increase in the level of phosphorus decreased the leaf area index which ultimately resulted in a reduction in yield. Tarila et al.(1977) found that increasing levels of applied phosphorus enhanced growth, flower and fruit numbers as well as the leaf number and area.

Iswaran and Jauhri (1969) observed that number of nodules per plant and the dry weight of the plants increased both with rock phosphate and lime pelleting in soybeans. Pandey (1969) reported that within certain limits, nodule formation gradually increased with phosphatic fertilizers. Sahu (1973) reported that in black gram, inoculation with phosphorus increased nodulation which contributed to the increase of nitrogen in shoots and roots. Similarly Chesney (1974) found that nodulation was increased by phosphorus application, indicating that the addition of nutrient is essential for the process of nodule formation. Studying the effect of graded doses of phosphorus on bengal gram Singh *et al*.(1975) concluded that application of phosphorus increased the number and dry weight of effective nodules per plant upto 90 days after sowing. Studies conducted by Roy and Mishra (1975) on soybean indicated that applied phosphorus exerted appreciable increase both in the number and size of nodules per sq.m. The number of nodules gradually increased upto 39.3 kg $P_2O_5$/ha, but above this level of phosphorus, there was a regular decrease reaching the lowest value at 65.5 kg/ha. This showed that very heavy dressing of phosphorus was detrimental to the yield as well as to the number and weight of nodules.

3.1. Effect of phosphorus on yield and its components

Gill *et al*. (1971 a) found significant linear response to applied phosphorus upto 50 kg $P_2O_5$/ha. They also found that foliar application of phosphorus was beneficial as a supplement to soil application. Chesney (1974) reported that yield was significantly increased by phosphorus dressings and that the response to phosphorus was linear. Rao *et al*.(1972) showed that seed yield differences among levels of phosphorus were significant, but the highest yield obtained at 90 kg $P_2O_5$/ha did not differ from 45 kg $P_2O_5$/ha, in soybean. Dubey *et al*. (1975) found that fodder yield of cowpea was increased by the application 100 kg $P_2O_5$/ha compared with no phosphorus.

Rajendra Prasad *et al*. (1968) reported that about 25% increase in grain legume production could be achieved by fertilizing with 33.6 kg $P_2O_5$/ha and that a further increase by 15% in grain legume production could be achieved by an additional application of 33.6 kg $P_2O_5$/ha. Sharma (1968) observed that phosphorus application increased grain yield in peas. Bains (1969) found that grain yield of beans was positively correlated with available phosphorus in the soil. Experimenting with soybean, Baumgartner *et al*. (1974)

reported that application of 80 kg $P_2O_5$/ha increased the yield of grains significantly compared to 40 kg/ha. Such results of significant positive responses to fertiliser phosphorus were also reported by Shekhawat *et al.*(1967), Singh *et al.*(1969) and Nandpuri *et al.*(1973), in peas; Singh (1970), Sharma *et al.*(1975), Rathi and Singh (1976) and Chundawat *et al.*(1976), in gram; Shekhawat *et al.*(1972) in moth, Panda (1972) and Jej Singh *et al.*(1975), in black gram; Chahal and Virmani (1973) in groundnut; Eira *et al.* (1974) in black beans; Hamissa *et al.*(1975) in beans; Singh *et al.*(1976) in pigeon pea and Ramakrishnan *et al.* (1977) in green gram.

Sosulski (1974) observed that effects of phosphorus fertilisation on seed production in field peas were negligible except to depress the yield at the highest level tried. Panwar *et al.*(1976) observed that phosphorus application significantly increased grain yield of black gram, which was linear upto 60 kg $P_2O_5$/ha. Thereafter a reduction in yield was observed. On the contrary, Subramanian *et al.*(1977) reported that applied phosphorus had no significant effect on the yield of black gram. Similar results were obtained in groundnut by Nanukumba and Edse (1974) and Kolar *et al.*(1976).

Mascarenhas and Kiihl (1974) obtained no significant increase in yields due to application of 0, 40, 80 or 120 kg/ha of phosphate to soybean.

Manjhi and Choudhury (1971) working on bengal gram, found significant yield responses to applied phosphorus. Phosphate at 75 kg/ha produced significantly higher yields than 25 kg/ha. Phosphate at 100 kg/ha caused a significant depression in yield as compared to 75 kg $P_2O_5$/ha.

Garg *et al.*(1971 b) reported that response to phosphorus level was noticeable only upto 37 kg $P_2O_5$/ha; thereafter the green fodder yield of cowpea did not increase significantly.

Kesavan and Morachan (1973) reported that the influence of phosphorus on the number of pods per plant was significant in soybean. According to Sable and Khuspe (1977) in soybean, pod number and their weight due to application of phosphorus did not show a regular trend. The 100 seed weight increased significantly due to graded levels of phosphorus. Grain and straw yields were not, however, influenced significantly by phosphorus application.

### 3.2. Effect of phosphorus on quality, composition and uptake of nutrients

Studies made by Singh *et al.* (1971) on the effect of different levels of phosphorus on the oil content of soybean seed did not reveal any definite trend, but the protein content increased with incremental doses of phosphorus, probably due to the efficient and effective functioning of nitrogen fixing bacteria. Garg (1971 a) reported that applioation of phosphorus increased both protein and phosphorus contents in peas. Gill et al. (1972) while exploring the effect of nitrogen and phosphorus on fodder yield and chemical composition of cowpea, found that the crude protein content increased markedly with increase in phosphorus level. Kesavan and Morachan (1973) confirmed the above results by showing a linear trend in protein content of soybeans with increasing levels of phosphorus. Sosulski et al.(1974) also obtained significant increase in protein content of field peas at 56 kg $P_2O_5$/ha; but higher rates gave no additional increases in the level of seed protein. Ramalingaswamy and Narasimhan (1976) revealed that in soybean, the protein percentage and amount of protein per plant were favourably influenced by phosphorus fertilization.

In contrast to the above findings, Sundaram et al.(1973) reported that phosphorus application did not influence the crude protein content in lucerne. Regarding phosphorus content, application of 160 kg

$P_2O_5$/ha recorded the highest value, followed by 200 kg/ha. Crude protein:phosphorus ratio also was influenced by the level of phosphorus fertilization. Whenever phosphorus content increased, the crude protein:phosphorus ratio declined.

Increased protein contents due to application of phosphorus were also reported by Chowdhury *et al.* (1971) in gram; Sable and Khuspe (1972) in soybean; Jej Singh *et al.*(1975) and Panwar *et al.* (1976) in black gram.

Bains (1967) observed that additional increments of phosphorus fertilizer increased the phosphorus content in bean plants. Increase in phosphorus content of black gram plants was recorded at the pre-flowering stage, but remained more or less constant during crop matutity. Phosphorus content of the plants at 40 kg $P_2O_5$/ha level was greater in comparison to treatment without phosphorus (Harishankar and Kushwah, 1971). Likewise, White (1972) reported that in *Stylosanthes humilis*, *Phaseolus atropurpureum* and *Desmodium intortum*, increasing levels of soil phosphorus had a significant effect on the phosphorus concentration in the plant tops. Panwar and Jain (1974) observed that dry matter production decreased and the contents of nitrogen and phosphorus increased significantly when phosphorus levels were increased in *Phaseolus aureus*. Sharma and Yadav (1976) reported that uptake of phosphorus increased with increasing levels of applied phosphorus in gram. Parodi *et al*.(1977) investigating into the effects of phosphorus application on dry matter yield and nitrogen, phosphorus and potassium contents in beans, concluded that increasing the phosphorus rate from 0 to 10 ppm increased plant phosphorus content, but had no effect on the nitrogen and potassium contents or dry matter production.

Sinha (1970), studying the uptake of phosphorus in peas using radio-tracer techniques, observed that there was no significant difference in dry matter yield or total phosphorus content of the plant, consequent to application of 30 or 60 kg $P_2O_5$/ha. However, 60 kg $P_2O_5$/ha showed a trend of increase in the total phosphorus content of the plant from seven week stage onwards. It was also observed that the maximum uptake of fertiliser phosphorus by the plant was at nine week growth stage, suggesting this as the critical growth period of peas for efficient use of applied phosphorus.

3.3. Effect of phosphorus fertilization of legumes on soil fertility

Dennison (1956), while analysing the problems of reclaiming certain infertile areas in the southern Sudan reported that of the crops tested, cowpeas, by far, gave the highest and quickest cover and they also gave a very noticeable response to 250 kg of superphosphate per acre. Bains (1967) found that available phosphorus content of the soil increased in general with the addition of phosphorus to field peas. Similarly Garg *et al*.(1971 b) reported improvement in the contents of available nitrogen and phosphorus in the soil, due to phosphorus fertilization of cowpea.

The findings of Nihal Singh and Khatri (1972) indicated that phosphorus application of different legumes increased the organic carbon and nitrogen oontent of the soil. The soil organic carbon content was significantly high at 80 kg $P_2O_5$/ha as compared to the untreated control. With increase in phosphorus level, there was increase in content of nitrogen also.

4.0. Effect of potassium on growth attributes

Tewari (1965) reported that addition of potassium had no effect on the formation of nodules in cowpea. Vijayakumar (1967) observed that potassium exerted significant negative effect on height of cowpea plants. Chesney (1974) found an increase in nodulation in cowpea due to potassium application. Nair et al.(1970) reported that lack of potassium significantly affected both nodulation and nitrogen fixation in groundnut.

Satyanarayana and Rao (1975) investigating into the effects of manures on growth aspects of cowpea, observed that potassium showed depressive effects on the weight of shoots.

4.1. Effect of potassium on yield and yield components

Comparatively few studies seem to have been carried out on the effect of potassium on the yield of legumes. Shekhawat et al. (1967) observed significant variation in yield over control by the application of potash to peas. Tisdale and Nelson (1971) opined that potassium was chiefly required for production and translocation of carbohydrates. Chesney (1974) found that the yield of cowpea was significantly increased by potassium application upto 55 kg $K_2O$/ha. On the other hand, Puntamkar et al. (1967) observed little response to the application of potash to groundnut. Bains (1969) reported that potash levels had no effect on the yield of legumes. Eira et al. (1974) experimenting with black gram, revealed that response to potassium was not significant and yields tended to decrease with increasing rates. Similar results were also reported by Singh et al. (1969) in peas; and Hamissa et al. (1975) in beans; Chowdary (1977) in groundnut and Dale Smith and Smith (1977) in soybean.

## 4.2. Effect of potassium on quality, chemical composition and uptake of nutrients

Application of potassium increased the crude protein from 15.9 per cent for no potassium to 17.7 for 25 kg $K_2O$/ha (Gill et al. 1971 b).

Bains (1967) reported that the potassium content in field peas increased with additional increments of potash. Bishop et al. (1976) found that in soybean the most consistent effect of increasing rates of potassium was a decrease in leaf magnesium status. Concentration of potassium in leaves, tops and grain increased with the amount of applied potassium. According to Terman (1977), marked reciprocal relationships occurred among concentrations of potassium and calcium or magnesium in top trifoliate leaves and top growth. The concentration of potassium and chlorine increased with top dressing rates of muriate of potash in red clover, but that of total non-structural carbohydrates, N, P, Ca, Mg, Na, Cu, Zn, B, Sr and Mn decreased.(Dale Smith and Smith, 1977).

Puntamkar and Bathkal (1967) found application of potassium alone decreased the phosphorus uptake in groundnut and increased the total uptake of potassium. Swamy and Lal (1970) concluded that uptake of potassium and yield of crops were lowest in those soils having low amount of extractable potassium. A significant correlation between water soluble potassium and uptake by plants was also observed by them.

5.0. Combined effect of nitrogen, phosphorus and potassium

While Bishop et al. (1977) found that fertilizers had little effect on the percentage of nitrogen, phosphorus, potassium, calcium and magnesium in leaf tissues in soybeans and field peas, Chowdary et al. (1977) observed increased protein contents with increase in fertility levels of all the three nutrients.

According to Chowdhury et al. (1971), grain yield did not benefit from nutrient application in bengal gram.

However, straw yield increased significantly with the supply of nitrogen in combination with phosphorus as also with nitrogen and potassium or nitrogen plus potassium plus phosphorus. Panda (1972) found that the combination of 60 kg nitrogen and 90 kg phosphate/ha gave significantly higher yield of grain in mung. Chesney (1974) reported that phosphorus x potassium interaction was significant in cowpea. Hamissa et al. (1975) reported that bean plants responded well to the combined application of nitrogen and phosphorus.

Ezedinma (1965) found that dry matter production in cowpea appeared to be more affected by a combination of nitrogen and phosphorus than by any individual nutrient. The influence of potassium in increasing the shoot and root weight depended on its combined influence with phosphorus in cowpea (Satyanarayana and Rao 1975). In trials with bengal gram, Singh et al. (1975) found that application of nitrogen and phosphorus increased the number and dry weight of effective nodules per plant.

# MATERIALS AND METHODS

# MATERIALS AND METHODS

The investigation was conducted at the Instructional Farm, Vellanikkara attached to the College of Horticulture with the object of studying the effects of nitrogen, phosphorus and potassium on the growth and yield of cowpea, variety P.118.

## I. MATERIALS

### 1.1. Site, climate and soil

The farm is situated at 32.1°N lattitude and 16.76°E longitude, at an altitude of 22.25 metres. This area enjoys a typical humid tropical climate.

The details of the meteorological observations for the period are presented in Appendix-I and Fig.1.

The soil of the experimental area was a deep, moderately well drained, medium clay loam, the chemical characteristics of which are presented in Table-1.

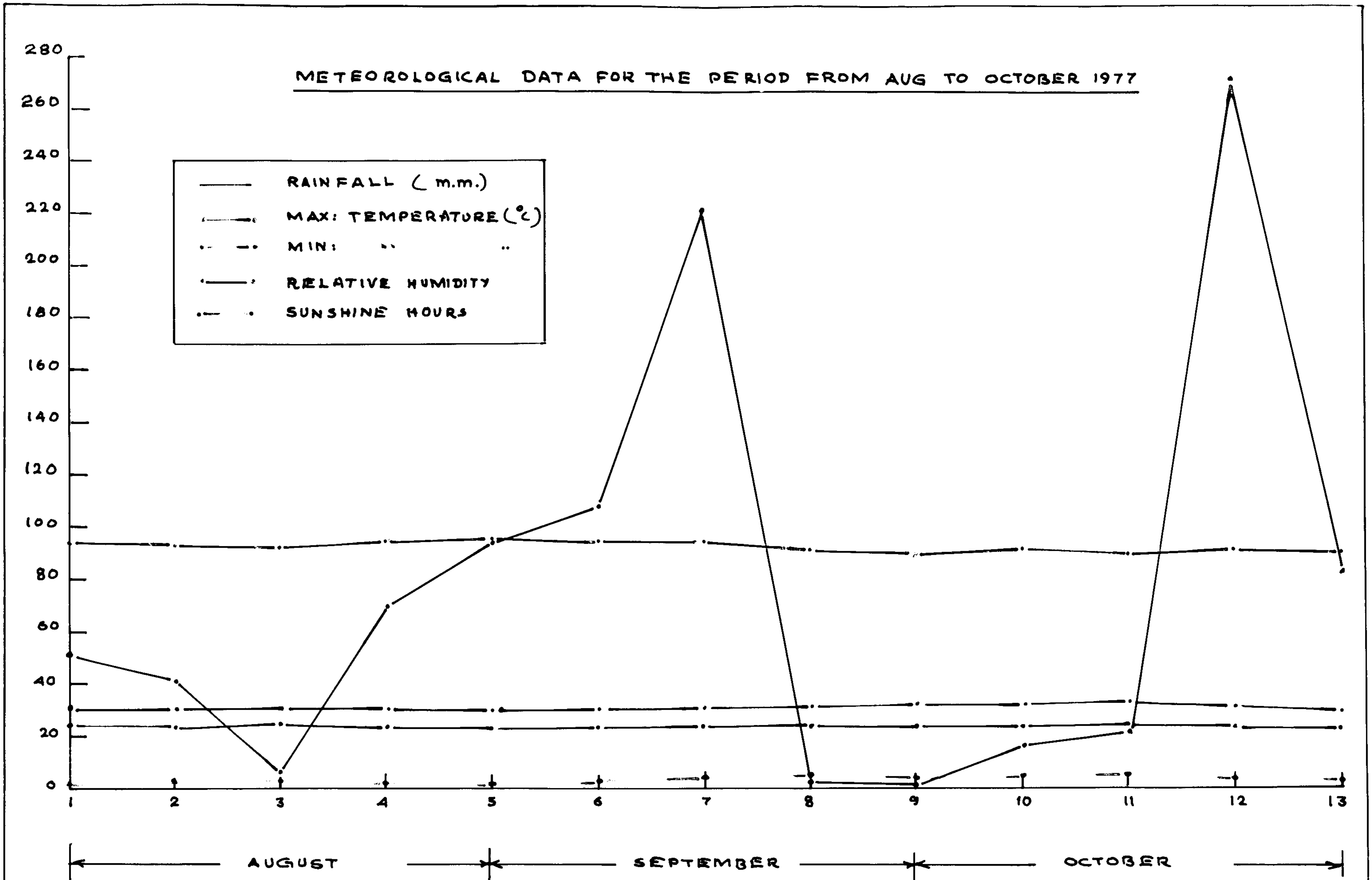

METEOROLOGICAL DATA FOR THE PERIOD FROM AUG TO OCTOBER 1977
RAINFALL (m.m.)
MAX: TEMPERATURE (°C)
MIN: " "
RELATIVE HUMIDITY
SUNSHINE HOURS
280
260
240
220
200
180
160
140
120
100
80
60
40
20
0
1
2
3
4
5
6
7
8
9
10
11
12
13
AUGUST
SEPTEMBER
OCTOBER

FIG: 2

Table-1

Chemical characteristics of soil

| Constituent | Content in soil | Method used |
|---|---|---|
| Organic carbon | 0.8370% | Walkley and Black's titration method |
| Total nitrogen | 0.1008% | Microkjeldahl method |
| Available $P_2O_5$ | 0.0004% | In Bray I extract, chlorostannous-reduced molybdophosphoric blue colour method |
| Available $K_2O$ | 0.0047% | In neutral ammonium acetate extract, flame-photometric. |
| Total $P_2O_5$ | 0.0524% | In HCl extract as ammonium phosphomolybdate, volumetric. |
| Total $K_2O$ | 0.3841% | In HCl extract, flame photometric. |
| pH | 5.1 | 1:2 soil:solution ratio using a pH meter |

1.2. Season

The experiment was conducted during the period from August to October, 1977.

1.3. Seeds

The variety P.118 was selected for the study based on the results of a preliminary variety trial conducted during 1974-75 at the Rice Research Station, Pattambi. P.118 is a dwarf variety having a duration of approximately 70 days.

1.4. Manures and fertilizers

Farm yard manure at the rate of 5000 kg/ha was applied uniformly as basal dressing. In addition, lime was applied uniformly at the rate of 500 kg/ha about four days prior to sowing.

Ammonium sulphate, super phosphate and muriate of potash were used as fertilizers to supply the required quantities of nitrogen, phosphorus and potassium respectively.

The manures and fertilizers were analysed and the results are presented below:

1.4.1. Farm yard manure

| | | |
|---|---|---|
| N | - | 0.41% |
| P | - | 0.23% |
| K | - | 0.39% |

1.4.2. Fertilizers

| | | | |
|---|---|---|---|
| Ammonium sulphate | - | 20.00% | N |
| Super phosphate | - | 16.00% | $P_2O_5$ |
| Muriate of potash | - | 60.00% | $K_2O$ |

## II. METHODS

### 2.1. Lay out

The experiment was laid out in $3^3$ confounded factorial design with two replications. The higher order interactions $NPK^2$ and $NP^2K^2$ were partially confounded in replications I and II, respectively. The procedure followed for allocation of various treatments to different plots was in accordance with Yates (1937). The details of the lay out plan are furnished below.

| | |
|---|---|
| Total experimental area | - 400 sq.m. |
| Gross plot size | - 8.64 sq.m (3.6x2.4m) |
| Net plot size | - 3 x 2 m |
| Number of plots | - 54 |
| Number of blocks | - 6 |
| Number of replications | - 2 |

### 2.2. Treatments

Treatments consisted of all possible 27 combinations of nitrogen, phosphorus and potassium at three levels each, as detailed below.

#### 2.2.1. Levels of nitrogen

| | | |
|---|---|---|
| 1. | $n_0$ | - 10 kg N/ha |
| 2. | $n_1$ | - 20 ,, |
| 3. | $n_2$ | - 30 ,, |

## LAY OUT PLAN – $3^3$ CONFOUNDED FACTORIAL DESIGN – CONFOUNDING $NPK^2$ IN REP: I AND $NP^2K^2$ IN REP: II.

N

| REP: I | | | REP: II | | |
|---|---|---|---|---|---|
| $N_1P_1K_2$ | $N_0P_1K_1$ | $N_1P_2K_2$ | $N_2P_0K_0$ | $N_2P_2K_1$ | $N_1P_0K_2$ |
| $N_1P_2K_0$ | $N_2P_2K_1$ | $N_1P_0K_1$ | $N_2P_1K_2$ | $N_0P_0K_1$ | $N_1P_2K_0$ |
| $N_2P_1K_0$ | $N_0P_0K_0$ | $N_2P_0K_2$ | $N_1P_1K_1$ | $N_0P_2K_2$ | $N_0P_1K_0$ |
| $N_2P_0K_0$ | $N_0P_0K_1$ | $N_1P_0K_2$ | $N_2P_0K_2$ | $N_0P_0K_0$ | $N_1P_1K_0$ |
| $N_1P_1K_0$ | $N_0P_1K_2$ | $N_2P_2K_2$ | $N_2P_2K_0$ | $N_0P_2K_1$ | $N_1P_2K_2$ |
| $N_2P_1K_1$ | $N_1P_2K_1$ | $N_0P_2K_0$ | $N_1P_0K_1$ | $N_2P_1K_1$ | $N_0P_1K_2$ |
| $N_1P_2K_2$ | $N_0P_2K_1$ | $N_2P_1K_2$ | $N_2P_0K_1$ | $N_0P_2K_0$ | $N_1P_1K_2$ |
| $N_1P_1K_1$ | $N_0P_0K_2$ | $N_2P_2K_0$ | $N_2P_2K_2$ | $N_0P_0K_2$ | $N_1P_2K_1$ |
| $N_1P_0K_0$ | $N_2P_0K_1$ | $N_0P_1K_0$ | $N_1P_0K_0$ | $N_2P_1K_0$ | $N_0P_1K_1$ |

### TREATMENTS

| N | $P_2O_5$ | $K_2O$ |
|---|---|---|
| $N_0$ – 10 Kg./ha. | $P_0$ – 20 Kg./ha. | $K_0$ – 0 Kg/ha |
| $N_1$ – 20 " " | $P_1$ – 30 " " | $K_1$ – 10 " " |
| $N_2$ – 30 " " | $P_2$ – 40 " " | $K_2$ – 20 " " |

GROSS SIZE OF PLOT – 3.6 M x 2.4 M.

GROSS AREA OF PLOT – 8.64 Sq. M.

NET SIZE OF PLOT – 3 x 2 M.

NET AREA OF PLOT – 6 Sq. m.

SPACING – 20. CM. BETWEEN – PLANTS

30 " " ROWS

FIG: 1

2.2.2. Levels of phosphorus

| | | | |
|---|---|---|---|
| 1. | $p_0$ | - | 20 kg $P_2O_5$/ha |
| 2. | $p_1$ | - | 30 ,, |
| 3. | $p_2$ | - | 40 ,, |

2.2.3. Levels of potassium

| | | | |
|---|---|---|---|
| 1. | $k_0$ | - | 0 kg $K_2O$/ha |
| 2. | $k_1$ | - | 10 ,, |
| 3. | $k_2$ | - | 20 ,, |

2.3.0. Field culture

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

The land was ploughed thrice, clods broken and all the weeds and stubbles were removed. Farm yard manure was uniformly spread all over the field before the final ploughing. Beds of size 3.6 x 2.4m were laid out. Lime at the rate of 500 kg/ha was applied uniformly and thoroughly incorporated in the soil four days before sowing.

The fertilizers were applied as per the schedule of treatments a day before sowing and mixed with the soil by handraking.

The seeds at the rate of two per hole were dibbled at a spacing of 30 x 20 cm on the 18th of August, 1977. Thinning was done a week after sowing, retaining only one seedling per hole. The plots were hand weeded twice on the 20th and the 40th day after sowing. Two prophylactic sprayings with Dimecron were given first at 15 days after sowing and the second, 30 days after sowing.

2.3.1. Harvesting

Since vegetative phase of the crop was a little prolonged, harvesting was done thrice, starting on 11--10--1977 and ending on 28--10--1977. The second harvest was on 17--10--1977. All the pods were harvested by the 70th day of sowing. The produce from each plot was dried separately and the grain yield were recorded. The plants were pulled out after the final harvest and dried under sun for three days and weight recorded.

2.4. Observations recorded

A. Growth components

1. Height of plants

Five plants were selected at random in each treatment after leaving one border line on all the four sides. The height was taken from the cotyledonary node to the terminal node. This observation was taken at 30, 50 and 70 days after sowing.

2. Number of branches

The number of branches of the same plants were recorded at the 50th day after sowing.

3. Number of nodules

From each treatment, five random plants were pulled out carefully and the nodules were counted and average worked out at 30, 50 and 70 days after sowing.

4. Dry matter accumulation at harvest

The plants used for counting the number of nodules at the 70th day were used for estimating dry matter accumulation. After removal of root portion, they were dried to constant weights at 70°C.

B. Yield attributes

1. Number of pods per plant

The total number of pods on the above selected plants were noted and the average worked out.

2. Length of pods

From the selected plants, ten pods taken at random were measured and their average length calculated.

3. Number of seeds per pod

Pods used for measuring length were used for recording the number of seeds per pod.

4. Weight of hundred seeds

From each treatment, 100 dry seeds were drawn at random, and their weight recorded.

5. Grain yield per hectare

Harvesting was done by collecting mature pods from the net plots. The harvested produce was sun dried, threshed, cleaned and the weight of grain recorded.

6. Haulm yield per hectare

The plants in the net plots were pulled out after the removal of pods. They were sun dried and the total weight recorded.

7. Grain:Haulm ratio

Grain/haulm ratios were calculated using the weights of grain and haulm from the net plots.

C. Chemical analyses

Plant samples at 30, 50 and 70 days from sowing were dried to constant weights at 70°C. Dried samples were ground to pass a 20 mesh sieve and subjected to chemical analyses for total nitrogen, phosphorus and potassium. At harvest, grains were separately analysed for nitrogen, phosphorus and potassium.

1. Total nitrogen content of plant samples

The total nitrogen was estimated by the Kjeldahl procedure as given by Jackson (1973).

2. Phosphorus content of plants

The phosphorus content of plants was estimated colorimetrically (Jackson, 1973).

3. Potassium content of plants

The potassium content was estimated by flame photometry (Jackson, 1973).

D. Uptake of nutrients at harvest

1. Total uptake of nitrogen

This was calculated from the nitrogen content of plant and total dry weight of the plant samples at harvest.

2. Total uptake of phosphorus

From the phosphorus content of sample plants and dry matter yield at harvest, the uptake of phosphorus was calculated.

3. Total uptake of potassium

The potassium uptake at harvest was estimated from the potassium content of the sample plants and the dry matter yield.

E. Qualitative characters

1. Protein content of grains

The protein content of grain was calculated from the percentage of nitrogen using the factor 6.25.

2.5.0. Statistical analysis

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

2.5.1. Response

As the interaction between nitrogen and phosphorus was significant, a quadratic surface response was used, as this function accounted for interaction of the factors. The increasing and decreasing returns from combinations of these two factors could be worked out using this. The form of the function used was:

$$y = b_0 + b_1N + b_2P + b_3N^2 + b_4P^2 + b_5NP$$

# RESULTS

# EXPERIMENTAL RESULTS

The present investigation was undertaken to study the response of cowpea, variety P.118, to graded doses of nitrogen, phosphorus and potassium. The experimental findings are presented below.

## 1. Growth characters

### 1.1. Height of plants

Data on the mean height of plants at the different stages of growth are presented in Table 2 and Fig.3 and the analyses of variance in Appendix II.

The effect of nitrogen on plant height was found to be significant at the 50th day after sowing and at harvest. At the 30th day after sowing though all the three levels of nitrogen were at par statistically, there was proportionate increase in plant height with increasing levels of nitrogen. At the second stage, nitrogen at 30 kg/ha was found to be significantly superior to no nitrogen application. However, the differences between 10 and 20 and between 20 and 30 kg N/ha were not significant.

The application of phosphorus did not produce any significant effect on the height of plants at any of the three stages of growth.

## Table 2

**Effect of different levels of nitrogen, phosphorus and potassium on height of plants(in cm) at various stages of the growth of cowpea**

| Treatments | 30th day after sowing. | 50th day after sowing. | 70th day after sowing. |
|---|---|---|---|
| **Nitrogen kg/ha** | | | |
| 10 | 29.98 | 49.06 | 74.27 |
| 20 | 30.98 | 56.09 | 92.61 |
| 30 | 31.02 | 63.19 | 101.35 |
| 'F' Test | NS | Sig. | Sig. |
| SEm ± | 0.483 | 2.630 | 2.489 |
| CD (0.05) | - | 7.703 | 7.3 |
| **Phosphorus $P_2O_5$ kg/ha** | | | |
| 20 | 30.14 | 55.80 | 88.38 |
| 30 | 30.74 | 55.32 | 86.83 |
| 40 | 31.09 | 57.22 | 93.02 |
| 'F' Test | NS | NS | NS |
| SEm ± | 0.483 | 2.630 | 2.489 |
| CD (0.05) | - | - | - |
| **Potassium $K_2O$ kg/ha** | | | |
| 0 | 29.52 | 56.93 | 87.94 |
| 10 | 30.76 | 55.78 | 90.41 |
| 20 | 31.69 | 55.63 | 89.89 |
| 'F' Test | Sig. | NS | NS |
| SEm± | 0.483 | 2.630 | 2.489 |
| CD (0.05) | 1.417 | - | - |

HEIGHT OF PLANTS AT VARIOUS STAGES OF GROWTH

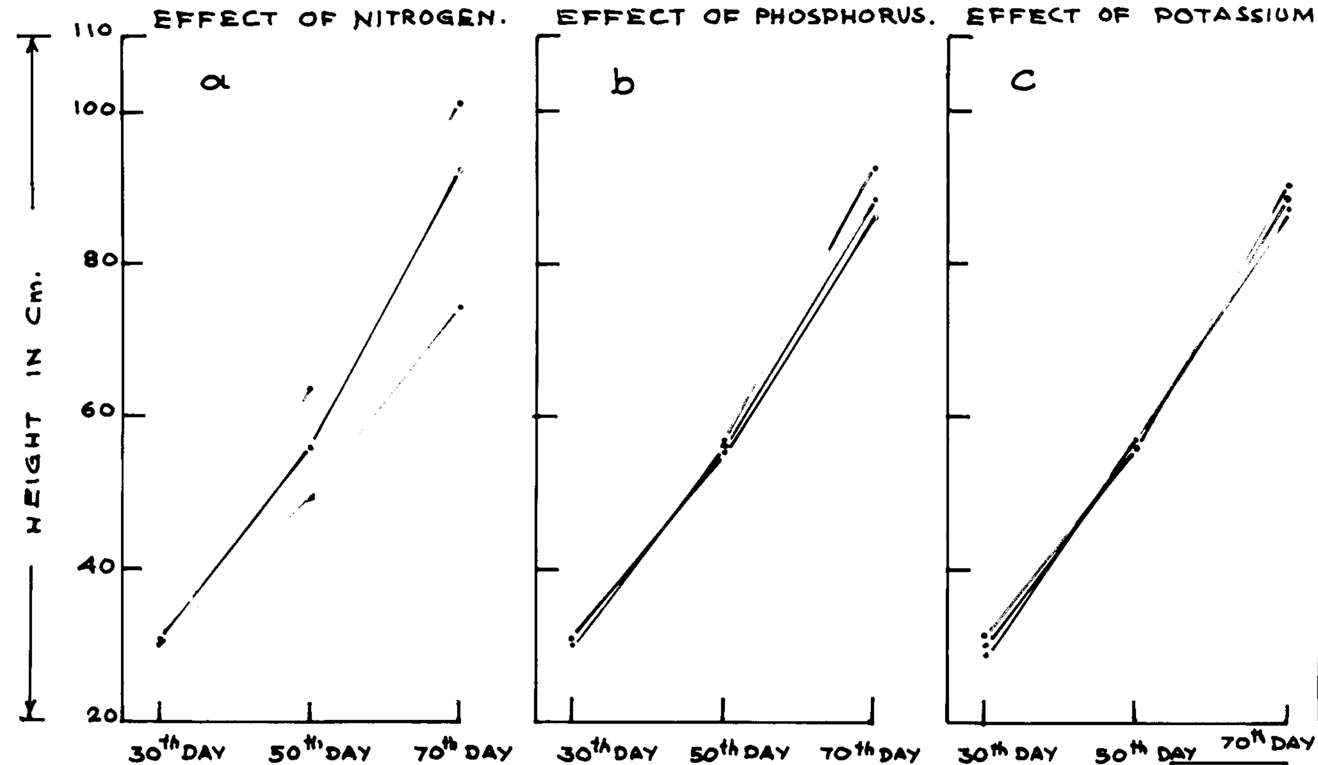



FIG: 3

NUMBER OF NODULES AT VARIOUS STAGES OF GROWTH

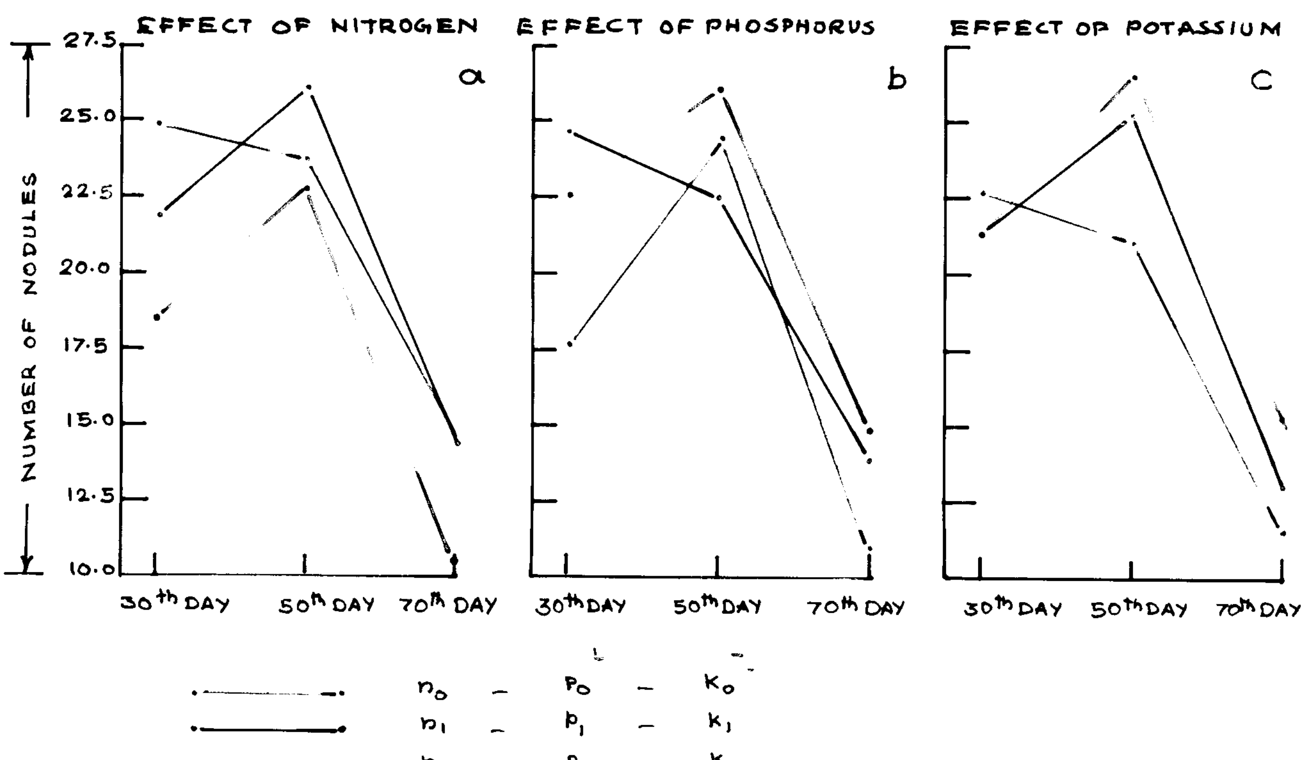



FIG: 4

Application of potash at 20 kg/ha was found to have significant influence on the height of plants at 30 days after sowing over no potassium application, but was on par with 10 kg $K_2O$/ha. Also the difference between 0 and 10 kg $K_2O$/ha was statistically not significant. At 50 and 70 days after sowing, the levels of potash had no significant influence on plant height.

The interactional effects of nitrogen, phosphorus and potassium were not significant.

1.2. Number of nodules

The mean number of nodules per plant for various treatments are presented in Table 3 and graphically represented in Fig.4. The analysis of variance is given in Appendix III.

The results revealed that the number of nodules per plant increased with the age of the plant till 50 days after sowing and thereafter the production of nodules tended to decline. At 30 days after sowing nitrogen had significant effect on the number of nodules per plant. But a decrease in the number of nodules was noticed with increasing doses of nitrogen. At 50 days after sowing levels of nitrogen had no significant effect on the number of nodules. Again at 70 days after

**Table 3**

**Effect of levels of nitrogen, phosphorus and potassium on the number of nodules per plant at various stages of growth**

| Treatments | 30 days after sowing | 50 days after sowing | 70 days after sowing |
|---|---|---|---|
| **Nitrogen kg/ha** | | | |
| 10 | 24.89 | 23.78 | 14.56 |
| 20 | 21.94 | 26.22 | 14.67 |
| 30 | 18.39 | 22.74 | 10.51 |
| 'F' Test | Sig. | NS | Sig |
| SEm± | 1.722 | 1.337 | 1.024 |
| CD (0.05) | 5.052 | - | 3.003 |
| **Phosphorus $P_2O_5$ kg/ha** | | | |
| 20 | 17.86 | 24.46 | 11.07 |
| 30 | 24.75 | 22.57 | 13.73 |
| 40 | 22.61 | 25.70 | 14.93 |
| 'F' Test | Sig. | NS. | Sig. |
| SEm± | 1.722 | 1.337 | 1.024 |
| CD (0.05) | 5.052 | - | 3.003 |
| **Potassium $K_2O$ kg/ha** | | | |
| 0 | 22.694 | 20.90 | 11.51 |
| 10 | 21.25 | 25.35 | 13.04 |
| 20 | 21.278 | 26.47 | 15.24 |
| 'F' Test | NS | Sig. | Sig. |
| SEm± | 1.722 | 1.337 | 1.024 |
| CD (0.05) | - | 3.922 | 3.003 |

sowing nitrogen was found to influence the number of nodules significantly. Both at 50 and 70 days after sowing the maximum numbers of nodules were observed at 20 kg N/ha.

Effect of phosphorus on the production of nodules was significant both at 30 and 70 days after sowing, but it was not significant at 50 days after sowing. Though at 50 and 70 days after sowing the maximum number of nodules was obtained at the highest level of phosphorus, at the 30th day after sowing the maximum number of nodules was found at 30 kg $P_2O_5$/ha.

The Table 3 shows that the effect of potassium was significant at 50th day after sowing and at harvest, but non-significant at 30 days after sowing. The highest number of nodules was produced at 20 kg $K_2O$/ha.

The interactional effects of nitrogen, phosphorus and potassium were not significant.

1.3. Number of branches

Data on Table 4 and Fig.5 show the mean number of branches 50 days after sowing. The analysis of variance is presented in Appendix II.

**Table 4**

**Effect of different levels of nitrogen, phosphorus and potassium on the number of branches per plant and dry matter production at harvest**

| Treatments | Number of branches per plant at 50 days after sowing. | Dry matter yield (g/sq.m) |
|---|---|---|
| **Nitrogen kg/ha** | | |
| 10 | 3.24 | 71.027 |
| 20 | 3.52 | 97.277 |
| 30 | 3.75 | 88.333 |
| 'F' Test | Sig. | Sig. |
| SEm± | 0.118 | 2.881 |
| CD (0.05) | 0.345 | 8.451 |
| **Phosphorus $P_2O_5$ kg/ha** | | |
| 20 | 3.29 | 78.177 |
| 30 | 3.41 | 85.538 |
| 40 | 3.81 | 92.927 |
| 'F' Test | Sig. | Sig. |
| SEm± | 0.118 | 2.881 |
| CD (0.05) | 0.345 | 8.451 |
| **Potassium $K_2O$ kg/ha** | | |
| 0 | 3.33 | 83.705 |
| 10 | 3.53 | 85.455 |
| 20 | 3.65 | 87.483 |
| 'F' Test | NS | NS |
| SEm± | 0.118 | 2.881 |
| CD(0.05) | - | - |

## NUMBER OF BRANCHES AT 50 DAYS AFTER SOWING

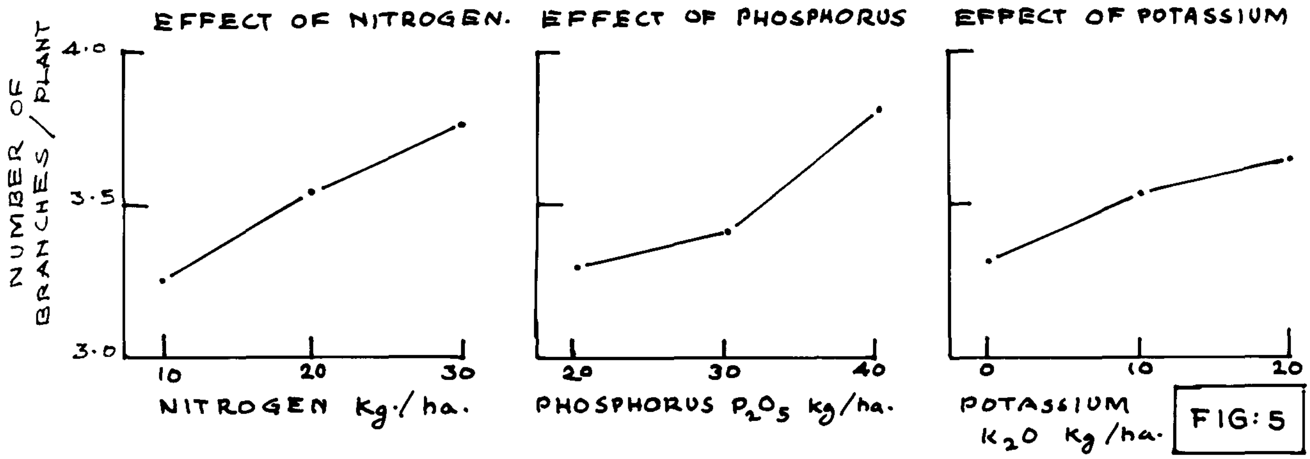



FIG: 5

## DRY WEIGHT OF PLANTS AT HARVEST

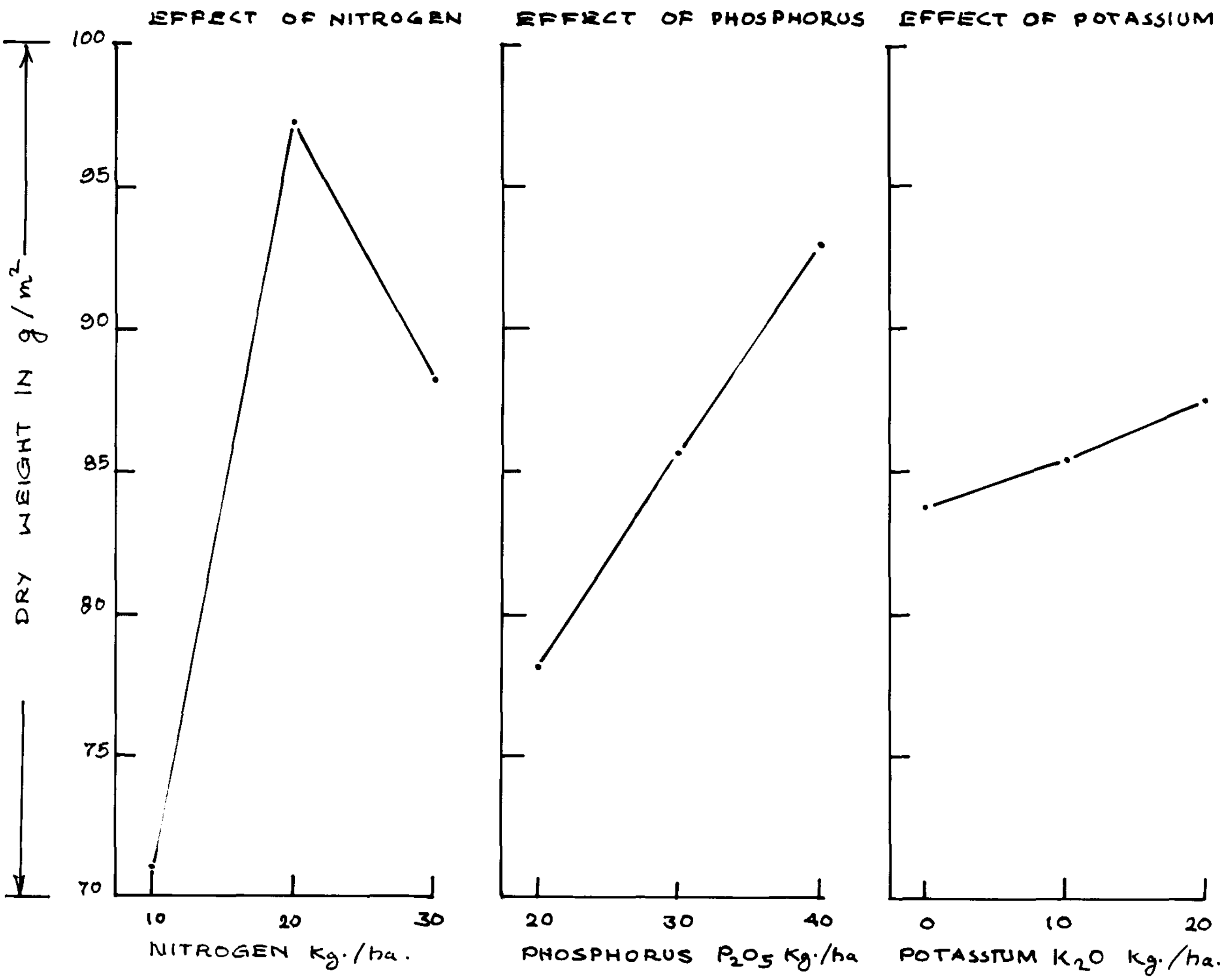



FIG: 6

The data reveal significant effect of nitrogen on the number of branches per plant. Nitrogen at 30 kg/ha was significantly superior to 10 kg N/ha but between 10 and 20 and between 20 and 30 kg N/ha there were no significant differences.

Application of phosphorus was found to have significant effect on the number of branches per plant. In this respect, phosphate at 40 kg/ha was significantly superior to 20 and 30 kg/ha, the latter two levels being on par.

Potassium did not produce any significant effect on the number of branches per plant.

The interactional effects of nitrogen, phosphorus and potassium were not significant.

1.4. Total dry matter production at harvest

The data on the dry matter production at harvest are presented in Table 4 and Fig.6. The analysis of variance of the data is shown in Appendix III.

The data reveal significant effect of nitrogen on dry matter production. At harvest nitrogen at 20 kg/ha produced the highest dry matter yield. The differences were significant among all the levels of applied nitrogen.

With regard to the effect of phosphorus, the highest dry matter yield was produced at 40 kg $P_2O_5$/ha; but the difference between $P_2O_5$ at 30 kg and 40 kg/ha was not significant. Similarly the difference between 20 and 30 kg $P_2O_5$/ha was also not significant.

Application of potash did not produce any significant response on the dry matter production.

The interactional effects of nitrogen, phosphorus and potassium were not significant.

2. Effect of nitrogen, phosphorus and potassium on yield components

2.1. Number of pods per plant

The data on the number of pods per plant are given in Table 5 and their graphical representation in Fig.7 (a) Appendix IV gives the analysis of variance.

Nitrogen exerted marked influence on the number of pods per plant with 20 kg N/ha producing more number of pods compared to 10 and 30 kg N/ha.

The effect of phosphorus was significant in increasing the number of pods per plant. The level, 40 kg $P_2O_5$/ha gave the maximum number of pods and was significantly superior to 20 and 30 kg $P_2O_5$/ha. At the

EFFECT OF NITROGEN, PHOSPHORUS AND POTASSIUM ON YIELD ATTRIBUTES

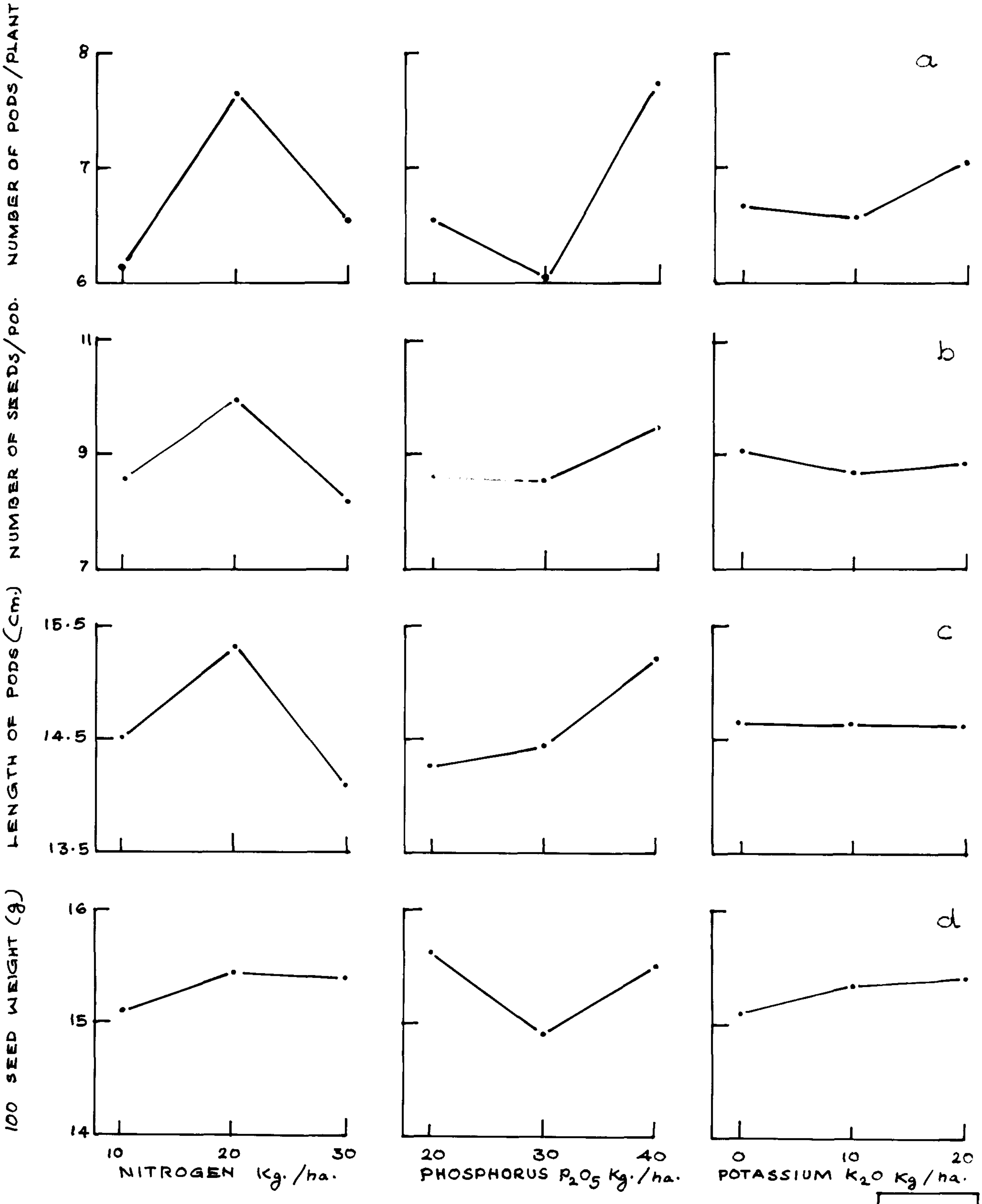



FIG: 7

**Table 5**

**Effect of levels of nitrogen, phosphorus and potassium on yield attributes**

| Treatments | No.of pods/ plant | No.of seeds/ pod | Length of pods in cm | 100 seed weight (g) |
|---|---|---|---|---|
| **Nitrogen kg/ha** | | | | |
| 10 | 6.17 | 8.56 | 14.49 | 15.095 |
| 20 | 7.69 | 9.95 | 15.31 | 15.477 |
| 30 | 6.56 | 8.18 | 14.10 | 15.342 |
| 'F' Test | Sig. | Sig. | Sig. | NS |
| SEm$\pm$ | 0.385 | 0.204 | 0.158 | 0.145 |
| CD (0.05) | 1.132 | 0.599 | 0.466 | - |
| **Phosphorus $P_2O_5$ kg/ha** | | | | |
| 20 | 6.58 | 8.61 | 14.24 | 15.511 |
| 30 | 6.07 | 8.58 | 14.44 | 14.905 |
| 40 | 7.76 | 9.50 | 15.22 | 15.499 |
| 'F' Test | Sig. | Sig. | Sig. | Sig. |
| SEm$\pm$ | 0.385 | 0.204 | 0.158 | 0.145 |
| CD (0.05) | 1.132 | 0.599 | 0.466 | 0.426 |
| **Potassium $K_2O$ kg/ha** | | | | |
| 0 | 6.70 | 9.09 | 14.67 | 15.101 |
| 10 | 6.63 | 8.72 | 14.63 | 15.370 |
| 20 | 7.07 | 8.87 | 14.59 | 15.442 |
| 'F' Test | NS. | NS. | NS. | NS. |
| SEm$\pm$ | 0.385 | 0.204 | 0.158 | 0.145 |
| CD (0.05) | - | - | - | - |

Table 6.

Combined effect of nitrogen and phosphorus on the number of pods

| Levels of phosphorus $P_2O_5$ kg/ha | Levels of nitrogen kg/ha | | | Mean |
|---|---|---|---|---|
| | 10 | 20 | 30 | |
| 20 | 6.2 | 6.66 | 6.77 | 6.54 |
| 30 | 6.1 | 5.83 | 6.22 | 6.05 |
| 40 | 6.0 | 10.55 | 6.66 | 7.73 |
| Mean | 6.10 | 7.68 | 6.55 | - |
| SEm$\pm$ | 0.667 | | | |
| CD(0.05) | 1.960 | | | |

same time between 20 and 30 kg $P_2O_5$/ha the difference was statistically not significant.

Neither the direct effect of potash nor its interactional effect with the other nutrients were found significant.

The interaction between nitrogen and phosphorus was significant. Table 6 gives the combined effect of nitrogen and phosphorus on the number of pods per plant. The treatment receiving 20 kg nitrogen and 40 kg $P_2O_5$/ha was significantly superior to all other treatments. The differences between other combinations were not significant.

2.2. Number of seeds per pod

The mean number of seeds per pod for various treatments are shown in Table 5 and graphical representation in Fig.7(b) and the analysis of variance in Appendix IV.

The effect of nitrogen was significant in increasing the number of seeds per pod. The maximum mean value was recorded at 20 kg N/ha which was significantly superior to the lower level of 10 kg and the higher level of 30 kg N/ha. The difference between 10 kg nitrogen and 30 kg N/ha was not significant.

## Table 7

**Combined effect of nitrogen and phosphorus on the number of seeds per pod**

| Levels of phosphorus $P_2O_5$ kg/ha | Levels of nitrogen kg/ha | | | Mean |
|---|---|---|---|---|
| | 10 | 20 | 30 | |
| 20 | 8.56 | 9.16 | 8.08 | 8.6 |
| 30 | 8.51 | 9.20 | 8.01 | 8.57 |
| 40 | 8.58 | 11.48 | 8.43 | 9.49 |
| Mean | 8.55 | 9.94 | 8.17 | |
| SEm± | 0.356 | | | |
| CD(0.05) | 1.041 | | | |

Application of phosphorus produced significant increase in the number of seeds per pod. Phosphorus at 40 kg $P_2O_5$/ha was superior to all the other levels. Phosphorus at 20 and 30 kg $P_2O_5$/ha were at par.

The nitrogen x phosphorus interaction was also found to he significant. The combined effect of nitrogen and phosphorus is given in Table 7. Plots receiving 20 kg nitrogen and 40 kg $P_2O_5$/ha registered the highest mean number of seeds per pod which was 11.48. Differences between other combinations were not significant.

The influenoe of potassium on this yield attribute was not significant at any of the levels. Its interactional effects also were not significant.

2.3. Length of pods

Analysis of variance for the length of pods is given in Appendix IV.

It is seen from Table 5 and Fig.7(o) that the higher level of nitrogen produced a depressive effect on the mean length of pod.

Phosphorus at the 40 kg/ha level produced the highest pod length. Though there was an increase in

Table 8

Combined effect of phosphorus and potassium on the length of pods

| Levels of potassium $K_2O$ kg/ha | Levels of phosphorus $P_2O_5$ kg/ha | | | Mean |
|---|---|---|---|---|
| | 20 | 30 | 40 | |
| 0 | 14.07 | 14.53 | 15.42 | 14.67 |
| 10 | 13.91 | 14.30 | 15.66 | 14.62 |
| 20 | 14.74 | 14.46 | 14.56 | 14.58 |
| Mean | 14.24 | 14.43 | 15.21 | |
| SEm± | 0.277 | | | |
| CD(0.05) | 0.81 | | | |

this yield attribute at 30 kg $P_2O_5$/ha compared to 20 kg/ha, the difference was not significant.

The direct effect of potassium was not significant. However, its interaction with phosphorus was statistically significant. The data on Table 8 give the combined effect of potassium and phosphorus. The treatment receiving 10 kg $K_2O$/ha and 40 kg $P_2O_5$/ha recorded the highest pod length of 15.66 cm, followed by the one receiving no potash and 40 kg $P_2O_5$/ha. At the 20 kg $P_2O_5$/ha level, potash exhibited significant difference between 10 and 20 kg/ha levels. At 40 kg $P_2O_5$/ha, the zero and 10 kg levels of potash, though at par, were superior to the 20 kg/ha level. At zero and 10 kg levels of potash the 40 kg $P_2O_5$ level was significantly superior to the other levels.

2.4. Hundred seed weight

The test weight under different treatments is given in Table 5 together with graphic representation in Fig. 7(d). Analysis of variance is appended as IV.

Nitrogen or potassium at any of the three levels tried did not exhibit any marked influence on the hundred seed weight. On the other hand, phosphorus at

20 and 40 kg/ha, which were on par statistically, influenced the hundred seed weight and these levels were superior to 30 kg $P_2O_5$/ha.

3. Effect of nitrogen, phosphorus and potassium on yield

3.1. Yield of grain

The data on mean yield of grain under various treatments, its graphical representation and analysis of variance are given in Table 9, Fig. 8 and Appendix V respectively.

The results presented in Table 9 reveal that application of nitrogen at 20 kg/ha registered the highest yield and it was statistically superior to all the other levels of nitrogen. The level of nitrogen at 30 kg/ha was significantly superior to 10 kg/ha.

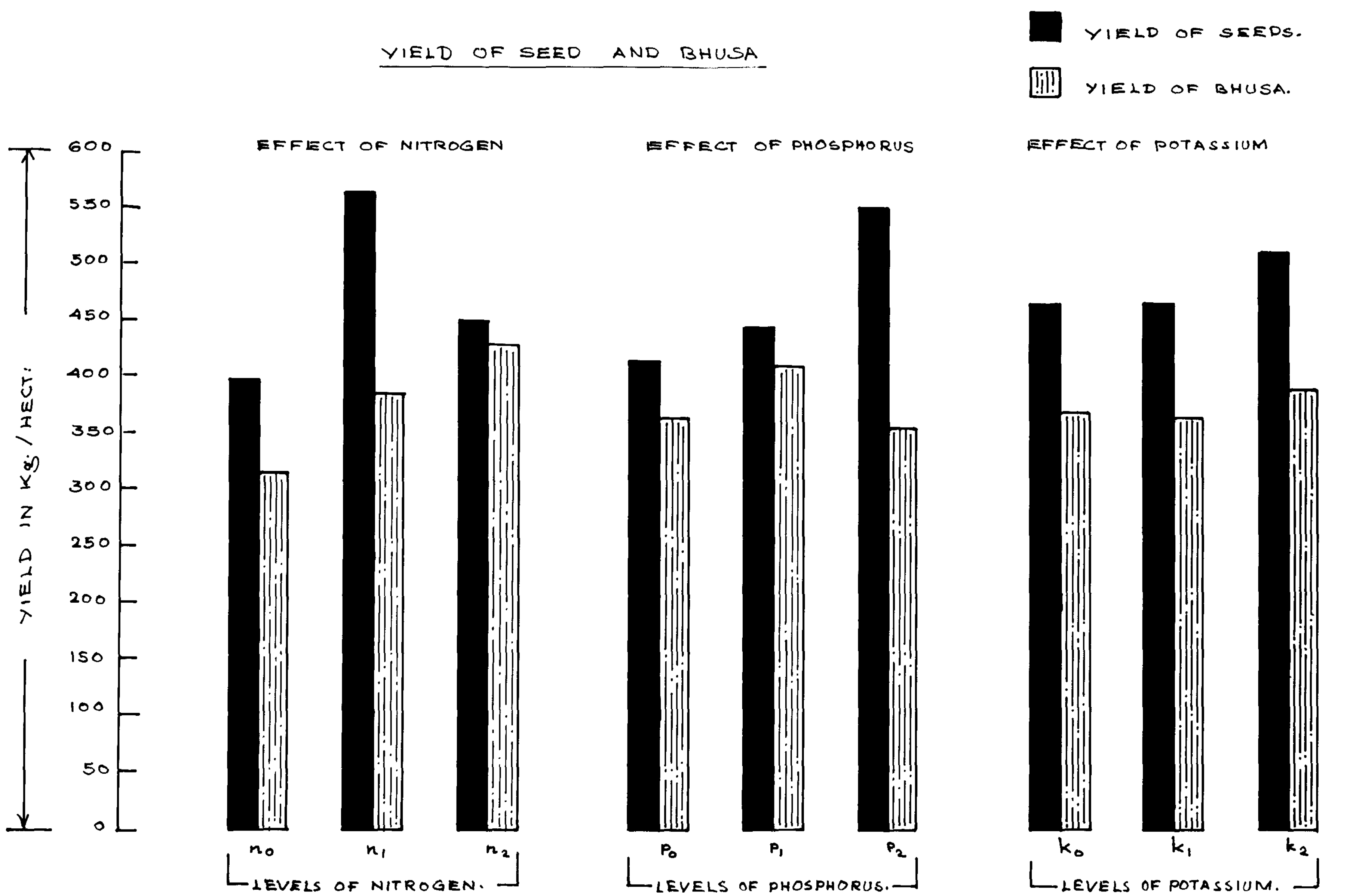
There was significant increase in yield with graded doses of phosphorus upto 40 kg $P_2O_5$/ha. The highest mean yield of 550 kg/ha was observed at 40 kg $P_2O_5$/ha. Though, there was an increase in yield at the 30 kg $P_2O_5$ level over the 20 kg level, the difference was statistically non-significant.

Influence of potassium on grain yield was not marked. The nitrogen x phosphorus interaction was significant. The data are presented in Table 10. The

Table 9

Effect of levels of nitrogen, phosphorus and potassium on yield of cowpea

| Treatments | Yield of grains in kg/ha | Yield of haulm in kg/ha | Grain/haulm ratio |
|---|---|---|---|
| Nitrogen kg/ha | | | |
| 10 | 396.36 | 313.89 | 1.302 |
| 20 | 566.26 | 383.43 | 1.604 |
| 30 | 451.44 | 431.94 | 1.089 |
| 'F' Test | Sig. | Sig. | Sig. |
| SEm± | 18.02 | 16.75 | 0.089 |
| CD (0.05) | 52.85 | 49.14 | 0.269 |
| Phosphorus $P_2O_5$ kg/ha | | | |
| 20 | 416.54 | 365.29 | 1.189 |
| 30 | 446.44 | 408.79 | 1.140 |
| 40 | 550.92 | 355.19 | 1.666 |
| 'F' Test | Sig. | NS | Sig. |
| SEm± | 18.02 | 16.75 | 0.089 |
| CD (0.05) | 52.85 | - | 0.269 |
| Potassium $K_2O$ kg/ha | | | |
| 0 | 464.40 | 372.69 | 1.332 |
| 10 | 466.09 | 365.38 | 1.405 |
| 20 | 483.58 | 391.20 | 1.258 |
| 'F' Test | NS | NS | NS |
| SEm± | 18.02 | 16.75 | 0.089 |
| CD (0.05) | - | - | - |



YIELD OF SEED AND BHUSA
YIELD OF SEEDS.
YIELD OF BHUSA.
EFFECT OF NITROGEN
EFFECT OF PHOSPHORUS
EFFECT OF POTASSIUM
YIELD IN Kg./HECT.
600
550
500
450
400
350
300
250
200
150
100
50
0
$n_0$
$n_1$
$n_2$
LEVELS OF NITROGEN.
$P_0$
$P_1$
$P_2$
LEVELS OF PHOSPHORUS.
$k_0$
$k_1$
$k_2$
LEVELS OF POTASSIUM.


FIG: 8

Table 10

Combined effect of nitrogen and phosphorus on grain yield in cowpea (kg/ha)

| Levels of phosphorus $P_2O_5$ kg/ha | Levels of nitrogen kg/ha | | | Mean |
|---|---|---|---|---|
| | 10 | 20 | 30 | |
| 20 | 353.58 | 472.75 | 423.30 | 416.54 |
| 30 | 432.18 | 519.40 | 387.73 | 446.43 |
| 40 | 403.31 | 706.63 | 543.30 | 551.08 |
| Mean | 396.35 | 566.26 | 451.44 | |
| SEm± | 31.21 | | | |
| CD(0.05) | 91.53 | | | |

treatment combination of 20 kg N/ha and 40 kg $P_2O_5$/ha recorded the highest grain yield of 706.63 kg/ha which was 99.36 per cent superior to the combination of 10 kg N/ha and 20 kg $P_2O_5$/ha. This treatment combination was superior to all the others. Regarding the effect of nitrogen at the three levels of phosphorus, the 20 kg/ha level always produced the highest yield. At the 20 kg level of $P_2O_5$/ha the difference between 10 and 20 kg N/ha was significant. Similarly, at the 30 kg level of phosphate the difference between 20 and 30 kg N/ha was significant. At the higher level of phosphorus, the differences amongst the various levels of nitrogen were significant. Both at 20 and 30 kg N/ha, the differences between 20 and 40 and between 30 and 40 kg $P_2O_5$/ha were significant.

3.2. Yield of haulm

The summary of the data on yield of haulm is given in Table 9 and in Fig.8. The analysis of variance is presented in Appendix V.

It is seen that nitrogen had significantly influenced the haulm yield. The different levels of nitrogen showed significant influence on the yield of haulm with nitrogen at 30 kg/ha producing the maximum.

Table 11

Combined effect of phosphorus and potassium on haulm yield in cowpea (kg/ha)

| Levels of potassium $K_2O$ kg/ha | Levels of phosphorus $P_2O_5$ kg/ha | | | Mean |
|---|---|---|---|---|
| | 20 | 30 | 40 | |
| 0 | 361.116 | 443.066 | 313.883 | 372.688 |
| 10 | 320.850 | 418.050 | 357.233 | 365.377 |
| 20 | 413.900 | 365.250 | 394.450 | 391.200 |
| Mean | 365.288 | 408.788 | 355.188 | - |
| SEm $\pm$ | 29.018 | | | |
| CD (0.05) | 85.096 | | | |

Phosphorus and potassium did not produce any marked influence on haulm yield of cowpea.

The interactional effects of phosphorus and potassium were however, significant. The data on Table 11 give the combined effect phosphorus and potassium on the haulm yield of cowpea. The highest haulm yield was obtained from the treatment combination of 30 kg $P_2O_5$/ha with no applied potash. Among the different levels of potash at 20 kg $P_2O_5$/ha, the response was significant at 20 kg $K_2O$/ha as compared to 10 kg/ha. At 30 and 40 kg $P_2O_5$/ha, the difference between levels of $K_2O$ was not marked. The difference between the levels of phosphate with no potash application was significant between 30 and 40 kg $P_2O_5$/ha, the 30 kg/ha level being superior. At the 10 kg/ha level of potash difference was significant between 20 and 30 kg $P_2O_5$/ha.

3.3. Grain-haulm ratio

The data on grain-haulm ratio are given in Table 9. The analysis of variance is presented in Appendix V.

The effect of nitrogen was significant. Application of nitrogen at 20 kg/ha recorded the highest grain-haulm ratio. The higher level of nitrogen had

Table 12

Combined effect of nitrogen and phosphorus on grain/haulm ratio in cowpea

| Levels of phosphorus $P_2O_5$ kg/ha | Levels of nitrogen kg/ha | | | Mean |
|---|---|---|---|---|
| | 10 | 20 | 30 | |
| 20 | 1.23 | 1.27 | 1.06 | 1.18 |
| 30 | 1.29 | 1.21 | 0.92 | 1.13 |
| 40 | 1.37 | 2.34 | 1.28 | 1.66 |
| Mean | 1.29 | 1.60 | 1.08 | |
| SEm± | 0.161 | | | |
| CD (0.05) | 0.472 | | | |

a depressive effect on it. The lower level of nitrogen possessed a grain-haulm ratio which was significantly higher than that of 30 kg N/ha. The difference between 10 and 20 kg N/ha was also significant.

Phosphorus at the level of 40 kg $P_2O_5$/ha registered the highest mean value for grain-haulm ratio. However, the difference between the levels of 30 kg/ha and 20 kg/ha of phosphate was not marked. The interactional effect of nitrogen and phosphorus was significant (Table 12). The treatment combination of 20 kg nitrogen plus 40 kg $P_2O_5$/ha recorded the highest grain-haulm ratio of 2.34 which was significantly superior to all other combinations. The difference between other combinations were not significant.

Potassium did not have any marked influence on grain-haulm ratio.

## 4.0. Response

The quadratic response equation developed from the data is given below.

$$y = 541.3447 + 27.542\,N + 67.269\,P - 142.359\,N^2 + 37.375\,P^2 + 17.567\,NP$$

## 4.1. Derived yields

Derived yields calculated at various levels of

## Table 13

**Derived yields in kg/ha at various levels of nitrogen and phosphorus**

| Phosphorus $P_2O_5$ kg/ha | Nitrogen kg/ha | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 10 | 15 | 20 | 21.5 | 21.6 | 21.7 | 21.8 | 25 | 29 | 30 |
| 20 | 359.20 | 470.87 | 511.45 | 509.74 | 509.40 | 509.03 | 508.63 | 480.84 | 405.12 | 379.07 |
| 25 | 355.94 | 472.08 | 517.05 | 516.66 | 516.41 | 516.13 | 515.82 | 490.84 | 418.63 | 393.45 |
| 30 | 371.44 | 519.53 | 541.34 | 542.27 | 542.11 | 541.91 | 541.69 | 519.53 | 450.82 | 426.53 |
| 35 | 405.64 | 530.57 | 584.32 | 586.57 | 586.49 | 586.38 | 586.25 | 566.90 | 501.71 | 478.29 |
| 40 | 458.52 | 587.84 | 645.99 | 649.55 | 649.56 | 649.54 | 649.50 | 632.95 | 571.28 | 548.74 |
| 42 | 484.91 | 615.99 | 675.89 | 679.98 | 680.02 | 680.04 | 680.03 | 664.61 | 604.34 | 582.15 |
| 44 | 514.28 | 647.12 | 708.78 | 713.39 | 713.47 | 713.53 | 713.54 | 699.25 | 640.39 | 618.55 |

nitrogen and phosphate with the estimated equation is presented in Table 13. The data indicate that the yields at the initial stages increased and ultimately diminished giving a concave shape to the response curve when nitrogen was varied and phosphorus was fixed. From the Table 13 it is also evident that with increasing levels of phosphate the yield increases continuously. The analysis of variance table on yield presented in Appendix IV also prove this.

4.2. Optimum dose of nutrients

From the data presented in the Table 13 the optimum dose of nitrogen appears to be 21.6 kg N/ha. In the case of phosphate, no optimization was possible since yield tended to increase with increasing levels, even after the maximum quantity of phosphate tried which was 40 kg/ha. For example the derived yield at 42 and 44 kg $P_2O_5$/ha were 696.41 and 713.54 kg/ha respectively at 21.8 kg N/ha.

4.3. Economic dose of nutrients

The economic doses of nitrogen and phosphorus were estimated at the prevailing market rates of Rs.6.00 per kilogram of cowpea grain, Rs. 4.85 per kilogram of nitrogen and Rs. 3.37 per kilogram of phosphate. The

## Table 14

**Economics of combined application of nitrogen and phosphorus to cowpea (net returns: Rupees/hectare)**

| Phosphorus $P_2O_5$ kg/ha | Nitrogen kg/ha | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 10 | 15 | 20 | 21.5 | 21.6 | 21.7 | 25 | 30 |
| 20 | - | 645.77 | 865.0 | 844.92 | 843.14 | 842.23 | 657.09 | 22.22 |
| 25 | -36.41 | 636.18 | 881.75 | 872.13 | 870.15 | 867.60 | 700.24 | 91.65 |
| 30 | 39.74 | 904.03 | 1010.64 | 1008.94 | 1007.80 | 1005.81 | 855.88 | 273.28 |
| 35 | 228.09 | 953.42 | 1251.67 | 1257.89 | 1256.93 | 1255.78 | 1122.90 | 565.25 |
| 40 | 528.52 | 1280.19 | 1604.84 | 1618.92 | 1618.50 | 1617.89 | 1502.38 | 972.84 |
| 42 | 680.12 | 1442.35 | 1777.75 | 1794.76 | 1794.52 | 1794.15 | 1685.57 | 1166.56 |
| 44 | 849.60 | 1622.39 | 1968.10 | 1988.48 | 1988.48 | 1988.35 | 1886.67 | 1378.22 |

Price of 1 kg cowpea seeds — Rs. 6.00

Cost of 1 kg Nitrogen — Rs. 4.85

Cost of 1 kg Phosphorus — Rs. 3.37

combination of 21.5 kg N/ha and 40 kg $P_2O_5$/ha gave a profit of Rs. 1618.92 per hectare (Table 14). The net returns from phosphorus assumed a linear trend with increasing levels. This result indicate the need for trying higher levels of phosphorus to the crop for attaining optimum response. The economic optimum dose of nitrogen can be fixed at 21.5 kg/ha. As there is linear response to phosphate, its economic optimum fall outside the range tried. However, within the range tried 40 kg $P_2O_5$/ha can be considered as the economic dose.

5.0. Effect of nitrogen, phosphorus and potassium on plant contents of nitrogen, phosphorus and potassium at various stages of growth and their content in grain

5.1.0. Effect on nitrogen content of plants at various stages of growth

Nitrogen content of plants at different stages of growth are furnished in Table 15 and Fig.9. The analyses of variance are given in Appendix VI.

The results presented in the Table show that nitrogen application had significant influence on the percentage of nitrogen in plants excepting at 50 days after sowing. It can be seen that with an increase in the levels of applied nitrogen, the content of nitrogen

## Table 15

**Effect of levels of nitrogen, phosphorus and potassium on nitrogen content of cowpea at various stages of growth in grains (per cent)**

| Treatments | Nitrogen content at 30th day | Nitrogen content at 50th day | Nitrogen content at 70th day | Nitrogen content of grains |
|---|---|---|---|---|
| **Nitrogen kg/ha** | | | | |
| 10 | 3.643 | 2.56 | 2.201 | 2.596 |
| 20 | 3.871 | 2.42 | 2.547 | 3.287 |
| 30 | 4.076 | 2.62 | 2.625 | 3.667 |
| 'F' Test | Sig. | NS | Sig. | Sig. |
| SEm± | 0.079 | 0.107 | 0.0735 | 0.113 |
| CD (0.05) | 0.232 | - | 0.2165 | 0.332 |
| **Phosphorus $P_2O_5$ kg/ha** | | | | |
| 20 | 3.88 | 2.43 | 2.350 | 3.140 |
| 30 | 3.83 | 2.61 | 2.450 | 3.230 |
| 40 | 3.88 | 2.55 | 2.570 | 3.175 |
| 'F' Test | NS | NS | NS | NS |
| SEm± | 0.232 | 0.107 | 0.0735 | 0.113 |
| CD (0.05) | - | - | - | - |
| **Potassium $K_2O$ kg/ha** | | | | |
| 0 | 3.93 | 2.58 | 2.485 | 3.160 |
| 10 | 3.86 | 2.52 | 2.320 | 3.100 |
| 20 | 3.80 | 2.49 | 2.570 | 3.291 |
| 'F' Test | NS | NS | NS | NS |
| SEm± | 0.079 | 0.107 | 0.0735 | 0.113 |
| CD (0.05) | - | - | - | - |

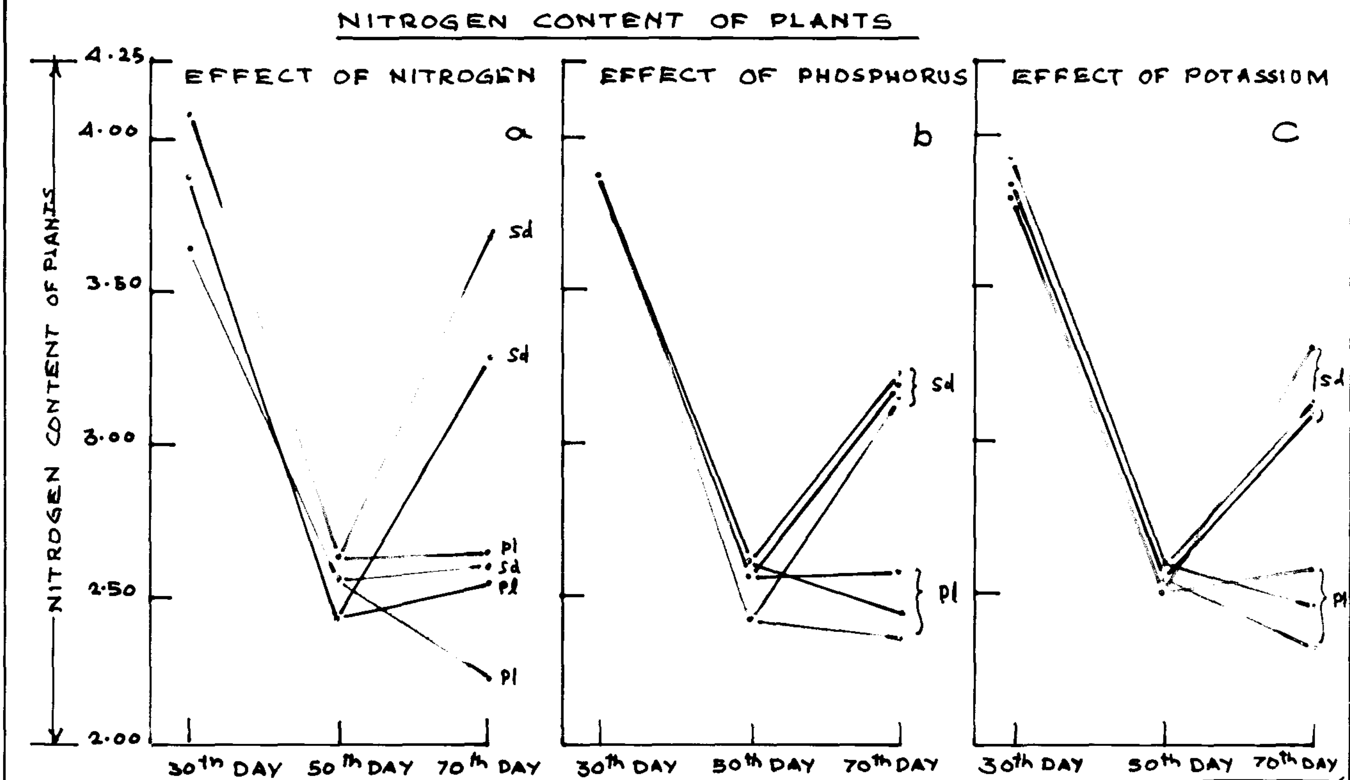



FIG:9

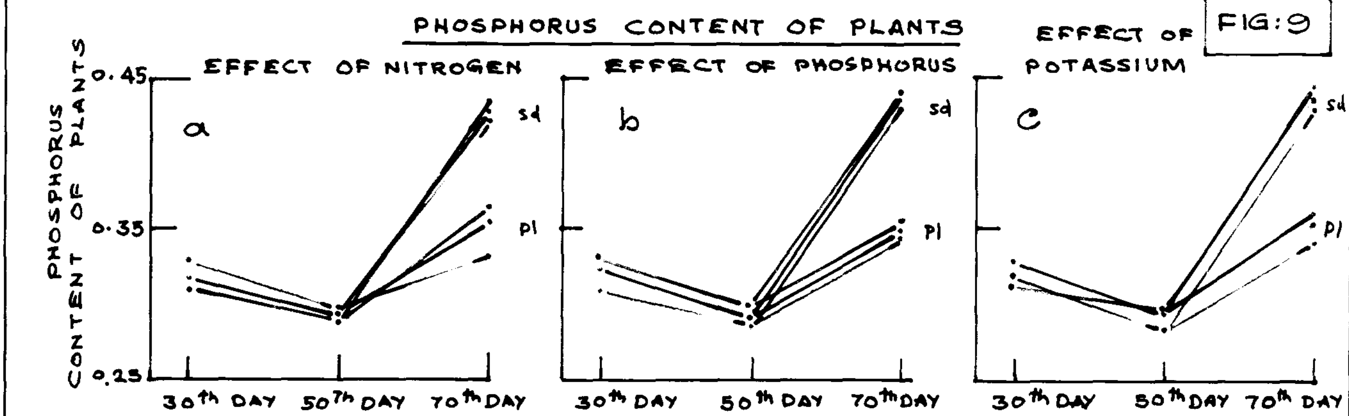



FIG:10

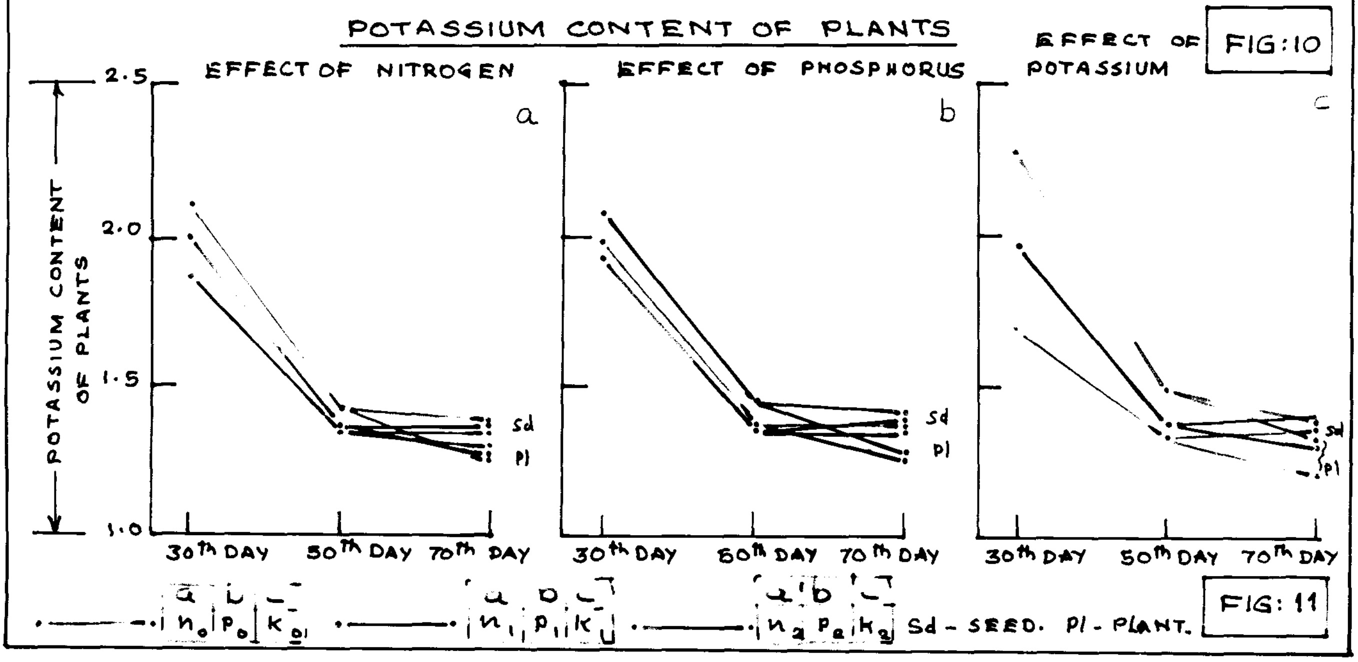



FIG: 11

in the plant tissue has increased. The differences were significant only between 10 and 30 kg N/ha at 30 and 70 days after sowing.

The influence of phosphorus and potassium was not pronounced. The interactional effects also were not significant.

5.1.1. Nitrogen content in grain

The levels of nitrogen were found to have marked influence on nitrogen content of grain. It was observed that there was significant increase in nitrogen content of seeds with increase in nitrogen application at the levels of 10, 20 and 30 kg N/ha. The data are presented in Table 15 and Fig.9. The analysis of variance in Appendix VI.

The effect of neither phosphorus nor potassium was significant.

5.2.0. Effect on phosphorus content of plants at various stages of growth

The data on phosphorus content of plants at different stages of growth are presented in Table 16 and depicted on the graph at Fig.10. The analyses of variance are presented in Appendix VII.

Table 16

Effect of levels of nitrogen, phosphorus and potassium on phosphorus content of cowpea at various stages of growth and grains (per cent)

| Treatments | Phosphorus content at 30th day. | Phosphorus content at 50th day. | Phosphorus content at 70th day. | Phosphorus content of grains. |
|---|---|---|---|---|
| **Nitrogen kg/ha** | | | | |
| 10 | 0.333 | 0.299 | 0.335 | 0.428 |
| 20 | 0.321 | 0.289 | 0.357 | 0.438 |
| 30 | 0.314 | 0.292 | 0.361 | 0.440 |
| 'F' Test | Sig. | NS. | NS. | NS. |
| SEm± | 0.0055 | 0.0082 | 0.010 | 0.0063 |
| CD (0.05) | 0.0147 | - | - | - |
| **Phosphorus $P_2O_5$ kg/ha** | | | | |
| 20 | 0.311 | 0.288 | 0.345 | 0.429 |
| 30 | 0.323 | 0.290 | 0.353 | 0.436 |
| 40 | 0.334 | 0.300 | 0.354 | 0.441 |
| 'F' Test | Sig. | NS. | NS. | NS. |
| SEm± | 0.0055 | 0.0082 | 0.01 | 0.0063 |
| CD (0.05) | 0.0147 | - | - | - |
| **Potassium $K_2O$ kg/ha** | | | | |
| 0 | 0.322 | 0.287 | 0.339 | 0.431 |
| 10 | 0.328 | 0.296 | 0.358 | 0.439 |
| 20 | 0.318 | 0.296 | 0.356 | 0.436 |
| 'F' Test | NS | NS | NS | NS |
| SEm± | 0.0055 | 0.0082 | 0.01 | 0.0063 |
| CD (0.05) | - | - | - | - |

Nitrogen was found to have significant influence on phosphorus content of plants at the 30th day. It is seen that the phosphorus content decreased with increasing levels of nitrogen. Nitrogen at 30 kg/ha was significantly inferior to the 10 kg level. However, the differences between the levels 10 and 20 and between 20 and 30 kg/ha were not significant. Nitrogen application did not produce any marked effect on the phosphorus content of plants at the 50th day and the 70th day after sowing.

Application of phosphorus influenced the percentage of phosphorus at the 30th day only. The highest phosphorus content was observed at the 40 kg/ha phosphate level, which was significantly superior to the 20 kg level. However, differences between the levels 20 and 30 and between 30 and 40 kg/ha were not marked. Influence of phosphorus was not significant at 50 and 70 days after sowing.

Potassium application did not produce any marked effect on the phosphorus content of plant tissues at any of the stages.

The interactional effects also were not significant statistically.

5.2.1. Phosphorus content in grain

Neither the effects of nitrogen, phosphorus and potassium nor their interactions were signifioantly different (Table 16 and Fig.10).

5.3.0. Effect on potassium content of plants at various stages of growth

The potassium content of plants at different stages of growth for various treatments are presented in Table 17 and Fig.11. The analyses of variance are given in Appendix VIII.

The data presented in the Table show that the potassium oontent at the 30th day increased with increasing levels of applied potash. There was significant increase in the content of potassium with increasing levels of potash application.

Potassium content at the 50th day after sowing increased with increasing levels of applied potash. The differences were, however, not significant. Significant increase in potassium content with increasing levels of potash application was noted on the 70th day. Nitrogen and phosphorus applioation did not produce any marked effect on potassium content of plant tissues at any of the stages. The various interactional effects also were not significant.

## Table 17

**Effect of levels of nitrogen, phosphorus and potassium on the potassium content of cowpea at various stage of growth and grain (per cent)**

| Treatments | Potassium content at 30th day. | Potassium content at 50th day. | Potassium content at 70th day. | Potassium content of grains |
|---|---|---|---|---|
| **Nitrogen kg/ha** | | | | |
| 10 | 2.094 | 1.438 | 1.268 | 1.372 |
| 20 | 1.879 | 1.353 | 1.288 | 1.359 |
| 30 | 1.977 | 1.380 | 1.299 | 1.350 |
| 'F' Test | NS | NS | NS | NS |
| SEm± | 0.084 | 0.046 | 0.0286 | 0.0078 |
| CD (0.05) | - | - | - | - |
| **Phosphorus $P_2O_5$ kg/ha** | | | | |
| 20 | 1.957 | 1.371 | 1.264 | 1.361 |
| 30 | 2.073 | 1.463 | 1.322 | 1.364 |
| 40 | 1.920 | 1.340 | 1.268 | 1.356 |
| 'F' Test | NS | NS | NS | NS |
| SEm± | 0.084 | 0.046 | 0.0286 | 0.0078 |
| CD (0.05) | - | - | - | - |
| **Potassium $K_2O$ kg/ha** | | | | |
| 0 | 1.700 | 1.319 | 1.213 | 1.340 |
| 10 | 1.979 | 1.379 | 1.302 | 1.378 |
| 20 | 2.271 | 1.477 | 1.339 | 1.363 |
| 'F' Test | Sig | NS | Sig | Sig |
| SEm± | 0.084 | 0.046 | 0.0286 | 0.0078 |
| CD (0.05) | 0.245 | - | 0.0839 | 0.023 |

5.3.1. Effect on potassium content of grain

Data are presented in Table 17 and Fig.11. Application of potash produced marked increase in the potassium content of grains. The levels of 20 kg and 10 kg $K_2O$/ha, which were on par, were significantly superior to the zero level.

Neither nitrogen nor phosphorus at any of the levels, produced significant change in the potassium content of grain. The various interactional effects were not pronounced.

6.0. Nutrient uptake by the plants at harvest

6.1. Uptake of nitrogen

The data on the uptake of nitrogen by plants at harvest are presented in Table 18 and Fig.12. The analysis of variance of the same is given in Appendix IX.

Nitrogen at 20 kg/ha was found to be superior to the lower level of 10 kg/ha. The quantity of nitrogen absorbed at 20 kg N/ha by the cowpea crop was 24.748 kg/ha. But the difference between the levels 20 and 30 kg were not significant.

The influence of phosphorus on the uptake of nitrogen by the plants also was significant. At the

Table 18

Effect of levels of nitrogen, phosphorus and potassium on the uptake of nitrogen, phosphorus and potassium (in kg/ha) by the plants at harvest

| Treatments | Uptake of nitrogen. | Uptake of phosphorus | Uptake of potassium |
|---|---|---|---|
| Nitrogen kg/ha | | | |
| 10 | 15.577 | 2.367 | 8.963 |
| 20 | 24.748 | 3.481 | 12.470 |
| 30 | 23.411 | 3.191 | 11.314 |
| 'F' Test | Sig | Sig | Sig |
| SEm± | 0.995 | 0.137 | 0.568 |
| CD (0.05) | 2.920 | 0.402 | 1.665 |
| Phosphorus $P_2O_5$ kg/ha | | | |
| 20 | 18.661 | 2.698 | 9.775 |
| 30 | 20.876 | 2.989 | 11.142 |
| 40 | 24.200 | 3.352 | 11.831 |
| 'F' Test | Sig | Sig | NS |
| SEm± | 0.995 | 0.137 | 0.568 |
| CD (0.05) | 2.920 | 0.402 | - |
| Potassium $K_2O$ kg/ha | | | |
| 0 | 20.955 | 2.831 | 10.107 |
| 10 | 20.144 | 3.082 | 11.107 |
| 20 | 22.637 | 3.127 | 11.578 |
| 'F' Test | NS | NS | NS |
| SEm± | 0.995 | 0.137 | 0.568 |
| CD (0.05) | - | - | - |

## NITROGEN UPTAKE BY PLANTS AT HARVEST

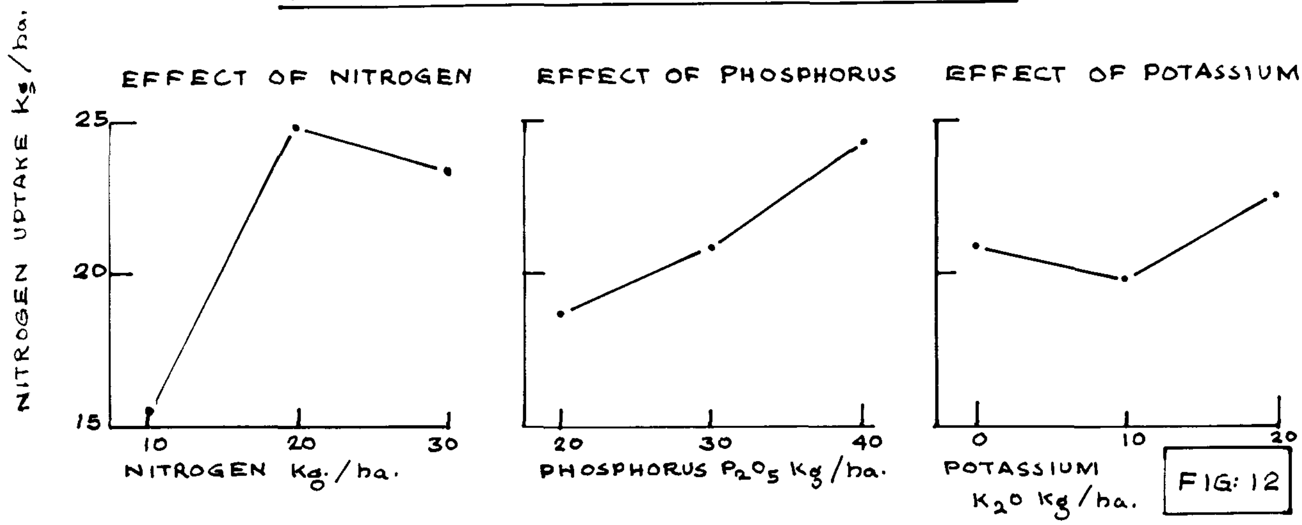



FIG: 12

## PHOSPHORUS UPTAKE BY PLANTS AT HARVEST

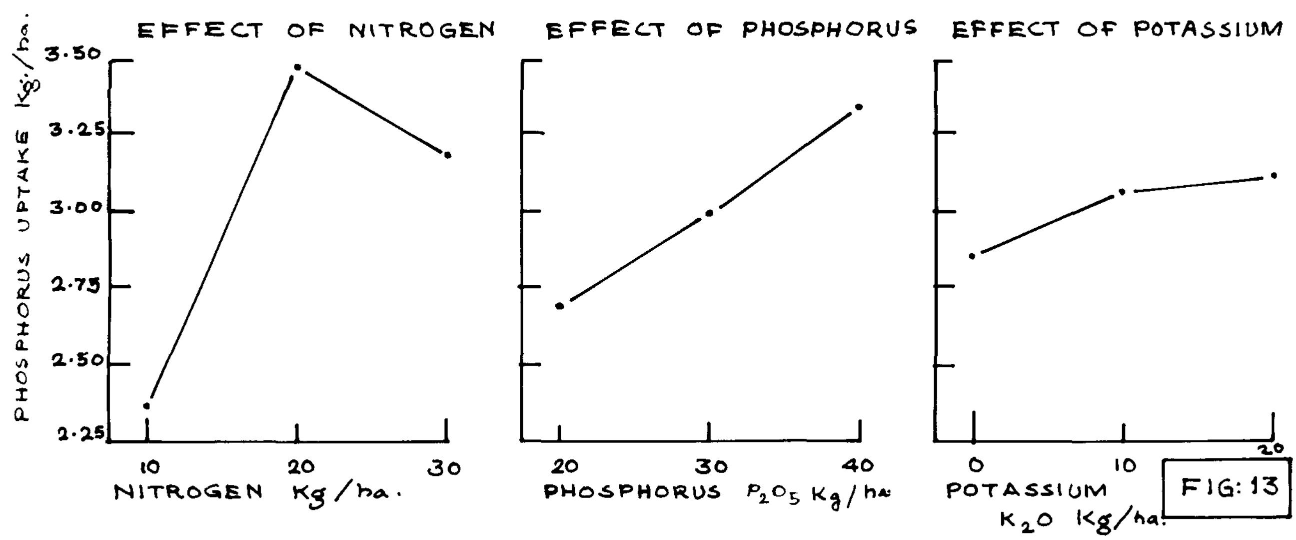



FIG: 13

## POTASSIUM UPTAKE BY PLANTS AT HARVEST

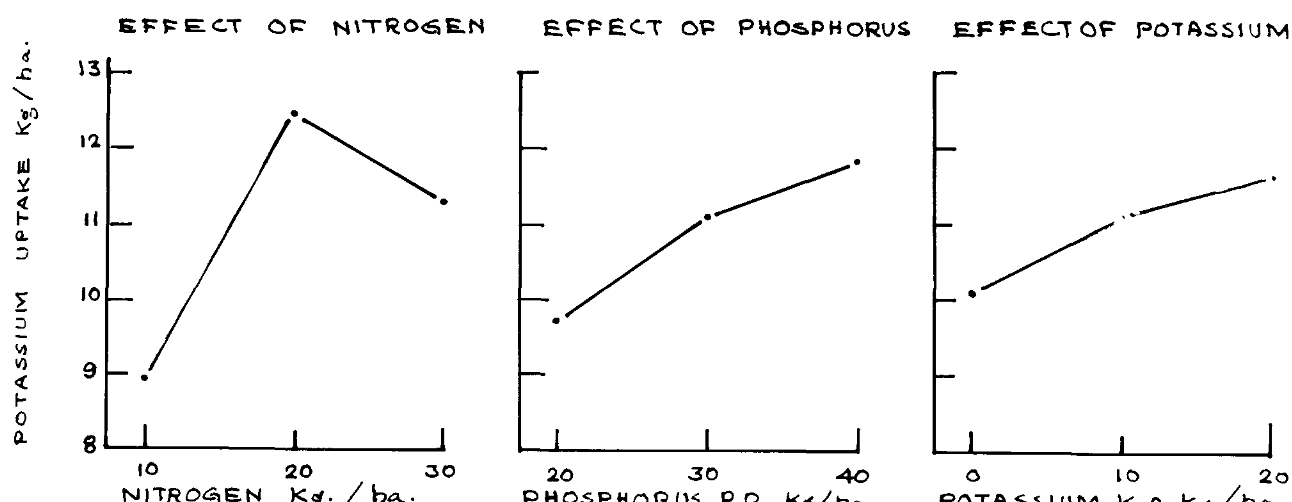



FIG: 14

40 kg/ha level, the plants absorbed the highest amount of nitrogen compared to that at 20 and 30 kg /ha.

The effect of potassium as well as the combined effects of different nutrients were not significant.

6.2. Uptake of phosphorus

The data on mean uptake are given in Table 18 and Fig.13. The analysis of variance is presented in Appendix IX.

From the data it can be seen that nitrogen significantly influenced the total uptake of phosphorus at harvest. The significant superiority of 20 kg N and 30 kg N/ha over 10 kg N/ha was well pronounced, but there did not exist any significant difference between 20 and 30 kg N/ha.

Phosphorus application also significantly increased the uptake of phosphorus by the plants. The 40 kg $P_2O_5$/ha level registered the highest uptake followed by the 30 kg/ha level, which were statistically at par. The 20 kg level was markedly inferior to the above levels of applied phosphorus.

The data are prepented in Table 19. At 20 and 40 kg levels of applied phosphate, the difference

Table 19

Combined effect of nitrogen and phosphorus on the phosphorus uptake by the plants at harvest (kg/ha)

| Levels of phosphorus $P_2O_5$ kg/ha | Levels of nitrogen (kg/ha) | | | Mean |
|---|---|---|---|---|
| | 10 | 20 | 30 | |
| 20 | 2.175 | 3.040 | 2.880 | 2.698 |
| 30 | 2.738 | 3.250 | 2.978 | 2.989 |
| 40 | 2.188 | 4.153 | 3.715 | 3.352 |
| Mean | 2.367 | 3.481 | 3.191 | -- |
| SEm± | 0.237 | | | |
| CD (0.05) | 0.697 | | | |

between 10 and 20 and between 10 and 30 kg levels of nitrogen were significant, the highest being obtained at the 20 kg level. The difference between the levels of nitrogen were non-significant at the 30 kg $P_2O_5$ level per hectare. When nitrogen was applied at the rate of 10 kg/ha applied phosphate did not influence the uptake of phosphorus. But at the 20 kg level of nitrogen, the 40 kg $P_2O_5$/ha level was significantly superior to the 20 and 30 kg levels, which were on par. Similarly in the treatments receiving 30 kg nitrogen per hectare, 40 kg of applied $P_2O_5$/ha had absorbed significantly higher quantities of phosphorus.

The effect of potassium was statistically not significant.

6.3. Uptake of potassium

Data are presented in Table 18 and Fig 14. The analysis of variance is given in Appendix IX.

Nitrogen exerted significant influence on the uptake of potassium. The 20 and 30 kg levels were significantly superior to 10 kg level of nitrogen.

Phosphorus, potassium or combinations of the three nutrients did not produce any marked response.

## 7.0. Effect of levels of nitrogen, phosphorus and potassium on qualitative characters of cowpea grains

### 7.1. Protein content of grains

The mean values for protein percentages are presented in Table 20 and Fig.15. The analysis of variance is given in Appendix IV.

It is seen that the protein content of seeds increased with increasing levels of nitrogen. The highest protein content of 22.921 per cent was registered by the treatment receiving 30 kg N/ha which was significantly superior to 20 kg N/ha. The latter dose in turn was superior to 10 kg N/ha. Neither phosphorus and potassium nor the interactions influenced the protein content of grains.

Table 20

Effect of levels of nitrogen, phosphorus and potassium on protein content of grain (per cent)

| Treatments | Protein contents of grain (per cent) |
|---|---|
| **Nitrogen kg/ha** | |
| 10 | 16.226 |
| 20 | 20.543 |
| 30 | 22.921 |
| 'F' Test | Sig |
| SEm± | 0.720 |
| CD (0.05) | 2.113 |
| **Phosphorus $P_2O_5$ kg/ha** | |
| 20 | 19.651 |
| 30 | 20.200 |
| 40 | 19.842 |
| 'F' Test | NS |
| SEm± | 0.720 |
| CD (0.05) | - |
| **Potassium $K_2O$ kg/ha** | |
| 0 | 19.752 |
| 10 | 19.351 |
| 20 | 20.591 |
| 'F' Test | NS |
| SEm± | 0.72 |
| CD (0.05) | - |

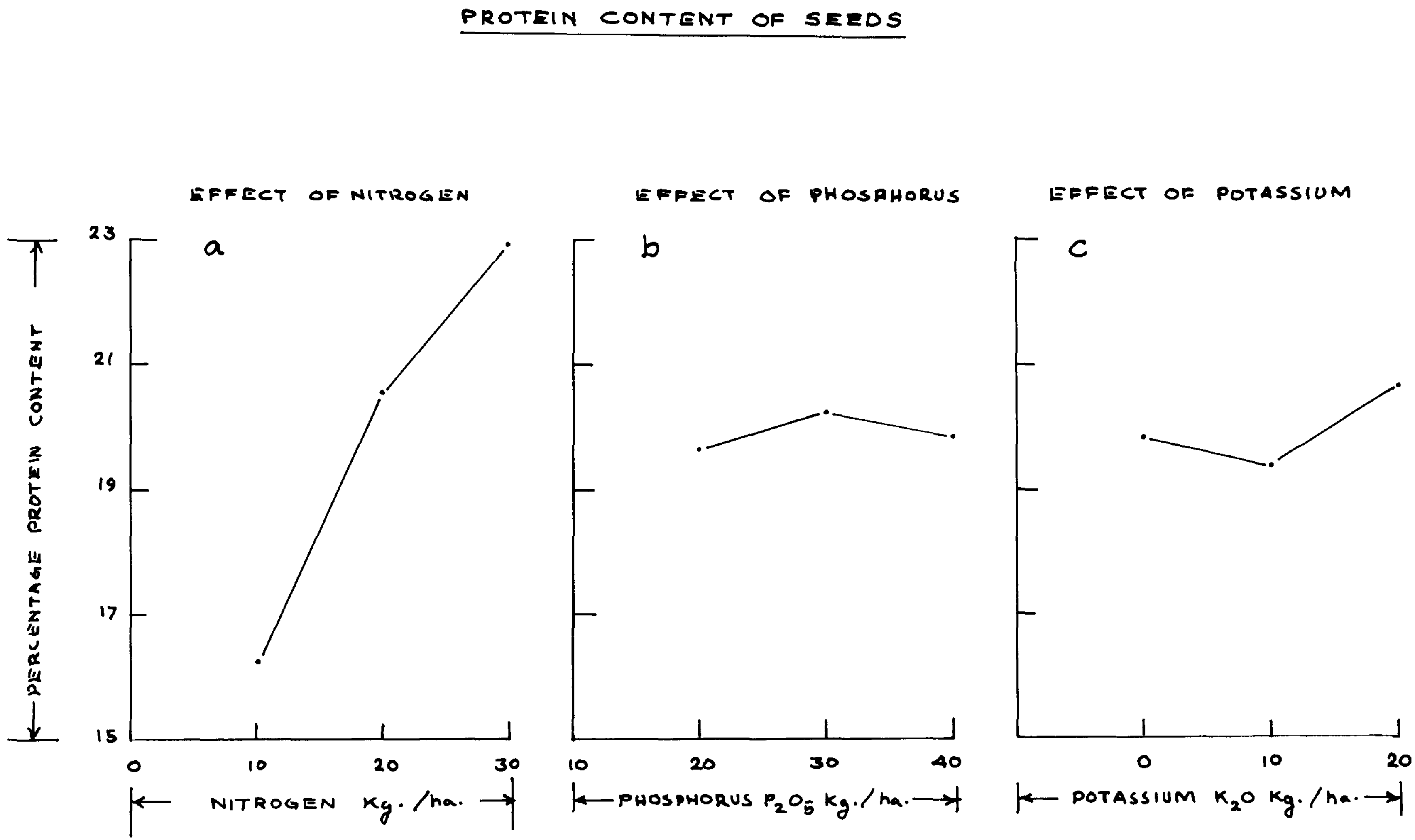

PROTEIN CONTENT OF SEEDS
EFFECT OF NITROGEN
EFFECT OF PHOSPHORUS
EFFECT OF POTASSIUM
PERCENTAGE PROTEIN CONTENT
a
b
c
23
21
19
17
15
0
10
20
30
10
20
30
40
0
10
20
NITROGEN Kg./ha.
PHOSPHORUS $P_2O_5$ Kg./ha.
POTASSIUM $K_2O$ Kg./ha.

FIG: 15

# DISCUSSION

# DISCUSSION

An investigation was carried out at the Instructional Farm, Vellanikkara, to study the effect of nitrogen, phosphorus and potassium on the growth and yield of cowpea, variety P.118.

The data recorded on the height of plants, the number of branches, number of nodules, total dry matter production at harvest, number of pods, number of seeds per pod, length of pods, hundred seed weight, yields of grain and haulm, and nutrient contents of plants at various stages of growth were statistically analysed. The results are discussed in the following pages.

## 1. Height of plant

As evident from Table 2 nitrogen increased the height of the plants at all the phases of growth. The treatment differences were, however, significant only at the 50th day and the 70th day after sowing. The increase in plant height is attributable to the rapid meristematic activity in plants due to nitrogen as reported by Crowther (1935). The increase in vegetative growth of the crop in response to applied nitrogen is in conformity with the findings of Nair (1966), Slabko (1970) and Battacharya (1971).

Application of phosphorus did not produce any significant effect on the height of plants. Sinha (1972) also did not observe any significant difference on growth in gram with dressings of phosphorus. Kesavan and Morachan (1973) found that successive additions of phosphorus to soybean gradually reduced the plant height but the differences were not significant.

Application of 20 kg $K_2O$/ha increased the height of the plants significantly at the 30th day after sowing. However at the other stages, the higher level tended to decrease the height. Depressive effect of potassium on the growth of cowpea at maturity has been reported by Vijayakumar (1967) and Satyanarayana and Rao (1975).

2. Number of nodules

As seen from Table 3 successive increments of nitrogen significantly depressed the number of nodules per plant at 30 days after sowing and at harvest. But at 50 days after sowing the effect of different levels of nitrogen was not significant, though there was reduction in the number of nodules at the higher level of nitrogen as observed at the other two stages. In legumes nitrogen fixation is at a maximum when the available soil nitrogen is at a minimum (Gibson, 1951). The depression in nodulation due to the application of nitrogenous fertilizer might probably be due to the fact that nitrogen fixing bacteria when provided with readily assimilable nitrogen became less efficient in fixing atmospheric nitrogen, thus retarding the formation of nodules. Whyte et al. (1953) and Cowling (1961) state that a high level of combined nitrogen in the soil would prevent deformation of roots thereby precluding the entry of nitrogen fixing bacteria. Russell (1961) expressed similar views. These might be the reasons for the depression observed in the number of nodules.

The number of nodules per plant increased with successive doses of phosphorus at all the stages except 30 days after sowing when the maximum number of nodules was obtained at 30 kg $P_2O_5$/ha. However, the differences were significant only at the first and the last stages of observation. A liberal supply of phosphorus is usually associated with increased root growth which in turn produces a higher number of nodules (Tisdale and Nelson, 1971). The presence of phosphates in the soil stimulates the rapid multiplication of rhizobia which leads to the formation of more nodules (James *et al*. 1944). Nair *et al*. (1957), Deshpande and Bathkal (1965), Iswaran and Jauhri (1969), Pandey (1969), Tyagim *et al*. (1972), Sahu (1973), Chesney (1974) and Singh *et al*. (1975) also reported favourable effect of phosphorus on nodulation.

Potassium significantly increased the number of nodules at 50 days after sowing and at harvest. According to Russel (1961) active nitrogen fixation depended on the availability of potassium. However legumes differ considerably in their requirement of this nutrient for their growth and development.

3. Number of branches

As seen in Table 4 nitrogen applied at the rate of 30 kg/ha produced the maximum number of branches per plant followed by the 20 kg level. The 30 kg/ha level of nitrogen was significantly superior to the 10 kg/ha level. The increase in the number of branches at the 30 kg/ha level did not lead to higher grain yield. However, yield of haulm increased considerably at the highest level of nitrogen. Similar results have been reported by Singh (1970) in grain and Prabhanjan Rao *et al*. (1973) in peas. The increased meristematic activity at the higher levels of nitrogen might have contributed to the increased response in terms of number of branches per plant.

Phosphorus application increased the number of branches per plant significantly at 40 kg $P_2O_5$/ha. Since phosphorus is a constituent of cell nucleus, it is closely associated with cell division and meristematic activity as shown by Bear (1965). Its application at higher levels might have contributed to higher rates of availability leading to an increase in the number of branches per plant. Similar results have been reported by Panda (1972).

Though the differences among levels of potash were not significant, there existed an increasing trend with regard to the number of branches per plant in response to the additional doses of potassium. The presence of higher amount of native potash in the soil might be the reason for lack of significant response to applied potash.

4. Total dry matter production at harvest

There was significant increase in dry matter yield of the plants in treatments receiving 20 kg N/ha

Dart *et al.* (1977) observed that nodulated plants showed a significant positive response in total dry weight with application of nitrogen. It can be seen that all the yield components are positively influenced by applied nitrogen. With regard to the 30 kg level, though the dry matter yield was significantly higher than that of the 10 kg level, it was inferior to the 20 kg level. The depression in dry matter production might be due to the negative effect of the higher amount of applied nitrogen on root nodulation, growth and yield attributes. Similar observations have been made by Slabko (1970), Gill *et al.*(1972), Panwar and Jain (1974) and Aathock (1975).

Plants depend on phosphorus near the roots in the early stages of its growth (Tisdale and Nelson, 1970). Application of fertilizer phosphorus may therefore be expected to result in increased availability of this nutrient. The high crop requirement at the early stages of growth coupled with the presence of easily available phosphorus in the soil might have resulted in increased response to this nutrient. It can be assumed that the initial favourable response to applied phosphorus continued till crop maturity leading to higher dry matter production. Increases in dry matter production have also been reported by Tyagim *et al*. (1972) in peas and Kesavan and Morachan (1973) in soybean.

Just like the other yield contributing characteristics, dry matter production also remained unaffected by the levels of applied potash.

5. Number of pods per plant

There was conspicuous and significant increase in the number of pods per plant at the 20 kg/ha level of nitrogen. Nitrogen at 30 kg/ha had a depressive effect on the mean number of pods when compared with 20 and 10 kg N/ha. This indicates that excessive amount of nitrogen has not contributed to the yield of pods but has only helped to increase the vegetative growth. Similar findings have been reported by Shukla (1964), Moolani and Jana (1965) in gram, Kurdikeri *et al*. (1973) in cowpea, Mclean *et al*. (1974) in fieldpeas, Chowdary *et al*.(1977) in groundnut and Sable and Khuspe (1977) in soybean.

Applied phosphorus increased number of pods per plant. Phosphate at 40 kg/ha was significantly superior to 30 and 20 kg/ha. An adequate supply of phosphorus early in the life of the plant is important in laying down the primordia for the reproductive parts. Phosphorus is also considered essential for the formation of fruits and seeds. The presence of easily available phosphorus seems to have stimulated the plant to produce more pods. The results of investigations conducted by Shukla (1964) in gram, Deshpande and Bathkal (1965) in green gram and Chowdary et al.(1977) in groundnut are in agreement with the above findings.

Potassium did not influence the mean number of pods significantly. The lack of response can be traced to the comparatively high status of potash in the soil.

The interactional effect of nitrogen and phosphorus on the number of pods per plant touched the level of statistical significance, when these nutrients were applied together, respectively, at 20 kg N and 40 kg $P_2O_5$/ha. A marked response to phosphorus was evident when nitrogen was applied at 20 kg/ha. But at the other level of nitrogen, the effect of phosphorus was not very conspicuous.

6. Number of seeds per pod

The effect of nitrogen was significant in increasing the number of seeds per pod with 20 kg N/ha excelling the other levels. The significant increase in the number of seeds per pod is attributed to the overall effect on the growth attributes. Singh (1970) in gram and Kurdikeri et al. (1973) in cowpea, also recorded similar observations.

It is evident from the results that phosphorus had significant influence on pod development. During the time of pod formation, nitrogen and phosphorus are translocated to the seeds which helps to increase seed setting. Increased number of seeds per pod was also observed by Sable and Khuspe (1977) in soybeans.

The number of seeds per pod was the maximum in the treatment receiving nitrogen at 20 kg/ha and phosphorus at 40 kg $P_2O_5$/ha. This treatment also produced the largest number of pods per plant. The conjunctive effect of nitrogen and phosphorus is clearly evident in the results.

Lack of response to potassium can be explained in terms of the high availability of potassium in the soil.

7. Length of pods

Nitrogen at 20 kg/ha resulted in a marked increase in the length of pods. This indicates that an adequate supply of nitrogen is important in increasing the length of pods. Corroboratory results have been reported by Kumar... *et al*. (1976) in soybean.

The length of pods was also influenced by applied phosphorus. The stimulatory effect of phosphorus on growth and seed setting might be the reason for the increase in pod length. Nair (1966) recorded increase in mean length of pods in cowpea by the application of phosphate at 55 kg/ha. Panda (1972) observed that length of pods increased with increasing levels of phosphorus in black gram.

Potassium did not influence the length of pods significantly. At 10 kg $K_2O$/ha, however, it tended to increase the effect of phosphorus. The maximum pod length was recorded by 40 kg $P_2O_5$/ha in the presence of 10 kg $K_2O$/ha.

8. <u>Hundred seed weight</u>

Though the differences were not significant statistically the hundred seed weight increased with increasing levels of applied nitrogen. Increases in test weight of grain as a consequence of nitrogen supply have been reported by Singh (1970) and Kurdikeri *et al*. (1973).

The increase in hundred seed weight obtained with the application of phosphorus is attributable to the effect of phosphorus on the plumpiness of seeds. This is in conformity with the results obtained by Nair (1966) in cowpea and Sable and Khuspe (1977) in soybean. Summerfield *et al*. (1976) observed that seed yields of nodulated cowpea plants were almost double those of non nodulated ones mainly through increases in mean seed weight and pod number. Similarly, in the present experiment, the favourable effect of applied phosphorus on root nodulation and the consequent increased availability of symbiotic nitrogen, might be the reasons for the increase in test weight of seeds.

Potassium did not influence hundred seed weight. Vijayakumar (1967) also did not observe significant influence for potassium on this character.

9. Yield of grain

It is evident from the Table 9 that nitrogen significantly increased the grain yield per hectare. The significant and marked increase in yield obtained in the experiment points to the fact that cowpea requires a reasonable amount of nitrogen for growth and production. As had been discussed earlier, significant positive response to applied nitrogen at 20 kg/ha was observed in all the growth characters and yield attributes.

Data on the above characters substantiate the positive response obtained in seed yield with increase in the level of nitrogen. The number of pods per plant, number of seeds per pod, length of pods and hundred seed weight were the maximum at 20 kg N/ha. The conjunctive effect of these attributes led to increased yields. Kumar _et al_. (1976) reported that pod yield in cowpea was intimately associated with the number of branches per plant, pods per plant, pod length, seeds per pod, and hundred seed weight. It can be observed that the cumulative effect of all these components had contributed to the higher grain yield. The number of nodules per plant was also the maximum at 20 kg N/ha. The crop might also have been benefitted by the nitrogen fixed in the root nodules. The study clearly indicates that addition of readily available nitrogen was beneficial to the crop as it promoted a good start before nitrogen fixation commenced. Similar observations were reported by Rama Rao and Patel (1975). The same pattern of response was observed in dry matter accumulation also. Increases in grain yield of legumes due to light dressings of nitrogen have been reported by Singh (1970), Prabhanjan Rao _et al_. (1973) and Sharma (1975) in gram, Battacharya (1971) in horsegram and KurMikeri _et al_.(1973) in cowpea.

The reduction in yield at higher doses of nitrogen might be attributed to the excessive vegetative growth leading to lower grain production. Similar depression in yield at higher levels of applied nitrogen has been noted by Sharma (1968) in peas and Tesman (1977) in soybean.

El Baradi (1975) reviewed the literature on cowpea and concluded that application of small amounts of readily available nitrogen at planting was necessary to stimulate nitrogen fixation.

The increase in grain yield obtained with the application of phosphorus might be attributed to the beneficial effect of phosphorus on root development, flower primordia initiation, stimulation of growth and formation and maturity of seeds. Phosphorus increased the number of pods, length of pods, number of seeds per pod and hundred seed weight. Moreover, phosphorus might have stimulated the rhizobial action in the root nodules leading to a larger fixation of atmospheric nitrogen (Mercer, 1948). Phosphorus might have also helped in the uptake of nitrogen and other nutrients from the soil (Robert and Olsen 1944). Corroboratory results have been obtained by Nair (1966), Rajendra Prasad *et al.* (1968), Gill *et al.* (1972) and Baumgartner *et al.* (1974) Chesney (1974) reported that in cowpea yield was significantly increased by phosphorus dressing and the response to phosphorus was linear.

The treatment combination of 20 kg N and 40 kg $P_2O_5$/ha registered the highest grain yield of 706.63 kg/ha. The synergetic influence of nitrogen and phosphorus is evident in the number of pods per plant and the number of seeds per pod also.

However, quite contrary to the effect of nitrogen and phosphorus, applied potassium failed to exert marked influence on the yield of grain. Similar results have been reported by Puntamkar and Bathkal (1967) in groundnut and Hamissa *et al*. (1975) in beans. The lack of response to application of potassium might be due to the higher amount of available potassium in the soil.

10. Haulm yield

The application of nitrogen resulted in significant increase in the yield of haulm (Table 9). The role of nitrogen in the promotion of vegetative growth is well known. A perusal of data on plant height (Table 2) and number of branches per plant (Table 4) indicate that there has been significant improvement in these growth attributes due to addition of nitrogen at all the stages of observation. The excessive vegetative growth even at the expense of grain production would have resulted in higher yield of haulm. This is in conformity with the findings of Nair (1966) and Vijayakumar (1967) in cowpea.

The response to phosphorus was not as conspicuous as that of nitrogen. A comparison of the data on the effect of phosphorus on plant height would reveal that this nutrient had only marginal influence on the vegetative growth. Garg _et al_.(1971 b) obtained similar results on fodder cowpea and Kesavan and Morachan (1973) in soybean.

Application of potash did not have any significant influence on the yield of haulm. As had been discussed earlier lack of consistent and significant response to fertilizer potassium on growth and yield is attributable to the fairly high potassium content of the soil, which could probably meet the crop requirement of the nutrient.

The maximum yield of haulm was recorded at 30 kg $P_2O_5$/ha in the absence of applied potash. Addition of potash, tended to depress the production of haulm at this level of phosphorus. At the higher level of phosphorus (40 kg $P_2O_5$/ha) on the other hand, potash increased the yield of haulm in a linear order.

11. <u>Grain-haulm ratio</u>

The lowest mean ratio was recorded at 30 kg N/ha (Table 9). The maximum value noted at the 20 kg level, points to the fact that the magnitude of contribution of applied nitrogen to seed production was more than that for vegetative growth at this level. The depression at higher level might be due to the increased vegetative growth which adversely affected seed production.

While applied phosphorus influenced the grain-haulm ratio through its favourable effect on the growth and yield components of the plant, potassium failed to show marked effect on the ratio.

The treatment receiving 20 kg N and 40 kg $P_2O_5$/ha registered the highest grain-haulm ratio of 2.34; possibly due to their synergetic effect on the yield of grain. The interactional effects were not statistically significant at the other treatment combinations.

12. <u>Optimum doses of nutrients</u>

The optimum level of nitrogen for maximum yield was arrived at 21.6 kg/ha from the quadratic surface response equation. For phosphorus, optimization of yield was not possible since the yield tended to increase with the increasing levels of applied phosphorus.

The economic optimum in respect of nitrogen can be fixed at 21.5 kg/ha (Table 14). As there is linear response to phosphorus its economic optimum fall outside the range tried. Further experimentation is required for attaining the economic dose of phosphate. However, within the range tried, 40 kg $P_2O_5$/ha can be taken as the optimum as well as the economic dosage.

## 13.0. Effect of nitrogen, phosphorus and potassium on the plant content of nitrogen, phosphorus and potassium at various stages of growth and their content in grain

### 13.1.0. Nitrogen content of plants at various stages of growth

The results presented in Table 15 show that nitrogen application had significant influence on the percentage of nitrogen in plants. Increase in nitrogen content consequent to nitrogen supply had been reported by Brevedan *et al*.(1977) in soybean, Bains (1967) in fieldpeas and Panwar and Jain (1974) in berseem. The significant reduction of nitrogen content due to lower level of nitrogen application might be due to the low availability and uptake of this nutrient. A decrease in nitrogen content could be noticed with the advance in the growth of the plant. The higher nitrogen content noticed in the early stage of growth might be attributed to the high meristematic activity at that time. This is in conformity with the findings of Puntamkar and Bathkal (1967).

Phosphate application did not influence the nitrogen content in plants. Similar results have been reported by Sundaram *et al*. (1973) in Lucerne.

13.1.1. Nitrogen content in grain

The significant increase in nitrogen content observed at 20 and 30 kg N/ha is attributable to the larger uptake of nitrogen from nitrogen treated plots. Enikov (1976) found that in chickpea increasing nitrogen rates increased the nitrogen content of seeds. The proportionately lower amount of nitrogen noticed in seeds at 10 kg N/ha might be due to the shortage of this element at the time of pod formation.

13.2.0. Phosphorus content of plants at various stages of growth

The higher levels of applied nitrogen at 30 days after sowing reduced the phosphorus content of plants. Similar depression in phosphorus content was also observed by Enikov (1976) with increasing levels of nitrogen in chickpea. At the later stages of growth the effect was, however, less pronounced.

The increase in phosphorus content with applied phosphate at 30 days after sowing might be through the increased availability of this nutrient in soil. Increases in phosphorus content with applied phosphatic fertilizers were also reported by Bains (1967), Parodi *et al*. (1977) and Aulakh and Pasricha (1977).

13.2.1. Phosphorus content in grain

The different levels of nitrogen, phosphorus and potassium did not produce any significant influence on phosphorus content of grain.

13.3.0. Potassium content of plants at various stages of growth

Potassium content of the plant tissues at 30 and 70 days after sowing was significantly influenced by levels of potassium tried. This might due to the higher content of available potash in the medium resulting in higher uptake. Similar results were obtained by Puntamkar and Bathkal (1967) and Bains (1967).

13.3.1. Potassium content in grain

Potassium content in grain was significantly influenced by levels of potash tried. Increases in potassium content in grain with applied potassic fertilisers were also reported by Bains (1967) and Puntamkar and Bathkal (1967).

The levels of applied nitrogen and phosphorus had no appreciable influence on the potassium content of grain.

14. Uptake of nitrogen at harvest

The uptake of nitrogen was maximum at 20 kg N/ha. The production of dry matter and yield was also highest at this dose of nitrogen. The significantly higher uptake of nitrogen at 20 kg/ha level suggests that the crop requires a reasonably good amount of nitrogen for proper development and that 10 kg/ha is an insufficient dose to support plant growth and production. The lack of response at the higher level tried, suggests that the crop requirement is met at the 20 kg/ha level of applied nitrogen along with the symbiotically fixed nitrogen. Further increase in the quantity of fertilizer nitrogen does not bring about beneficial effects in terms of yield. Similar results were obtained by Panwar and Jain (1974) and Enikov (1976).

The effect of phosphorus was found to be significant on the uptake of nitrogen. The same influence of phosphorus was noted in the case of vegetative characters like height of the plant, number of nodules and total dry matter production. This influence of phosphorus promoted the uptake of nitrogen at its higher level of application and was minimum at its lower level. The beneficial effects of higher levels of phosphorus in increasing the uptake of nitrogen have been reported by Singh et al. (1971) and Garg (1971 a).

Effect of potassium on the uptake of nitrogen was not significant.

15. Uptake of phosphorus by plants at harvest

From the data (Table 18) it is seen that nitrogen significantly influenced the total uptake of phosphorus. The reasons for increased uptake of phosphorus by nitrogen application could be mainly twofold. Nitrogen applied at 20 kg/ha, promoted not only the shoot growth, but proliferation of roots also. The increase in root growth might have enhanced absorption of nutrients. Another probable reason is the synergetic effect of nitrogen-phosphorus interaction which augmented the absorption of phosphorus in plants. Increased uptake of phosphorus with increasing levels of applied phosphorus was reported by Sharma and Yadav (1976) in gram and

Parodi *et al.*(1977) in beans. Phosphorus uptake was favourably influenced by the combined application of nitrogen at 20 kg/ha and phosphorus at 40 kg $P_2O_5$/ha. Corroboratory results were obtained by Ezedinma (1965).

The lack of response to potassium suggests the adequacy of soil supplies of this element to support plant growth.

16. Uptake of potassium

Nitrogen at 20 kg/ha significantly influenced the total uptake of potassium at harvest. As discussed earlier, this might be due to enhanced crop growth.

The effect of phosphorus was not significant statistically. The applied potash also did not exert any significant effect on the uptake of nutrient potassium.

17. Protein content of seeds

The effect of nitrogen in increasing the protein content of seeds was significant at all the levels of its application. The increase in content of organic nitrogen compounds in plant cells as a result of increased rate of nitrogen supply has been the general pattern of reported experimental works. John (1949) and Majumdar and Singh (1964) also observed such increase in the protein content of seeds with increasing levels of applied nitrogen. The superiority of higher levels of nitrogen in increasing the protein content of cowpea has been reported by Sharma and Singh (1973), Gill et al. (1972) and Mclean et al. (1974).

Effect of phosphorus and potassium in protein content was not significant.

# SUMMARY

## SUMMARY

A field experiment was conducted at the Instructional Farm attached to the College of Horticulture, Vellanikkara during the period from August to October 1977 to study the effect of graded doses of nitrogen, phosphorus and potassium on the growth and yield of cowpea, variety P.118. The treatments comprised of three levels each of nitrogen (10, 20 and 30 kg N/ha), phosphorus (20, 30 and 40 kg $P_2O_5$/ha) and potassium (0, 10 and 20 kg $K_2O$/ha). The experiment was laid out in a $3^3$ confounded factorial design confounding N $P^2K$ and N $P^2K^2$ in replications I and II respectively. The findings are summarised below.

1. Incremental doses of nitrogen increased the height of the plants at all the growth stages, but phosphorus did not produce any significant effect on this character. A significant linear increase in the height of the plants was obtained with incremental doses of potassium also, at the 30th day after sowing.

2. Application of nitrogen at 30 kg/ha and phosphorus at 40 kg $P_2O_5$/ha increased significantly the number of branches at the 50th day after sowing.

3. Nitrogen at 20 kg/ha registered the maximum number of nodules per plant at the 50th day and the 70th day after sowing. Applied phosphorus at 40 kg/ha produced the maximum number of nodules at the 50th and 70th day after sowing. Potassium exerted no appreciable effect on nodulation.

4. Nitrogen at 20 kg/ha and $P_2O_5$ at 40 kg/ha produced the maximum amount of dry matter at harvest.

5. Nitrogen at 20 kg/ha and $P_2O_5$ at 40 kg/ha significantly increased the number of pods per plant, the number of seeds per pod and the length of pods. Applied $P_2O_5$ at 40 kg/ha also increased the test weight of seeds significantly.

6. Nitrogen at 20 kg/ha and $P_2O_5$ at 40 kg/ha increased the grain yield significantly. The direct and combined effects of these nutrients at the above levels were significant.

7. Incremental doses of nitrogen increased the yield of haulm.

8. Nitrogen tended to depress the grain-haulm ratio at the higher level while phosphorus significantly increased the grain-haulm ratio at 40 kg $P_2O_5$/ha.

9. Nitrogen at 21.6 kg/ha was found to be the optimum level for maximum production of grain.

10. The optimum level of phosphorus could not be estimated since the crop exhibited a linear response beyond the maximum level tried.

11. Nitrogen application increased the nitrogen content of plants at all the stages.

12. The nitrogen content of grain was significantly influenced by the application of nitrogen.

13. Incremental doses of nitrogen significantly depressed the phosphorus content of plants at the 30th day after sowing. Though the differences were not significant the highest phosphorus content was observed at 10 kg N/ha at the 50th day after sowing. Graded doses of phosphorus increased its plant content at all the stages of observations though difference was significant only at the 30th day after sowing.

14. Phosphorus content of grain was not significantly influenced by any of the three nutrients tried.

15. Application of potassium increased the potassium content of plants at all the stages of observation. However, the difference was not significant at 50th day after sowing.

16. Potassium content of grain was maximum at 10 kg $K_2O$/ha.

17. Nitrogen uptake was significantly increased by the application of nitrogen at 20 kg/ha and $P_2O_5$ at 40 kg/ha.

18. Nitrogen at 20 and 30 kg/ha significantly increased the phosphorus uptake by plants. Incremental doses of phosphorus also increased the phosphorus uptake.

19. Nitrogen at 20 kg/ha significantly increased the uptake of potassium.

20. Graded doses of nitrogen markedly enhanced the protein content of grain while neither phosphorus nor potassium, nor their interactions with nitrogen had appreciable influence on the protein content.

21. Applied potassium did not exhibit any significant influence on the yield components and most of the growth attributes indicating the adequacy of soil supplies of the nutrient.

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# APPENDIX I

## Weather data (weekly averages) from 30th July to 28th Oct.1977

| Date | | | Weeks | Temp.°C | | Relative humidity | Total rain-fall mm. | Number of rainy days | Number of hours of bright sunshine |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Max. | Min. | | | | |
| July 30 | - | Aug. 5 | 1 | 29.9 | 23.9 | 94 | 52.5 | 6 | 2.1 |
| Aug.6 | - | Aug.12 | 2 | 30.1 | 23.6 | 93 | 40.5 | 6 | 2.2 |
| Aug.13 | - | Aug.19 | 3 | 30.3 | 24.2 | 92 | 7.3 | 2 | 2.6 |
| Aug.20 | - | Aug.26 | 4 | 29.6 | 23.7 | 94 | 69.6 | 7 | 1.2 |
| Aug.27 | - | Sept.2 | 5 | 29.4 | 22.9 | 95 | 93.9 | 5 | 1.1 |
| Sept.3 | - | Sept.9 | 6 | 29.9 | 23.1 | 94 | 107.5 | 7 | 2.4 |
| Sept.10 | - | Sept.16 | 7 | 30.3 | 23.7 | 94 | 221.0 | 5 | 4.2 |
| Sept.17 | - | Sept.23 | 8 | 31.2 | 24.0 | 91 | 2.1 | 1 | 5.2 |
| Sept.24 | - | Sept.30 | 9 | 31.6 | 24.0 | 89 | 1.0 | 1 | 2.9 |
| Oct.1 | - | Oct.7 | 10 | 31.7 | 23.2 | 91 | 15.7 | 4 | 5.3 |
| Oct.8 | - | Oct.14 | 11 | 32.2 | 24.1 | 89 | 20.5 | 5 | 5.3 |
| Oct.15 | - | Oct.21 | 12 | 31.5 | 23.5 | 91 | 271.0 | 6 | 3.8 |
| Oct.22 | - | Oct.28 | 13 | 29.3 | 23.3 | 90 | 82.7 | 7 | 2.7 |

## APPENDIX II

### Analyses of variance for growth components

| Source | Mean squares | | | | |
|---|---|---|---|---|---|
| | D.F. | Height of plants in cm | | | Number of branches at 50 days after sowing |
| | | 30 days after sowing | 50 days after sowing | 70 days after sowing | |
| Block | 5 | 39.70** | 123.77 | 110.96 | 0.53 |
| N | 2 | 6.28 | 898.32** | 3438.51** | 1.19* |
| P | 2 | 4.11 | 17.70 | 186.52 | 1.33* |
| N P | 4 | 3.59 | 60.40 | 26.46 | 0.19 |
| K | 2 | 21.28* | 9.07 | 30.61 | 0.48 |
| N K | 4 | 5.76 | 41.59 | 190.73 | 0.20 |
| P K | 4 | 3.48 | 189.73 | 39.04 | 0.29 |
| N P K | 2 | 0.99 | 45.39 | 14.77 | 0.23 |
| $N P^2 K$ | 2 | 5.35 | 84.64 | 237.05 | 0.16 |
| $N P K^2$ | 2 | 3.47 | 119.41 | 116.44 | 0.05 |
| $N P^2 K^2$ | 2 | 1.50 | 34.37 | 110.78 | 0.04 |
| Error | 22 | 4.20 | 124.15 | 111.51 | 0.25 |

* significant at 5 per cent
** significant at 1 per cent

## APPENDIX III

**Analyses of variance for growth components (continued)**

| Source | D.F. | Mean squares | | | |
|---|---|---|---|---|---|
| | | Number of nodules | | | Dry matter accumulation at harvest ($g/m^2$) |
| | | 30 days after sowing | 50 days after sowing | 70 days after sowing | |
| Block | 5 | 108.830 | 258.680** | 67.897* | 1862.184** |
| N | 2 | 190.685* | 57.585 | 101.362* | 3205.922** |
| P | 2 | 223.780* | 44.810 | 70.041* | 979.032** |
| N P | 4 | 110.840 | 44.018 | 19.489 | 344.487 |
| K | 2 | 12.280 | 156.360* | 76.531* | 64.338 |
| N K | 4 | 124.090 | 16.318 | 6.456 | 58.763 |
| P K | 4 | 89.633 | 8.138 | 18.330 | 332.518 |
| N P K | 2 | 89.330 | 4.850 | 28.290 | 27.345 |
| $N P^2 K$ | 2 | 436.030** | 23.025 | 24.600 | 21.436 |
| $N P K^2$ | 2 | 138.730 | 45.970 | 10.172 | 35.299 |
| $N P^2 K^2$ | 2 | 14.035 | 9.255 | 8.512 | 10.363 |
| Error | 22 | 53.395 | 32.171 | 18.874 | 149.483 |

* significant at 5 per cent
** significant at 1 per cent

# APPENDIX IV

## Analyses of variance for yield components and protein contents of grain

| Source | D.F. | Mean squares | | | | |
|---|---|---|---|---|---|---|
| | | Number of pods per plant | Number of seeds per pod | Length of pods in cm | Hundred grain weight | Protein content of grain per cent |
| Block | 5 | 3.48 | 2.07* | 0.98 | 0.990 | 10.020 |
| N | 2 | 11.20* | 15.68** | 6.85** | 0.680 | 207.310** |
| P | 2 | 13.48* | 4.95** | 4.79** | 2.160* | 1.420 |
| R-linear | 1 | | | | | |
| N P | 4 | 12.64* | 2.97* | 0.78 | 0.968 | 9.475 |
| K | 2 | 1.03 | 0.61 | 0.03 | 0.585 | 7.180 |
| N K | 4 | 3.19 | 1.20 | 0.46 | 0.408 | 23.143 |
| P K | 4 | 6.09 | 1.54 | 1.61* | 0.250 | 9.230 |
| N P K | 2 | 4.04 | 2.40 | 0.38 | 0.545 | 1.075 |
| $N P^2 K$ | 2 | 3.96 | 0.09 | 0.11 | 1.160* | 20.170 |
| $N P K^2$ | 2 | 6.31 | 0.52 | 0.65 | 0.140 | 1.111 |
| $N P^2 K^2$ | 2 | 1.85 | 0.54 | 0.10 | 0.480 | 30.035 |
| Error | 22 | 2.68 | 0.76 | 0.46 | 0.379 | 9.342 |

* significant at 5 per cent
** significant at 1 per cent

## APPENDIX V

### Analyses of variance for yield

| Source | D.F. | Mean squares | | |
|---|---|---|---|---|
| | | Yield kg/ha | | Grain-haulm ratio |
| | | Grain | Haulm | |
| Block | 5 | 66352.93** | 26935.37** | 0.244 |
| N | 2 | 135249.16** | 63373.66** | 1.205** |
| P | 2 | 89834.55** | 14601.66 | 1.516** |
| P.linear | 1 | 162521.80** | -- | -- |
| P.quadratic | 1 | 17147.30 | -- | -- |
| N P | 4 | 25725.00* | 4763.86 | 0.575* |
| K | 2 | 2029.51 | 3188.70 | 0.097 |
| N K | 4 | 1584.87 | 2002.49 | 0.171 |
| P K | 4 | 4262.37 | 14550.74* | 0.293 |
| N P K | 2 | 4824.49 | 8374.04 | 0.441 |
| N $P^2$K | 2 | 1563.46 | 11569.74 | 0.457 |
| N P $K^2$ | 2 | 725.93 | 1946.82 | 0.043 |
| N $P^2K^2$ | 2 | 37.21 | 5178.81 | 0.341 |
| Error | 22 | 5842.83 | 5052.40 | 0.157 |

* significant at 5 per cent
** significant at 1 per cent

# APPENDIX VI

## Analyses of variance for nitrogen contents of plant tissues at various stages of growth and in grain

| Source | D.F. | Mean square | | | |
|---|---|---|---|---|---|
| | | Nitrogen content (per cent) | | | |
| | | 30 days after sowing | 50 days after sowing | 70 days after sowing | Grains |
| Block | 5 | 0.104 | 0.202 | 0.128 | 0.26 |
| N | 2 | 0.840** | 0.182 | 0.917** | 5.31** |
| P | 2 | 0.015 | 0.140 | 0.215 | 0.04 |
| N P | 4 | 0.095 | 0.057 | 0.046 | 0.24 |
| K | 2 | 0.070 | 0.033 | 0.298 | 0.18 |
| N K | 4 | 0.035 | 0.347 | 0.143 | 0.61 |
| P K | 4 | 0.380 | 0.200 | 0.436 | 0.24 |
| N P K | 2 | 0.065 | 0.394 | 0.041 | 0.03 |
| $N^2$P K | 2 | 0.165 | 0.208 | 0.633** | 0.52 |
| N P $K^2$ | 2 | 0.310 | 0.095 | 0.139 | 0.03 |
| N $P^2K^2$ | 2 | 0.050 | 0.149 | 0.055 | 0.77 |
| Error | 22 | 0.105 | 0.208 | 0.098 | 0.23 |

* significant at 5 per cent
** significant at 1 per cent

## APPENDIX VII

**Analyses of variance for phosphorus content of plant tissues at various stages of growth and in grain**

| Source | D.F. | Mean squares: Phosphorus content (per cent) — 30 days after sowing | 50 days after sowing | 70 days after sowing | Grain |
|---|---|---|---|---|---|
| Block | 5 | 0.0031* | 0.00190 | 0.0017 | 0.0005 |
| N | 2 | 0.0017* | 0.00045 | 0.0035 | 0.0008 |
| P | 2 | 0.0024* | 0.00075 | 0.0005 | 0.0006 |
| N P | 4 | 0.0003 | 0.00150 | 0.0025 | 0.0001 |
| K | 2 | 0.0005 | 0.00050 | 0.0020 | 0.0003 |
| N K | 4 | 0.0008 | 0.00070 | 0.0041 | 0.0007 |
| P K | 4 | 0.0024 | 0.00100 | 0.0011 | 0.0009 |
| N P K | 2 | 0.000005 | 0.00070 | 0.0006 | 0.0004 |
| $N^2P$ K | 2 | 0.0002 | 0.00020 | 0.0021 | 0.0010 |
| N P $K^2$ | 2 | 0.0013 | 0.00311 | 0.0035 | 0.0002 |
| N $P^2K^2$ | 2 | 0.0011 | 0.00070 | 0.0026 | 0.0008 |
| Error | 22 | 0.00049 | 0.00120 | 0.0018 | 0.00075 |

* significant at 5 per cent
** significant at 1 per cent

## APPENDIX VIII

**Analyses of variance for potassium contents of plant tissues at various stages of growth and grain.**

| Source | D.F. | Mean square | | | |
|---|---|---|---|---|---|
| | | Potassium contents (per cent) | | | |
| | | 30 days after sowing | 50 days after sowing | 70 days after sowing | Grain |
| Block | 5 | 0.078 | 0.0374 | 0.1042** | 0.0032* |
| N | 2 | 0.205 | 0.0330 | 0.0045 | 0.0023 |
| P | 2 | 0.115 | 0.0740 | 0.0189 | 0.0004 |
| N P | 4 | 0.133 | 0.0155 | 0.0135 | 0.0027 |
| K | 2 | 1.465** | 0.1141 | 0.0750* | 0.0066** |
| N K | 4 | 0.015 | 0.0311 | 0.0377 | 0.0005 |
| P K | 4 | 0.038 | 0.0038 | 0.0043 | 0.0018 |
| N P K | 2 | 0.170 | 0.0110 | 0.0509 | 0.0008 |
| $N^2$ P K | 2 | 0.025 | 0.0155 | 0.0389 | 0.0001 |
| N P $K^2$ | 2 | 0.0002 | 0.0025 | 0.0079 | 0.0000 |
| N $P^2K^2$ | 2 | 0.120 | 0.0441 | 0.0198 | 0.0022 |
| Error | 22 | 0.0128 | 0.0380 | 0.0148 | 0.0011 |

* significant at 5 per cent
** significant at 1 per cent

## APPENDIX IX

**Analyses of variance for uptake of nitrogen, phosphorus and potassium at harvest**

| Source | D.F. | Mean square | | |
|---|---|---|---|---|
| | | Nitrogen uptake kg/ha | Phosphorus uptake kg/ha | Potassium uptake kg/ha |
| Block | 5 | 117.686** | 2.45** | 11.197 |
| N | 2 | 441.780** | 6.011** | 57.479** |
| P | 2 | 139.898** | 1.842* | 19.678 |
| N P | 4 | 36.081 | 1.018 | 9.924 |
| K | 2 | 29.113 | 0.456 | 10.033 |
| N K | 4 | 13.785 | 0.234 | 0.754 |
| P K | 4 | 37.827 | 0.627 | 5.180 |
| N P K | 2 | 11.393 | 0.154 | 4.537 |
| N $P^2$K | 2 | 55.097 | 0.286 | 3.072 |
| N P $K^2$ | 2 | 13.869 | 0.102 | 2.346 |
| N $P^2K^2$ | 2 | 3.317 | 0.344 | 2.558 |
| Error | 22 | 17.863 | 0.339 | 5.816 |

* significant at 5 per cent
** significant at 1 per cent

# EFFECT OF DIFFERENT LEVELS OF NITROGEN, PHOSPHORUS AND POTASSIUM ON GROWTH AND YIELD OF COWPEA, (*Vigna sinensis* SAVI) VARIETY P. 118


By

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## ABSTRACT OF A THESIS

Submitted in partial fulfilment

of the requirement for the degree

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COLLEGE OF HORTICULTURE, VELLANIKKARA – TRICHUR



1978

ABSTRACT

An experiment was conducted at the Instructional Farm, Vellanikkara during the second crop season of 1977 to study for effect of different levels of nitrogen, phosphorus and potassium on the growth and yield of cowpea, variety P.118.

The experiment was laid out in a $3^3$ confounded factorial design confounding $N P^2K$ and $N P^2K^2$ in replications I and II, respectively.

The study revealed that plant height increased with incremental doses of nitrogen. Nitrogen at 20 kg/ha level contributed to increased nodulation which in turn favourably increased the grain yield. Phosphorus also had significant positive effect on nodulation. Nitrogen at 20 kg/ha and phosphorus at 40 kg $P_2O_5$/ha exerted a significant positive influence on the total dry matter production of the crop at harvest.

Through their increased response in terms of number of pods per plant, number of seeds per pod and length of pods, nitrogen, at 20 kg/ha and $P_2O_5$ at 40 kg/ha increased the grain yield per hectare significantly. Application of nitrogen at 30 kg/ha registered the maximum haulm yield.

The grain-haulm ratio was maximum for the combination of 20 kg nitrogen and 40 kg $P_2O_5$/ha.

Nitrogen at 21.6 kg/ha was found to be the optimum level for maximum grain production. The optimum level of phosphorus could not be estimated since the crop exhibited a linear response beyond the maximum level tried.

Nitrogen application increased the plant content as well as the grain content of the element. Similarly application of phosphorus and potassium increased the plant contents of phosphorus and potassium, respectively.

The uptake by nitrogen and phosphorus was significantly influenced by the 20 kg N/ha and 40 kg $P_2O_5$/ha.

The protein content of grain increased with increasing levels of nitrogen.

Applied potassium did not exhibit any significant influence on the yield components and most of the growth attributes.