INFLUENCE OF THE METHOD OF APPLICATION OF N AND P ON THE GROWTH, YIELD AND QUALITY OF BLACKGRAM [*Vigna mungo* (L.) *Hepper*]

BY

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THESIS

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1983

DECLARATION

I hereby declare that this thesis entitled "Influence of the method of application of N and P on the growth, yield and quality of blackgram (*Vigna mungo* (L.) Hepper)" 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 any degree, diploma, associateship, fellowship or other similar title at any other University or Society.

Vellayani,
11th March, 1983.

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CERTIFICATE

Certified that this thesis, entitled "Influence of the method of application of N and P on the growth, yield and quality of blackgram (Vigna Mungo (L.) Hepper)" is a record of research work done independently by Smt.ELIZABETH K.SYRIAC under my guidence and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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Introduction

INTRODUCTION

Pulses are the most suitable crops for cultivation under drought conditions as they have the unique capacity to grow well under such situations by virtue of their efficient, deep root system. The role of legumes in the recuperation of soil fertility is universally recognised. Inclusion of legumes in every known system of farming all over the world bears testimony to this fact.

The production of pulses in India during 1980-81, a good weather year, is only 10.16 mill. tonnes which is far below the requirement in the country. The answer to achieving a higher level of pulse production lies in increasing the yield per unit area per unit time through the adoption of a higher level of agricultural technology. Due to the rise in the price of fertilizers, increasing fertilizer use efficiency to maximise the return per unit of fertilizer is of paramount importance in India. A modest increase in fertilizer use efficiency by 10-15 percent can mean a considerable saving in fertilizer bill and favourable output/input ratio to the farmer. More recently, fertilization of legumes with phosphorus and/or nitrogen has made great contribution to the technology of crop production.

Blackgram (Vigna mungo (L) Hepper) is a very important pulse crop as it forms an essential component of the vegetarian diet in India. The importance of blackgram to our agriculture also stems from the fact that it has a high digestibility co-efficient of 70-91 percent (Patwardhan, 1912) and has a protein content of 23 percent. But the total acrage and production of this pulse in a year is only about 2 million hectares and 0.7 million tonnes respectively with an average yield ranging from 350-850 kg. per hectare.

To achieve a substantially high yield of this pulse crop, considerable research efforts are to be made to evolve situation specific fertilizer management practices like identification of soils where specific fertilizer materials will be most suitable, manipulation of application technique, balanced application for synergestic interactions etc.

Although legumes symbiotically fix nitrogen, it has been recognised that application of a small quantity of nitrogen enhances early vegetative growth (Dart et al 1977). Also the leaves are known to serve as a nitrogen reservoir for developing seeds when the nitrogen uptake by roots declines during reproductive growth when the symbiotic nitrogen fixation activity is rapidly decreasing (Sinclair and De Wit, 1975). So the leaves should be supplied with enough nitrogen at flowering so as to enable them to translocate enough nitrogen to the developing pods. Moreover, applying the entire quantity of nitrogen through the soil in a single dose is not a feasible practice as it is associated with a low production efficiency of the fertilizer used. Even split application through soil at different growth stages is not advisable in dry lands since the moisture content in the soil is insufficient for its complete absorption. So experiments must be conducted to find out the feasibility of foliar application of nitrogen to legumes at different growth stages.

Legumes are known to make high demands of phosphorus for the production of several enzymes of which phosphorus is an important constituent. But phosphorus is readily fixed in most of the soils and recovery is relatively low. (Dean, 1956). During flowering and fruit development stages of many crops the supply of phosphorus is inadequate in most of the soils and this may seriously reduce crop yields (Skinner and Purvis, 1949). Also the short duration of the crop makes it impossible to completely utilize the fertilizer phosphorus supplied through soil.

It has been well established that the fertilizer elements that are absorbed through roots can be well absorbed through the foliage (Rajat De, 1969). According to Wittwer <u>et al</u> (1963). "Once a crop's primary needs have been met through soil application, foliar fertilization can possibly play a supplementary role during critical stress periods when plants, for a variety of reasons cannot absorb enough nutrients through the roots".

But so far, no attempts have been made to find out the relative efficiency of soil and foliar application of nitrogen and phosphorus to blackgram. So the present study was undertaken with the following objectives:

1. To evaluate the comparative efficiency of soil and foliar application of N,P. and their combinations on the growth, yield and quality of blackgram.
2. To workout the cost benefit ratio as influenced by different methods of fertilizer application.
3. To assess the possible extent of fertilizer saving.

Review of literature

2. REVIEW OF LITERATURE

An investigation was conducted to assess the effect of N, P and their combinations applied in the soil and through the foliage at critical stages on the growth, yield and quality of blackgram. A review of research work done on the related aspects of blackgram and other legumes are given in the following pages.

A. NITROGEN.

i) Effect of nitrogen on growth and growth characters:

a. Soil application:-

Shukla (1964) reported that in bengalgram (*Cicer arietinum* L.) the vegetative growth of plant was stimulated very much by the application of nitrogen.

Singh (1970) observed little stimulatory effect on the growth of bengal gram (*Cicer arietinum*) plants by the application of nitrogen.

From identical growth chamber experiments with *Pisum arvense* and *Pisum sativum*, Rinno *et al* (1973) noticed that single nitrogen application at the onset of flowering significantly increased aerial yields of P.*arvense* and P.*sativum*.

Huxley *et al* (1976) reported that application of mineral nitrogen (20 and 179 ppm) to both inoculated and uninoculated soya bean increased vegetative growth and dry matter content.

Bhangoo and Albrittan ~~et al~~ (1976) noted that grain and vegetative matter yield of Lee Soybean isolines increased significantly due to applied nitrogen.

From an investigation conducted by Sij *et al* (1979) on Soybean cv. Bragg, it was found that 'starter' N did not significantly influence leaf area, plant height or fresh weight of soybean plants. Enough N was apparently available from cotyledons, rainfall, soil and nodule to allow maximum vegetative development during the initial seven weeks of growth.

Rabie *et al* (1979) based on their studies on soybean concluded that nitrogen applied to the surface and mixed with the soil increased the dry weight of plants.

It was shown by Richards and Soper (1979) that aerial yields of *Vicia faba* was not affected by nitrogen fertilizers upto 600 mg N/pot applied at seeding, by 300 mg N per pot applied in four 75 mg portions nor by single mid season application of 300 mg N per pot. Only the highest rate of nitrogen, employed, ie, 900 mg N/pot, at seeding significantly increased faba bean yield, the increase being 13.2 percent.

Haystead *et al* (1980) found that 10 percent more of carbon fixed per day was available for growth in white clover plants supplied with combined nitrogen. The rate of root growth and shoot growth were greater in the plants supplied with a moderate level of combined nitrogen.

According to Maag and Nosberger (1980) providing nitrate nitrogen to *Trifolium pratens* enhanced shoot growth, reduced root weight/total dry weight ratio, shortened the time until the onset of lateral shoot growth and increased the leaf area of individual leaves.

Minchin *et al* (1981) had shown that providing inorganic nitrogen to nodulated cowpea resulted in more leafy plants.

b. Foliar application:-

Varma and Rao (1974) reported that foliar application of 2.5 and 5 percent solutions of urea to 15 and 30 days old *Phaseolus aureus* (*Vigna radiata*) seedlings inoculated with an efficient strain of rhizobium, reduced plant growth.

Patra (1974) from an investigation on the response of ground nut to foliar application of urea at pegging stage reported that spraying of urea had no effect on the growth of plants because normally growth rate beyond the stage at which urea was applied gradually declines.

Rabie *et al* (1978) observed that 20 cm^3 of 1 percent urea solution applied as a foliar spray to 18 day old soybean plants increased the drymatter accumulation.

ii) Effect of nitrogen on yield and yield attributes:

a. Soil application:-

Norman and Krampitz (1945) found that in soybean increased yields and higher total nitrogen contents resulted from the application of mineral nitrogen.

Singh (1970) observed marked increase in the seed yield of gram (*Cicer arietinum*) by the application of 22.5 kg.N/ha.

In soybean (*Glycine max*.L) application of nitrogen at the rate of 85 Kg/ha either at the time of planting or at flowering gave the highest seed yield. (Ghorashy *et al* 1971).

Venugopalan and Morachan (1974) observed no significant increase in the seed yield of green gram by the application of nitrogen.

Summerfield (1975) found an increased seed yield in cowpea cv. Prima due to an increase in the number of pods per plant and average seed weight by the application of inorganic nitrogen.

Huxley *et al* (1976) noticed that the seed yields of soybean was only slightly increased by mineral nitrogen application (179 ppm N).

An experiment conducted by Samokhunalov and Panin (1976) on nitrogen nutrition of pea showed that fertilizer nitrogen applied to meet 25 to 50 percent of the nitrogen requirement for pea markedly increased seed yields.

Penk (1977) observed an increase in seed yields, seed N content and seed oil content and oil yield of soybean by the supply of nitrogenous fertilizers.

The highest seed yields in cowpea was obtained by the application of 67 percent of N at sowing or 20 days after sowing and 33 percent at flowering. (Haque and Gbla 1978).

From trials conducted on soybean Sorensen et al and Pens (1978) obtained variable results on soybean yields by nitrogen fertilization. Seed yield, plant N content and seed size were generally lineraly related to rate of N application.

Brevedan et al (1978) reported that increasing the supply of N to soybean plants during the period from initial bloom to the end of bloom increased yields by 33 percent in the green house and 28 to 32 percent in the field.

Highest yield of dwarf kidney bean (*Phaseolus vulgaris*) was given by providing N at all growth stages with the greatest increase being rewarded by the application at mid flowering to pod elongation, followed by early pod filling to maturity (Hasegaava and Nomura ~~et al~~ 1978).

Hoshi et al (1978) from their studies on the effect of top dressing N fertilizers on the growth and seed yield of soybean concluded that yields increased with delay in application of nitrogen and it was pointed out that N should be applied after flowering. He also found that pod production was higher with ammonia N than with nitrate N.

Mudholkar and Hiawat (1978) reported that application of 25 kg.N/ha to bengalgram (_Cicer arietinum_) had no effect on yield.

Seed yields of cowpea cv. Ife Brown increased significantly by the application of mineral N.(Osiname.,1978).

Sij _et al_ (1979) showed that 'starter N' did not significantly influence the yield of soybean(_Glycine max_.)

Srivastave and Varma (1981) observed significant increase in the grain and straw yield of greengran (_Phaseolus aureus_) by the application of N and seed inoculation over control. Minchin _et al_ (1981) reported that providing inorganic N during vegetative period produced larger number of potential reproductive sites and larger seed yields than those dependant on nodules before flowering. Applying inorganic N during the reproductive period improved seed yields significantly compared to plants dependant on nodules throughout growth.

b. Foliar application:-

In a study conducted by Peeran _et al_ (1970) it was observed that applying half nitrogen before sowing and the reminder as a foliar spray in 2 split doses, 4 and 6 weeks after sowing increased the average seed yields to 1411 Kg pods/ha compared to 1308 kg/ha by the soil application of entire quantity (22 Kg N/ha). Yield increases were smaller where the full N rate was applied as foliar spray in 2 or 3 split doses dne month after sowing and subsequently at fortnightly intervals. than applying nitrogen partly through soil and partly through foliage.

Patra (1974) reported that foliar spray of 4 percent urea increased the yield of groundnut lineraly by 46 percent over control. The number of mature pods per plant and consequently the grain yield also increased by 50 percent. Urea spraying at pegging had increased the filling quality of pods by 3 percent because of better absorption of nutrients particularly calcium by the pegs. It was shown by Kalashnik (1976) that on podsolized chernozem soils in the Ukraine, peas that were given 150 kg Kainite + 50 kg Nitrophoska and a foliar spray of 10 kg N as urea per ha at the tendril formation stage produced on the average seed yields of 4.04 t/ha compared to the yield of 3.58 t/ha in peas which did not receive any nitrogen.

Foliar application of 20 cm^3 of 1 percent urea solution to 18 day old soybean plants increased the number but not the weight of pods.(Rabie et al 1979).

In a trial conducted by Pancholy and Guy (1979) urea was applied to the groundnut leaves at 0, 10, 20 and 40 lb N/acre. Urea increased the grain yield but the highest rate ofapplication had a negative effect on yield.

Syverud et al (1980) reported that foliar fertilization of soybeans with nitrogen increased the yield and seed weight. In trials with soybean, application of 20 kg N/ha as ammonium sulphate at flowering increased yields by 7.5 percent while foliar application of urea increased it by 8.1 percent. Foliar application of urea at early pod formation stage increased seed yield by 5.3 per cent (Cheng, 1980).

Antony and Katre (1980) had shown that the supply of 20 kg N/ha as a basal dose alone and in combination with 2 percent urea applied at flower initiation failed to give a significant increase in the yield of groundnut.

iii) Effect of nitrogen on nodulation:

a) Soil application:-

De Souza (1969) found that application of 100 lb N/acre increased seed yields in non-inoculated plants but decreased them in inoculated plants of soybean. Application of 22.5 kg N/ha markedly increased nodulation, nitrogen fixation and yield of gram (*Cicer arietinum*). N increased nodulation more by increasing the number of nodules. (Singh, 1970).

Hashimoto (1976) had shown that application of N (100 ppm) decreased the nitrogen fixing activity of soybean but with 40 ppm N the decrease was negligible from about 10 days after the beginning of flowering. Yagodina ~~et al~~ and Verovki (1978) reported that drymatter accumulation by root nodules of yellow lupin was inhibited with mineral N supply. Saadat *et al* (1978) observed a decrease in the number of nodules per plant in soybean by the application of N (0 or 100 kg N/ha)

Sundaram *et al* (1979) opined that with increase in the N level of the soil, nodulation was significantly reduced in bengalgram (*Cicer arietinum*). Maximum number of nodules was recorded at zero nitrogen level as well as at 50 kg N/ha. The results suggested that the application of nitrogenous fertilizers to bengalgram at more than 50 kg N/ha adversely affect both nodulation and nitrogenase activity of the nodules which is likely to reduce the fixation of atmospheric nitrogen by the crop. According to Awonaik *et al* (1980) *Phaseolus Vulgaris* induced less nodular tissue and lower nitrogenase activity per plant when nitrogen was applied.

Scherer and Danzeisen (1980) reported that in *Vicia faba* given 0 to 800 mg N/pot nodule weight per pot at the start of flowering was higher without than with nitrogen. At later stages nodule weight was similar with 0, 100 and 200 mg N/pot. N uptake attributed to microbial N fixation was greatest when 100 mg N/pot was applied.

Islam and Afandi (1980) found that application of 120 kg N/ha reduced nodule formation in all cultivars of lentil though the reduction was smaller in the lower nodulating ones. It was shown by Minchin *et al* (1981) that providing inorganic N to cowpea during vegetative period stimulated nodulation and nitrogenase activity than those dependant upon nodules before flowering. Applying inorganic nitrogen during reproductive period impaired nitrogenase activity and restricted symbiotic longevity compared to plants dependant on nodules throughout growth. Khurana and Dudeja (1981) observed that in chickpea inoculation and or applied N had no significant effect on the number of nodules per plant. Inoculation increased nodules dry weight and applied N decreased it.

b) Foliar application:

From an investigation on foliar application of urea at peggaing stage to groundnut Patra (1974) observed that nodulation gradually decreased with increase in concentration of urea spray.

Rabie *et al* (1979) reported that in soybean nodule dry weight decreased by the foliar application of 20 ml. of 1 percent urea solution to 18 day old plants.

Field experiments conducted by Balan *et al* (1980) on soybean with or without seed inoculation fertilization with 0 - 90 kg N/ha as NH_4NO_3 or urea applied at sowing or as foliar spray during growth showed that seed yields were higher at 5 sites out of 14 with than without N, and at 12 sites out of 14 with than without inoculation. Higher seed yields were obtained with selected native *Rhizobium japonicum* strains and N was unnecessary when very active strains were used.

iv) Effect of nitrogen on protein:

a. Soil application:-

Singh and Singh (1968) reported that application of 10 kg N significantly increased the protein content of grain by 2.23 percent in soybean.

Singh *et al* (1969) observed a progressive increase in the protein percentage of pea grains with an increase in the level of nitrogen from 0 to 22 kg/ha.

Singh (1970) noticed that in gram (*Cicer arietinum*) application of 22 kg N/ha increased the protein content to 16.3 percent compared to 14.73 percent with no nitrogen application.

Increase in the protein content of soybean was observed with increase in the level of N (Kesavan and Morachan, 1973). Rajendran *et al* (1974) reported that in blackgram the entire protein content of seed increased from 22.8 to 28 percent with increase in levels of nitrogen (0, 30 and 60 kg N/ha). Punnose and George (1974) also noticed an increase in the seed protein content with increase in the levels of nitrogen (0, 10 and 20 kg N/ha) in groundnut. An investigation carried out by Saadat and Firuzeh (1976) had shown that the protein content of soybean increased with increase in the levels of nitrogen.

b. Foliar application:-

From the trials on the podsolized chernozem soils in the Ukraine with peas given 150 kg Kainite + 50 kg

Nitrophoska/ha, foliar spray of 10 kg N as urea in 400 litres of water/ha at the tendril formation stage increased seed protein content from 0.8 to 2.92 percent (Kalashnik, 1976)

Pancholy and Guy (1979) observed no differences in the protein content and characteristic protein profile of groundnut seeds with the foliar application of urea at 0, 10, 20 and 40 lb N/acre.

Lysenko (1979) reported that a foliar spray of nitrogen as urea or ammonium nitrate to pea at the end of the vegetative growth period increased the seed protein content by 4.2 percent N applied to leaves was accumulated in globulins. A similar late topdresing increased the leaf protein content and N as urea was more effective than N as ammonium nitrate. Syverud et al (1980) observed an increase in the percentage of nitrogen in soybean seeds by the foliar application of nitrogen.

v) Nitrogen content and uptake of nitrogen:

a. Soil application:-

Norman and Krampitz (1945) reported that in soybean higher nitrogen content was resulted from the application of available combined nitrogen. Geo.D.Thornton (1946) observed that a greater proportion of combined nitrogen added to soybeans at planting was recovered in tops and roots where as a higher proportion of that added at mid season was found in the seed. Gnetieva (1971) reported that N uptake by beans (*Phaseolus vulgaris*) was highest at the bud formation and early flowering stages and decreased during grain formation and grain ripening stages. The highest content of nitrogen occured in the pods followed by leaves and stems. Application of NPK irrespective of their rates and proportions in a fertilizer mixture markedly increased the N content and had little effect on P and K content of seed.

Huxley *et al* (1976) observed increased nitrogen content of soybean plants by mineral nitrogen application. It was shown by Bhangoo *et al* (1976) that in nodulated and non-nodulated Lee soybean N content and total nitrogen uptake increased significantly from applied nitrogen. Sorensen and Pensas (1978) found that at 7 sites out of 13 plant nitrogen concentration of soybean increased by N application (0-224 kg N/ha) and that the nitrogen content of plant was generally linearly related to the rate of N application.

Hoshi *et al* (1978) observed that in soybean uptake of ammonia nitrogen was more rapid than the uptake of nitrate nitrogen. There was an increase in the total N content per plant in chickpea with inoculation and or applied nitrogen (Khurana and Dudeja, 1981).

b. Foliar application:-

Gorde and Kibe (1973) observed the greatest uptake of N by china mung crop (*Phaseolus aureus*) by a single foliar application of 20 lb N/acre on the 25th day after sowing. 25lb N per acre applied in 3 split applications on 25th, 35th and 40th days after sowing also gave promising results. Application of 90 Kg N-60 Kg N at sowing + 30 Kg N as a foliar spray at the start of flowering - increased the seed nitrogen content of soybean by 7 percent over control (Penk, 1977).

Rabie *et al* (1979) reported that soybean plants given 20 ml of 1 percent urea solution applied as a foliar spray to 18-day old plants increased the total nitrogen accumulation in plants. Reddy *et al* (1981) had shown that application of 15 or 30 Kg N/ha in the form of urea either basal or both basal plus foliar application at physiological stages to groundnut increased the N content in vegetative and reproductive parts. Soil application increased N content in plants significantly over foliar application.

B. PHOSPHORUS:

i) Effect of phosphorus on growth and growth characters:-

a) Soil application:-

Bhattacharya (1971) reported that in horsegram (*Dolichos biflorus*) the vegetative growth of the crop in respect of length of vine and number of branches per plant was significantly influenced by phosphorus application both with and without lime, however the effect was more pronounced in lime dressed soil.

With increase in the levels of P (30, 60 and 90 Kg P_2O_5/ha) plant height and number of branches significantly increased in Pusa baisakhi mung. (Panda, 1972).

Kesavan and Morachan (1973) observed a significant negative effect of the increased levels of P (0,50 and 100 Kg/ha) on the height of soybean plants. Gill and Cheema (1976) noticed that there was no response to added phosphorus with respect to vegetative growth and plant height in summer mung.

Kandaswamy et al (1977) found that the drymatter yield of Sirsa-I lucerne increased by phosphorus application. Shallan et al (1977) reported that in broad beans (Vicia faba L.) plant height was significantly increased by increase in P levels (0, 36, 72 or 108 Kg P_2O_5/ha). Number of branches per plant was significantly increased by the highest level of P application. Sachidanand et al (1980) reported that application of P (80, 160 or 240 ppm) significantly increased the overall drymatter yield in soybean and maximum yield was given by the lowest level of P application (80 ppm).

It was shown by Singh et al (1980) that various growth attributes like plant height, leaf number, branch number and plant dry weight were significantly increased in field pea by the increase in P levels (0 to 100 kg. P_2O_5/ha).

b. Foliar application:

An experiment carried out at the IARI to study the response of soil and foliar application of phosphorus applied alone or in combination with B, Mo, Cu and Mn on agronomic characters of peas had shown that the treatments did not cause any significant difference in any of the characters studied, viz, height of the plant, leaf area index and dry weight. (Kherde and Yawalkar, 1966). Duraiswamy Reddy and Palaniappan (1979) reported that phosphorus application through soil increased the plant height in CO-2 greengram on 45th day and at harvest but foliar application decreased it. Leaf area index was not influenced by phosphorus application.

Malakandaiah and Rajeswara Rao (1979) observed that when phosphorus was supplied through foliage to groundnut plants under saline conditions, there was an increase in dry weight, leaf area and stomatal frequency and this increase was more marked when plants received P for 2 periods, viz, 20 to 25 days and 30 to 35 days after sowing.

ii) Effect of phosphorus on yield and yield attributes:-

a. Soil application:-

In pot trials with urd (*Vigna mungo*), mung (*Vigna radiata*) and soybeans (*Glycine max*)Ravankar and Badhe (1975) observed that application of 80 Kg P_2O_5/ha to mung and soybean and 120 Kg P_2O_5/ha to urd gave the highest seed yields. Applied P increased the 100 seed weight also. In trials under rainfed conditions with gram (*Cicer arietinum*) given various levels of P, seed yields were increased from 1.57 t/ha without P to 2.28, 2.84 and 3 t/ha with 25, 50 and 75 Kg P_2O_5/ha respectively. (Rath and Singh 1976).

Zeyada (1976) observed a significant increase in the yield of straw, pods and seeds of fieldbean with the application of 150 Kg P fed as calcium super phosphate. In one of the trials conducted by Jones et al (1977) soybean was given P (0, 15, 30 and 60 Kg/ha) either alone or along with K (0 and 112 Kg/ha). It was seen that either P or K applied alone increased pod formation.

Shallan et al (1977) reported significant increase in pod weight, seed weight and number of seeds per plant in broadbeans (*Vicia faba* L) by P application (0, 36, 72 or 108 Kg P_2O_5/ha). Seed yields increased from 1.01 t/ha to 1.52 t/ha with increase in P_2O_5 application from 0 to 108 Kg/ha. Studies conducted by Subbiah (1978) on Pusabaisakhi greengram (*Vigna radiata*) showed that seed yields were higher with 26 Kg P_2O_5/ha than without P or soaking seeds in 1 percent KH_2PO_4 solution for 12 hours. Alhawat et al (1979) opined that application of P had marked effect on cowpea in increasing the yield attributes viz, number of pods per plant, length of pod, hundred grain weight, and grain yield. However higher levels of P (60 Kg P_2O_5/ha) did not cause additional increase in any of the plant characters and grain yield over lower level of P (30 kg P_2O_5/ha).

Mudholkar and Ahlawat (1979) noticed that the yield components and seed yields of gram (Cicer arietinum) grown on calcareous sandy loam soils were increased with 40 Kg P_2O_5/ha applied at sowing but yield was not increased further with 80 Kg P_2O_5/ha. It was shown by Singh et al (1980) that pod number was significantly increased with increase in P levels (0 to 100 Kg), 60 Kg P_2O_5/ha giving the highest seed yields. Devarajan et al (1980) reported that grain yield of redgram, blackgram and greengram increased significantly due to phosphorus application at 25 Kg P_2O_5/ha. It was also reported by Haque et al (1980) that the seed yields and number of pods per plant were significantly increased by P levels in soybean.

b. Foliar application:-

Kherde and Yawalkar (1966) observed that soil and foliar application of phosphorus (44.8 Kg P_2O_5/ha) to peas either alone or in combination with Mo, B,Ca and Mn caused no significant difference in grain yield, straw yield and their ratio. However, there were trends of increase in yield due to foliar application compared to soil application.

Studies conducted by Gill et al (1971) on cowpea showed that phosphate application either to soil (0, 25 and 50 Kg P_2O_5/ha) or as foliar spray (0 & 25 Kg P_2O_5/ha) increased the seed yields of cowpea and that 25 Kg P_2O_5/ha given as a foliar spray applied at flowering was on par with

50 Kg P_2O_5/ha applied to soil at sowing. The highest seed yield was obtained with 50 Kg P_2O_5/ha applied to soil at sowing followed by 25 Kg P_2O_5/ha given through foliage at first flush of flowering.

Singh et al (1971) reported that application of 22 Kg P/ha as single super phosphate in 2 equal foliar sprays to chickpea (Cicer arietinum Linn) at the peak vegetative and flower initiation stages or 33 Kg P as a single foliar spray at the peak vegetative phase resulted in average grain yields of 1.72 and 1.77 tonnes/ha respectively compared with 1.61 tonnes/ha is plots given band application of 45 Kg P/ha. Nalamwar et al (1972) observed an increase in the yield of groundnut (Arachis hypogaea) by the application of 22 Kg P_2O_5/ha either through soil or through foliage.

From the trials with peas (Pisum sativum L.) Iswaran and Sen (1973) found that seed inoculation with an efficient strain of rhizobium and 4 foliar sprays with 2 percent P solution applied at ten days interval beginning three weeks after sowing increased the number of seeds per pod, seed yield per plant and plant P content compared with inoculated and uninoculated controls. It was shown by Sharma et al (1975) that foliar application of 25 Kg P_2O_5/ha or applying 50 Kg P_2O_5/ha in 2 equal split dressings, before sowing and as a foliar spray increased the yield of gram (Cicer arietinum) by 13.7 and 34.4 percent respectively.

Shukla (1975) reported that on acid clay soil soybeans when given a foliar spray of 15 or 30 Kg/ha of P gave higher yields than its soil application. Protein content of grain was also significantly increased by the treatment. Phosphorus was applied to blackgram either through soil (0, 25 and 50 Kg P_2O_5/ha) or through foliage (6.25 and 12.5 Kg P_2O_5/ha). Maximum grain yield was obtained with 25 Kg P_2O_5|ha through soil + 12.5 Kg P_2O_5/ha applied as a foliar spray. (Subramaniam et al 1977).

Reddy and Palaniappan reported that application of 10 to 40 Kg P_2O_5/ha to the soil and/or as a foliar spray had no significant effect on yield components and seed yield of Phaseolus aureus cv. Co-2 grown on a soil of medium P status.

In gram (Cicer arietinum) application of 25 Kg P_2O_5/ha increased average seed yields by 256 Kg. Combining the soil application of 25 Kg P_2O_5/ha with a foliar spray of 1 percent P_2O_5 + 2 percent N increased yield by 4.62 Kg/h over those obtained with foliar spray applied alone. (Suryawanshi and Chaudhari, 1979) Subramaniam and Palaniappan (1981) observed that in blackgram variety Co-2 foliar application of 6.25 and 12.5 Kg P_2O_5/ha gave about the same yield as soil application of 25 or 50 Kg P_2O_5/ha.

In a field trial by Srivastava and Varma (1981) green gram was given 3 levels of P, viz, 20, 40 and 60 Kg P_2O_5/ha applied either fully through soil or half through soil + half as a foliar spray. Though the split application of P showed increasing trends in yield and yield attributes it did not reach the level of significance.

iii) Effect of phosphorus on nodulation and nitrogen fixation

a. Soil application:-

Rewari *et al* (1965) observed that the amount of nitrogen fixed by the cluster bean crop (*Cyamopsis tetragonalobus* (L) Taub) treated with different phosphates was positively and significantly related to its phosphate uptake from the soil. Khare and Rai (1968) reported that leguminous crops when treated with phosphorus increased the nitrogen content of soil significantly in the order soybean, dhaincha, urd, cowpea, moong and sunhemp. The total amount of N (plant and soil) fixed symbiotically in the phosphate treated pots over control was more than double in each case. It was found by Nair *et al* (1970) that in groundnut lack of P resulted in the greatest reduction in nodulation and nitrogen fixation, compared to the effects of Ca, Mo, Mg and K.

Singh (1970) opined that response to P application was very conspicuous in gram (*Cicer arietinum*) and growth, nodulation and N fixation were stimulated significantly. P increased nodulation more by increasing the weight of nodules. P significantly increased the number and dry weight of nodules and N fixation in gram. (Sinaha, 1971) Ravankar et al (1972) found that application of 120 Kg P_2O_5/ha for urd (Vigna mungo) and 80 Kg P_2O_5/ha for mung (Vigna radiata) were optimum for increasing nodulation and nitrogen fixation.

Jones et al (1977) reported that either P or K applied alone increased the number of nodules per plant and per unit volume of soil in soyabean. Yadava and Chokhey Singh (1978) had shown that application of 30 or 60 Kg P_2O_5/ha significantly increased nodule number over control.

Haque et al (1980) observed a moderate positive linear effect of rates of P on number of nodules and a highly significant linear effect of P upon nodule weight in soybean.

b. Foliar application:-

In one of the trials by Despande and Bathkal (1965) mung was given P either through soil (0,20, 40 or 60 lb P_2O_5/ha) or through foliage (10 lb P_2O_5/ha). Increase in nodule number was noticed with increase in phosphate levels and there was no significant difference between 20 lb P_2O_5 supplied through soil and 10 lb P_2O_5 supplied through foliage.

Iswaran and Sen (1973) observed that in peas (Pisum sativum L) seed inoculation with an efficient strain of rhizobium and 4 foliar spray of solutions containing 2 percent P applied at 10 days interval beginning three weeks after sowing increased the number of nodules per plant compared with inoculated and uninoculated controls.

IV. Effect of phosphorus on protein content:

a. Soil application:-

Singh et al (1969) reported that application of phosphoric acid (0 to 90 Kg/ha) to pea varieties did not influence protein content in grain. Garg et al (1971) observed an increase in the protein content in grains of peas due to P application at 20 and 40 Kg P_2O_5/ha.

Malik et al (1972) in a trial with cowpea observed that application of P had no effect on seed protein content.

Kesavan and Morachan (1978) showed that protein yield of soybean varieties increased by the increase in the rate of P_2O_5 application. Ravankar and Badhe (1975) observed that application of 80 Kg P_2O_5/ha to mung and soybean and 120 Kg P_2O_5/ha to urd increased the seed protein content.

b) Foliar application:-

Shukla (1975) observed that on acid clay soil soybean when given a foliar application of 15 or 30 Kg/ha P increased the protein content of grain significantly, compared to its soil application.

Belikov and Burtseva (1967) reported that application of powdered superphosphate at 100 Kg/ha or

500 ml/ha of a superphosphate solution containing 2 percent P_2O_5 at the beginning of pod formation to leaves increased the protein percentage of soybean seeds.

V. Phosphorus content and uptake of phosphorus:-

a) Soil application:-

Sinha (1971) reported that in gram, application of a starter dose of 10 Kg N/ha gave higher uptake of total P by the plant at all stages of growth. With 10 Kg N/ha as basal dressing, 30 and 60 Kg P_2O_5/ha showed an increasing trend in the uptake of total and fertilizer P in favour of the latter. Rajendran and Krishnamoorthy (1975) from the trials with blackgram reported that the uptake of P in the shoot, seed and husk samples were significant for P With increase in levels of P the uptake of P also increased.

Ravankar and Badhe (1975) noticed that in urd, mung and soybeans given 0 to 120 Kg P_2O_5/ha, applied P increased N and P uptake by plants at different growth stages. It was shown by Kandaswamy et al (1977) that application of P significantly increased the uptake of N, P, K and Ca in lucerne variety Sirsa-I.

Singh and Saxena (1977) observed that although P concentration in plant parts was reduced owing to nitrogen fertilization and inoculation, the uptake was considerably increased in soybean. In redgram, greengram and blackgram application of P increased the P content in grain and straw. (Devarajan et al, 1980). Sachidanand et al (1980) reported that application of phosphorus to soybeans (80, 160 or 240 ppm P_2O_5) significantly increased the P content in plants.

A trial conducted by Cassman et al (1981) to find out the phosphorus requirement of soybean and cowpea as affected by the mode of N nutrition showed that the P concentration of N fixing soyvean plants was significantly lower than that of N supplied plants at all levels of applied P fertilizer.

b) Foliar application:-

Belikov and Burtseva (1967) observed that application of powdered superphosphate at 100 kg/ha or 500 ml/ha of a super phosphate solution containing 2 percent P_2O_5 applied at the beginning of pod formation of soybean leaves increasec the total and organic P content of grain.

Nalamwar et al (1972) reported that the percentage uptake of P_2O_5 was more when the crop was fertilizer with phosphatic fertilizer, either through soil or through foliage than its zero level. When blackgram was given phosphorus either through soil (0, 25 or 50 Kg P_2O_5/ha) or through foliage (6.25 or 12.5 Kg P_2O_5/ha) it was found that foliar application of P at the rate of 12.5 Kg P_2O_5/ha had significantly increased the uptake of P. (Rajamannar et al, 1979)

III. Combination effect of N and P

i) On growth and growth characters:

a) Soil application:-

From an investigation conducted on gram (Cicer arietinum) variety BR 77, Shukla (1964) concluded that application of 20 lb N + 30 lb P_2O_5/acre gave maximum response of almost all plant characters viz, height of plants, number of branches per plant etc, compared to the sum of their independant effects. Ezedinma (1965) found that plant height and number of leaves per plant were increased by the combined application of N and P (20 lb N + 40 lb P_2O_5/acre).

In Pusabaisakhi mung, Panda (1972) observed increase in plant height and number of branches per plant with increase in levels of N and P. The economic level was found to be 30 Kg N + 30 Kg P_2O_5/ha.

Cassman (1978) found that at the four lowest P levels (.005, .02, 0.05, 0.2 ppm phosphate P) nitrogen provided in the nutrient solution did not increase the plant dryweight. At all P levels plants recycling upon symbiotically produced nitrogen as their sole N source had a smaller root percentage of total weight than plants provided with nitrogen.

b) Foliar application

Badillo - Feliciano *et al* (1977) observed no difference in the plant height of pigeon pea (*Cajanus cajan*) by the foliar application of nutrileaf at 2.24 Kg/ha given at 1 week, 2 week, 3 week or monthly intervals or N and P as urea and superphosphate respectively applied at equivalent amounts at 2 week intervals. In blackgram

Plant height at harvest was not influenced by either water spray or 3 percent diammonium phosphate spray. Spraying diammonium phosphate twice (at flowering and a fortnight later) recorded significantly higher drymatter production after pod maturation stage. (Ramaswamy and Ramaiah, 1980).

ii. On yield and yield attributes:-

a) Soil application:-

Sen et al (1962) observed better response in berseem yield to the addition of nitrogen and phosphorus compared to the addition of phosphorus alone. Shukla (196 from an investigation on gram (*Cicer arietinum*) pointed out that increasing the dose of N in the absence of P slightly depressed grain yield but in combination with P increase in the dose of N, particularly 20 lb N/acre, had a positive relationship with yield. The straw yield increased with increase in N supply when it was used in combination with P.

Singh and Singh (1968) opined that in soybean combined application of 10 Kg N and 80 Kg P_2O_5/ha significantly increased grain yield by 36.23 percent over control. Rajagopalan et al (1970) observed that in blackgram application of 2 tons of compost in combination with 20 lb P_2O_5 and 10 lb N/acre gave increased yields over no manure plots. With increase in the dose of N and P yield of grain and bhusa, length of pod and average weight of seeds per plant increased in Pusabaisakhi mung. The level of 30 KgN+ 30Kg P_2O_5/ha was the most profitable and economical dose (Panda, 1972).

Rajendran et al (1974) noticed an increase in the seed yield of blackgram (Phaseolus mungo L) with increase in the level of N and P. Significant increase in the seed yields of soybean was obtained by the combined application of N and P. Seed yield was highest (0.74 t/ha) with 150 Kg N + 225 Kg P_2O_5/ha, 0.71 t with 200 Kg N + 300 Kg P_2O_5/ha and 0.70 t with 200 Kg N/ha compared with 0.27 t/ha without applied fertilizer. (Aleman et al, 1974.)

Agarwal and Narang (1975) reported that the combined application of 20 Kg N + 80 Kg P_2O_5/ha gave maximum average seed yields of 1.72 t/ha in soybean.

From the trials conducted on soybean (Glycine hispida maxim) Axinte (1975) obtained highest seed yields by the combined application of N and P followed by N alone and no fertilizer application. Tej Singh et al (1975) obtained significantly higher grain yield with 25 Kg N + 50 kg P_2O_5/ha over the untreated control in moong. From a trial conducted at the Rice Research Station, Pattambi Viswanathan et al (1979) obtained maximum yield of cowpea with 37.67 Kg N and 37.37 Kg P_2O_5/ha. The economic doses of fertilizers were 23.12 Kg N and 23.55 of Kg P_2O_5/ha.

b. <u>Foliar application:-</u>

Application of 2 percent N, 2 percent P and 2 percent K increased the seed yields of soybean by 240 Kg/ha over control. (Axinte, 1973).

Badillo-Feliciano <u>et al</u> (1977) noticed no difference in seed weight and grain pod ratio of pegeon peas by foliar application of nutrileaf at 2.24 Kg/ha given at 1 week, 2 week, 3 week or monthly intervals or N and P as urea and super phosphate respectively applied in equivalent quantities at 2 week intervals.

In field trials in Florida by Robertson <u>et al</u> (1977) yields of soybean cultivars were not affected by 1 to 5 foliar application (beginning at podset) of 170 litres per hectare of a solution containing 28, 2.9, 8.4 and 1.2 Kg/170 litre of N, P, K and S respectively. Garcia (1977) observed that the optimum rate of NPK and S for foliar fertilization of soybean at filling was 80, 8, 24 and 4 Kg/ha respectively which gave yields 1.04 t/ha higher than that in control plots.

Herbert and Daugherty (1978) observed that foliar application during seed filling totalling 80 Kg N. 8 Kg P, 24 Kg K and 4 Kg S/ha generally decreased yields in lupin. Lysenko (1970) reported that foliar sprays with ammonium nitrate to pot grown peas at the end of flowering increased seed yields where a basal dressing of 1g P_2O_5/pot was applied and slightly decreased yields where basal dressing was 0.5 g, but foliar spraying of urea increased yields in the pots given a basal dressing of 0.5 g P_2O_5.

It was shown by Suryawanshi and Chaudhari (1979) that combining the application of 25 Kg P_2O_5/ha with foliar spray of 1 percent P_2O_5 + 2 percent N increased yields by 462 Kg/ha over those obtained with the same foliar spray applied alone. A foliar spray of 2 percent P + 2 percent N or 1 percent P + 1 percent N gave similar yields.

Keogh et al (1979) found that foliar fertilization of soybean with 60 lb N, 14.4 lb P_2O_5, 21.6 lb K_2O and 3.5 lb S/acre reduced yields to 52.1 bushels per acre compared with 57.7 bushels in untreated plots.

Subramaniam and Palaniappan (1980) observed that foliar application of 12.5 Kg P/ha was as effective as the combined foliar application of 10 Kg N + 12.5 Kg P/ha in increasing the yield of blackgram, but maximum yield was recorded by the combination.

Pillai et al (1980) from an experiment on cowpea variety C-152 obtained highest seed yields by the soil application of half the recommended dose of N (10Kg/ha) as basal dressing and a foliar spray of 2 percent diammonium phosphate (D.A.P.) solution, 20 and 30 days after sowing. In a field experiment conducted by Ramaswamy and Ramaiah (1980) 3 percent D.A.P. was sprayed on blackgram variety Co.4 once at the commencement of flowering and a fortnight later as compared with water-sprays at the corresponding stages. It is found that spraying D.A.P. twice increased the number of pods per plant, shelling percentage, 100 grain weight and ultimately resulted in increased grain yield.

iii) On nodulation:-

Ivanov (1979) observed that the application of 60 Kg/ha each of N, P_2O_5 and K_2O alone and in different combinations had no significant effect on growth and nodulation of lupin, grown on grey-brown forest soils.

iv) On protein content:-

Tej Singh et al (1975) observed significant increase in the protein content of moong (Phaseobus aureus Roxb.) over the untreated control by the application of 25 Kg N + 50 Kg P_2O_5/ha. It was suggested that P application may stimulate nodule production and thus higher rates of N fixation.

Application of N and P increased the seed protein content of soybean varieties Pb No.I, Bragg and Clark 63, compared with the untreated control. (Agarwal and Narang, 1975)

Ivanov (1979) reported that in white lupin, application of 60 Kg/ha each of N, P_2O_5 and K_2O had no significant effect on drymatter and crude protein yields.

Dekov and Losanchels Alvares (1980) reported that in rainfed trials, application of N, P, K and Mo at various levels to 4 *Phaseolus Vulgaris* cultivars increased the protein and starch content in seeds. The optimum rate was 40 Kg N + 80 Kg P_2O_5 + 30 Kg K_2O + 100 Kg Mo/ha.

V) On N & P uptake:

From the studies conducted on greengram, Yadava and Chokhey Singh (1978) observed that the application of N and P increased the uptake of N by the crop and the fixation of N in the soil over control.

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Materials and methods

3. MATERIALS AND METHODS

A field experiment was conducted to evaluate the comparative efficiency of soil and foliar application of N, P and their combinations on the growth, yield and quality of blackgram.

LOCATION:

The experiment was conducted in the summer rice fallows of the Rice Research Station, Kayamkulam which comes in the Onattukara tract.

MATERIALS:

Soil:

The soil of the experimental area was sandy loam. The data on the analysis of the soil before starting the experiment is given in Table-1.

Table - 1

Analysis of the soil before starting the experiment

	Content
Total nitrogen (Kg/ha)	1260
Available P_2O_5 (Kg/ha)	45
Available K_2O (Kg/ha)	63
p^H	5.3

SEASON AND CLIMATE:

The experiment was conducted during summer season of 1981-82. The crop was sown on 30th January and the harvest was completed by 19th April 1982.

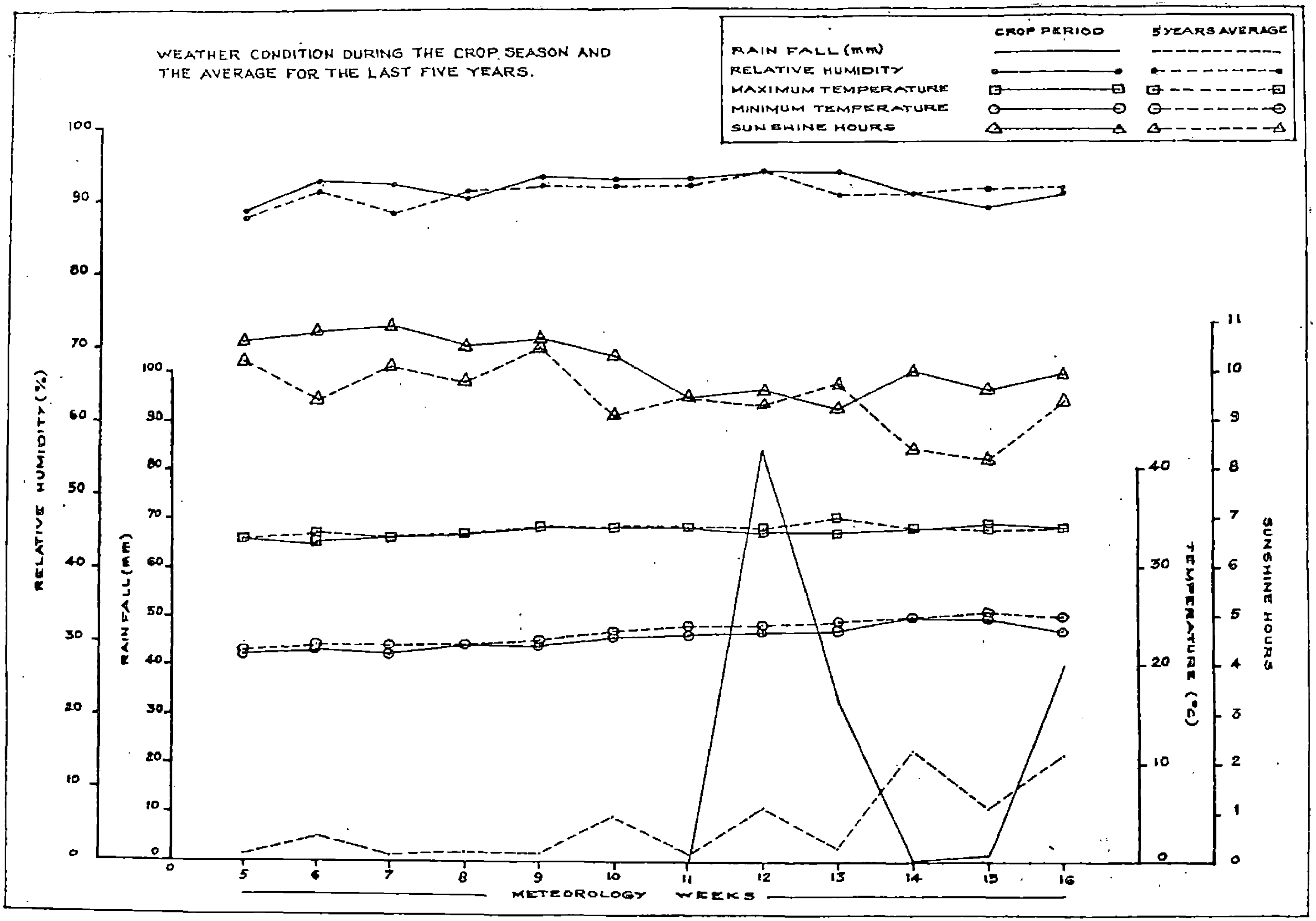
The meteorological parameters such as temperature rainfall, relative humidity and sunshine hours were recorded during the above period. The weekly averages of temperature, relative humidity and sunshine hours and weekly total of rainfall during the cropping period and the previous five years were recorded and are given in figure 1 and Appendix.1.

CROPPING HISTORY OF THE FIELD:

The experimental site was under bulk crop of paddy during the first and second crop seasons of 1981-1982.

VARIETY AND SEED:

Blackgram variety T9 evolved at C.Z.Azad University of Agricultural Sciences, Kanpur was used for the study. It is a high yielding variety of approximately 90 days duration. Plants are erect with dark green leaves. Seeds are dark and medium in size.



WEATHER CONDITION DURING THE CROP SEASON AND THE AVERAGE FOR THE LAST FIVE YEARS.
CROP PERIOD
5 YEARS AVERAGE
RAIN FALL (mm)
RELATIVE HUMIDITY
MAXIMUM TEMPERATURE
MINIMUM TEMPERATURE
SUNSHINE HOURS
RELATIVE HUMIDITY (%)
RAINFALL (mm)
TEMPERATURE (°C)
SUNSHINE HOURS
METEOROLOGY WEEKS

Seeds with 96 percent germination was obtained from M/s.Super Seeds, Coimbatore - 2.

FERTILIZERS:

Urea (analysing 46 percent N), Super phosphate (analysing 16 percent P_2O_5) Diammonium Phosphate (analysing 18 percent N and 46 percent P_2O_5) and Muriate of potash (analysing 60 percent K_2O) were used for the study. Fresh urea solution of 2 percent concentration and 3 percent solution of D.A.P. were used for foliar application.

METHODS:

Design and layout:

The experiment was laid out in Randomised Block Design. The layout plan of the experiment is given in Fig.2.

Treatments:

There were fifteen treatments as given below:-

T_1 - N full basal as urea (20 kg N/ha as per the Package of Practices recommendations of K.A.U., 1980)

T_2 - 1/2 N basal + 1/2 N through foliage at flowering.

T_3 - 1/2 N basal + 1/4 N through foliage at Veg.phase + 1/4 N through foliage at flowering.

T_4 - 1/3 N basal + 1/3 N through foliage at Veg.phase + 1/3 N through foliage at flowering.

T_5 - 1/2 N basal + 1/4 N through foliage at flowering.

T_6 - P full basal (30 kg P_2O_5/ha) as super phosphate. (as per package of practices recommendations of K.A.U.)

T_7 - 1/2 P basal + 1/2 P through foliage at flowering.

T_8 - 1/2 P basal + 1/4 P through foliage at Veg.,phase + 1/4 P through foliage at flowering.

T_9 - 1/3 P basal + 1/3 P through foliage at the Veg. phase + 1/3 P through foliage at flowering.

T_{10} - 1/2 P basal + 1/4 P through foliage at flowering.

T_{11} - N and P full basal as Diammonium Phosphate (D.A.P.) + Urea

T_{12} - 1/2 N and P basal + 1/2 N and P through foliage at flowering

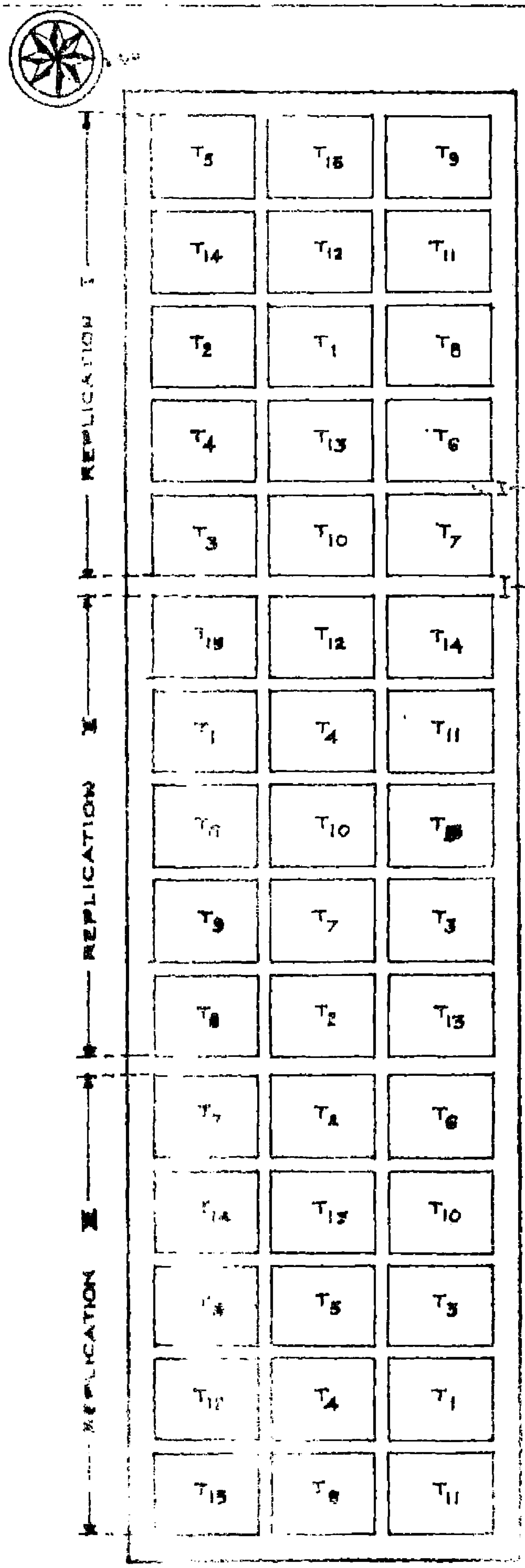
T_{13} - 1/2 N and P basal + 1/4 N and P through foliage at the veg. phase + 1/4 N and P through foliage at flowering.

T_{14} - 1/3 N and P basal + 1/3 N and P through foliage at the veg. phase + 1/3 N and P through foliage at flowering.

T_{15} - 1/2 N and P basal + 1/4 N and P through foliage at flowering.

No. of replications	-	3
Total number of plots	-	45
Gross plot size	-	5M x 4M
Net plot size	-	4.6M x 2.6M
Spacing	-	20 cm x 10 cm.

LAY OUT PLAN – RANDOMISED BLOCK DESIGN



GROSS PLOT SIZE 5 M x 4 M.

TREATMENTS			
	BASAL (SOIL)	VEGITATIVE PHASE (FOLIAR)	FLOWERING (FOLIAR)
T_1	N FULL	----	----
T_2	1/2 N	----	1/2 N
T_3	1/2 N	1/4 N	1/4 N
T_4	1/3 N	1/3 N	1/3 N
T_5	1/2 N	----	1/4 N
T_6	P FULL		
T_7	1/2 P	----	1/2 P
T_8	1/2 P	1/4 P	1/4 P
T_9	1/3 P	1/3 P	1/3 P
T_{10}	1/2 P	-----	1/4 P
T_{11}	N + P FULL	-----	-----
T_{12}	1/2 N + 1/2 P	-----	1/2 N + 1/2 P
T_{13}	1/2 N + 1/2 P	1/4 N + 1/4 P	1/4 N + 1/4 P
T_{14}	1/3 N + 1/3 P	1/3 N + 1/3 P	1/3 N + 1/3 P
T_{15}	1/2 N + 1/2 P	-----	1/4 N + 1/4 P

CULTURAL OPERATIONS:

Field preparation:

Experimental area was tilled using a power tiller; stubbles were removed, clods broken, field levelled and laid out into blocks and plots.

Fertilizer application:

Dolomite was applied at 400 Kg/ha one week prior to sowing. Potassium at 10 Kg/ha as Muriate of potash was given in each plot as a basal dose, at the time of field preparation. For basal application of Nitrogen and phosphorus required quantities of Urea, super phosphate and diammonium phosphate were weighed separately as per treatments and thoroughly mixed with the soil. Foliar application was done twice-during the vegetative phase and at flowering. For this 2 percent solution of urea, 6.25 percent solution of super phosphate and 3 percent solution of diammonium phosphate were used.

Seeds and Sowing:

Seeds were treated with rhizobium culture and were dibbled at the rate of 2 seeds per hole at a spacing of 10 cm. in shallow furrows taken 20 cm. apart and covered with a thin layer of soil, and planked. Germination was completed in five days.

Aftercare:

Hand weeding was done twice during the growth period of the crop. Spraying with 0.25 percent malathion was done once against aphids and leafrollers. The general stand of the crop was satisfactory.

Harvest:

The dry pods from the net area were picked thrice, dried and threashed plotwise. At the last picking, plants from the net area were uprooted and sundried. The grain, husk and bhusa from the net plot were separately weighed and recorded.

Sampling:

Two rows of plants were left out on all sides as border rows. One row next to the border row on one side was left as destructive row for taking sample plants for leaf area determination, chemical analysis etc. Again one row next to it was left out as a border row. The net plot area was 11.96 m^2. From the net area ten plants were selected randomely, tagged and biometric observations were recorded till harvest.

OBSERVATIONS RECORDED:

A. Observations on growth characters:

1. Height of the plant:

The height of the tagged plants were measured from the cotyledonous node to the tip of the growing point at the four growth stages viz., 20th, 40th and 60th day after sowing and also at harvest. The mean plant height was worked out and expressed in cms.

2. No. of leaves per plant:

The number of green leaves present in the observational plants were counted at the four growth stages and mean number of leaves recorded.

3. Leaf area index:

This observation was also recorded at four growth stages of the plant. Leaf area was calculated using the punch method (Winter et al ,1956). Five plants were removed from the destructive row, leaves were separated and punched. The discs as well as the remaining leaf portions were dried in a hot air oven at 70 $\pm$ 10°C and their respective dry weights were recorded. From this leaf area, and LA1 were worked out.

4. Number of branches per plant:

The total number of branches in the observational plants were recorded at harvest time and the average worked out.

5. Number of nodules per plant:-

At flowering five plants from each plot were pulled out from the destructive row, soil washed off, nodules counted and average worked out.

6. Dry weight of nodules per plant:

The nodules separated for nodule count were ovendried and the average weight recorded.

B. Observations on yield and yield attributes:-

1. Number of pods per plant:

The total number of pods produced by the observational plants were counted and the average worked out.

2. Length of pod:

From the observational plants in each plot, 20 pods were randomly selected, length measured and the average length was worked out and expressed in cm.

3. Number of seeds per pod:

The total number of seeds in the selected twenty pods were counted and the average number of seeds per pod was worked out.

4. Seed yield per plant:

The pods harvested from the observational plants in each plot were sundried, threashed, winnowed and weighed at 12 percent moisture level. The average seed yield per plant was then worked out.

5. 100 seed weight:

Weight of 100 seeds selected at random from the observational plants in each plot was determined, and expressed in grams.

6. Grain yield:

The pods obtained from the net plot were dried, threashed, winnowed and the weight of grain was determined at 12 percent moisture and expressed in Kg/ha.

7. Husk yield:

The husk obtained from each net plot was also dried and weight determined and expressed in Kg/ha.

8. Haulm yield:

After picking pods the plants from the net plot were pulled out, dried for 3 days, weighed and the yield of bhusa was expressed in Kg/ha.

9. Total drymatter production:-

After sundrying, the samples were dried to a constant weight in a hot air oven at 80°C ± 5°C for 48 hours and weight was recorded. Based on that, for each treatment drymatter production was computed and expressed in Kg/ha.

10. Harvest index:

Based on the yield of grain, and total drymatter in each net plot, harvest index was worked out using the formula

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

C. Chemical Analysis:

a) Plant Analysis:

Samples taken for chemical analysis were ovendried at 80°C ± 5°C, ground in a Wileymill and used for chemical analysis. The N, P and K content of the plants were analysed separately.

i) Nitrogen content:-

Nitrogen content in plant samples was determined by modified microkjeldahl method (Jackson, 1967).

ii) Phosphorus content: Phosphorus content in plant samples was determined by Vanado Molybdo Phosphoric yellow method (Jackson, 1967) using Klett Summerson Photoelectric colorimeter.

iii) Potash content:

Potassium content in plant samples was determined using 'EEL' flame photometer.

iv) Uptake studies:-

Nitrogen, Phosphorus and potassium uptake of plant at harvest were determined by multiplying the content of these nutrients in plants with the dry weights of plants and expressed in Kg/ha.

b. Soil analysis:

Soil samples collected from individual blocks before the start of the experiment and from each plot after the experiment were analysed for total N, available phosphorus and available potassium content of the soil. Total nitrogen content in soil samples was determined by modified micro-kjeldahl method (Jackson, 1967) and available phosphorus by Bray's method (Jackson, 1967). Avabilable potassium was determined by Ammonium acetate method (Jackson, 1967).

D. Quality characters:-

i) Protein content of the grain:-

Protein content of grain (percentage) was calculated by multiplying the nitrogen percentage of grai by the factor 6.25 (Simpson et al, 1965).

ii) Grain protein yield:

Grain protein yield was calculated by multiplying the protein content of grain with its total dry weight and expressed in Kg/ha.

iii) Protein content of bhusa:-

By multiplying the nitrogen content (percentage) of bhusa by the factor 6.25, the percentage of protein in bhusa (Simpson et al, 1965) was computed.

E. Statistical Analysis:-

The data obtained were statistically analysed by employing the method described by Panse and Sukhatme (1978) and important correlations were also worked out.

The data were analysed with the help of a Micro 2200 Hindustan Computer at the College of Agriculture, Vellayani.

Results

4. RESULTS

A field experiment was carried out in the summer rice fallows of the Rice Research Station, Kayamkulam during 1981-82 to find out the influence of methods of application of N and P on the growth, yield and quality of blackgram. The results obtained in the present study along with the statistical analysis are presented below:-

A. Growth characters:

1. Height of plants

Data on mean height of plants recorded at 20th, 40th and 60th days after sowing and at harvest are presented in Table 2 and the analysis of variance in Appendix II.

The height was not significantly influenced by the treatments on the 20th day. But the treatments had significant influence on plant height during the subsequent stages.

T 14 recorded the maximum height at all the three stages (40th and 60th day after sowing and at harvest). T 14 was on par with T 15, T 4 and T 3 at 40th day and the minimum height was recorded by T 6 which was on par with T8, T9, T10, T11 and T7.

Table 2

Height of plants (cm) at different stages of growth

Treatments	20 days after sowing	40 days after sowing	60 days after sowing	at harvest
T1	5.73	13.83	17.33	23.21
T2	5.97	15.07	24.47	26.29
T3	5.78	15.63	26.17	26.28
T4	5.67	17.73	27.17	28.0
T5	5.5	14.8	19.53	23.60
T6	5.42	10.7	13.97	17.66
T7	6.03	13.03	18.17	22.71
T8	5.0	12.2	18.70	22.42
T9	5.2	12.2	17.67	20.73
T10	5.62	12.4	18.67	19.87
T11	5.62	12.77	18.57	20.43
T12	5.83	15.17	22.13	23.94
T13	5.57	15.23	23.63	27.03
T14	6.85	18.43	27.67	28.58
T15	6.07	18.23	24.20	25.93
F test	N.S	Sig.	Sig.	Sig.
C D (.05)	...	2.93	3.12	4.08

On 60th day T 4 and T 3 were an par with T 14 and the minimum height was shown by T 6. At harvest, T 14 was on par with T 4, T 13, T 12, T 3 and T 15 and T 6 was on par with T 10, T 11 and T 9 which recorded the minimum height.

2. Number of leaves per plant:

Observations on the number of leaves per plant were recorded on 20th, 40th and 60th days after sowing and at harvest. The data on mean number of leaves are given in Table 3 and the analysis of variance in Appendix II.

Significant effect of treatments an leaf number was noticed only on 60th day after sowing. Maximum number of leaves was observed in T 13 and this treatment was on par with T 14, T 4, T 3,T 12, T 15, T 2 and T 5, whereas T 6 produced the least number of leaves per plant. T 9, T 8, T 7 and T 10 were on par with T 6.

3. Leaf area index:

Leaf area indices were also determined on 20th, 40th and 60th days after planting and at harvest. The mean values are presented in Table 4 and the analysis of variance in Appendix II.

The treatments had no significant effect on the leaf area index at the first two stages of growth and at harvest. But on 60th day, the leaf area index varied

Table 3

Number of leaves per plant at different stages of growth

Treatments	20 days after sowing	40 days after sowing	60 days after sowing	at harvest
T1	4.23	9.06	11.0	9.20
T2	4.30	10.03	12.4	11.24
T3	4.30	10.16	13.20	11.92
T4	4.30	10.43	13.60	13.34
T5	4.33	10.13	11.80	12.59
T6	4.03	8.93	8.27	9.03
T7	4.07	9.43	9.35	11.18
T8	4.17	9.36	9.33	10.84
T9	4.23	9.20	8.97	9.90
T10	4.2	9.53	9.47	9.90
T11	4.2	8.47	11.14	9.41
T12	4.4	10.36	13.2	13.14
T13	4.47	10.43	14.5	13.77
T14	4.57	11.57	13.9	15.57
T15	4.43	10.36	12.8	11.30
F test	N.S.	N.S.	Sig.	N.S.
C D (.05)	..	..	2.66	..

Table 4

Leaf area index at different stages of growth

Treatments	20 days after sowing	40 days after sowing	60 days after sowing	at harvest
T1	.16	0.66	2.09	1.75
T2	.17	1.23	2.66	2.61
T3	.17	1.47	2.62	2.55
T4	.17	1.28	2.62	2.55
T5	.17	1.33	2.66	2.44
T6	.16	0.97	1.83	1.61
T7	.16	1.05	2.30	1.99
T8	.13	1.01	2.26	2.01
T9	.16	1.0	2.13	2.03
T10	.14	1.02	1.86	1.85
T11	.15	0.96	2.07	1.94
T12	.17	1.55	2.61	2.26
T13	.17	1.14	2.45	2.05
T14	.18	1.57	3.67	2.28
T15	.21	1.27	2.53	2.36
F test	N.S.	N.S	Sig.	N.S.
C D (.05)	..	..	0.87	..

significantly due to treatments. T 14 recorded the maximum value and it was significantly superior to the other treatments. T 6 had shown the lowest index.

4. Number of branches per plant:-

The number of branches per plant was recorded at maturity and the mean values are given in Table 5 and the analysis of variance in Appendix II.

There was no significant difference between treatments in their effects on the number of branches per plant.

5. Number of nodules per plant:

The mean number of nodules per plant at flowering is presented in Table 5 and the analysis of variance in Appendix II.

It was observed that the number of nodules per plant varied significantly due to treatments. The highest number was found in T 12 which was on par with T 15, T 14, T 8 and T 9. T 1 recorded the lowest nodule number and there was no significant variation among T 1, T 4, T 10, T 3, T 8, T 11 and T 2.

6. Dry weight of nodules per plant:

Data on the dry weight of nodules per plant is furnished in Table 5 and the analysis of variance in Appendix II.

The treatments varied significantly in their effects on nodule dry weight. Maximum dry weight was

Table 5

Number of branches, Numver of nodules and dry weight of nodules per plant.

Treatments	No. of branches per plant	No. of nodules per plant	Dry wt. of nodules per plant (mg)
T1	2.28	19.50	33.42
T2	2.93	23.50	37.47
T3	3.20	21.30	34.83
T4	3.27	20.80	34.15
T5	2.60	24.2	35.14
T6	2.31	24.5	41.23
T7	2.97	22.13	38.43
T8	3.37	26.30	45.37
T9	3.28	25.40	46.72
T10	2.58	20.83	39.71
T11	2.48	23.10	37.14
T12	3.15	28.41	46.83
T13	3.52	27.3	44.37
T14	3.63	26.9	44.87
T15	3.07	27.52	45.92
F test	N.S.	Sig.	Sig.
C D (.05)	...	3.80	2.72

recorded by T 12 which was on par with T 9, T 5, T 8, T 14 and T 3. T1 recorded the lowest value.

B. Yield and yield attributes:

1. Number of pods per plant:

Data on the number of pods produced per plant at harvest is presented in Table 6 and the analysis of variance in Appendix III.

It is found that the number of pods per plant varied significantly due to treatments. T 14 recorded the maximum number and it was on par with T 13, T 8, T 4, T 7 and T 15. T 1 was found to produce the least number of pods per plant.

2. Length of pod:

Pod length was measured at harvest and the mean values are given in Table 6, and the analysis of variance in Appendix III.

The treatments were found to be non significant in their effects on pod length.

3. Number of seeds per pod:-

Data on the number of seeds per pod is given in Table 7 and the analysis of variance in Appendix III.

There was no significant difference among the treatments in the number of seeds per pod. However, T 14 recorded the maximum number of seeds per pod.

Table 6

Number of pods per plant. Number of seeds per pod, length of pod, seed yield per plant and 100 seed weight

Treatment	No. of pods per plant	No. of seeds per plant	length of pod (cm)	seed yield per plant (g)	100 seed weight (g)
T1	8.68	5.73	3.77	2.38	3.74
T2	13.70	6.23	4.27	3.06	3.95
T3	12.57	6.33	4.40	2.92	3.78
T4	19.30	6.0	4.07	3.93	3.97
T5	16.54	5.93	4.03	3.08	3.95
T6	11.77	5.73	4.10	2.01	3.68
T7	18.57	6.0	3.97	4.67	4.04
T8	19.90	5.8	4.0	4.64	4.01
T9	12.74	6.0	4.07	2.79	3.86
T10	11.77	5.87	3.87	2.71	3.89
T11	10.17	5.27	3.70	2.70	3.78
T12	13.51	6.33	4.20	3.81	4.01
T13	20.92	6.13	4.17	5.15	4.02
T14	21.11	6.37	4.17	4.92	4.04
T15	15.65	5.97	4.10	4.12	4.01
F test	Sig.	N.S.	N.S.	Sig.	Sig.
C D (.05)	7.15	...	...	1.56	0.25

4. Seed yield per plant:

The data on the seed yield per plant is given in Table 6 and the analysis of variance in Appendix III.

The effect of the treatments on seed yield per plant was significant. T 14 recorded the maximum seed yield and it was on par with T 13, T 7, T 8, T 15, T4 and T 12. The minimum seed yield was in T6.

5. Hundred seed weight:

The mean values are furnished in Table 6 and the analysis of variance in Appendix III.

Treatments showed significant influence on hundred seed weight. The highest value was recorded by T 7 which was on par with T 14, T 13, T 15, T 8, T 12, T 4, T 2, T 5, T 10 and T 9. T 6 recorded the minimum value.

6. Grain yield:

Data on grain yield are presented in Table 7 and the analysis of variance in Appendix III.

Grain yield varied significantly due to treatments. T 14 recorded the maximum yield and it was on par with T 13 which inturn was on par with T 4, T 8, T 15, T 7. The lowest value was recorded by T 1.

7. Haulm yield:

Data on haulm yield are given in Table 7 and the analysis of variance in Appendix III.

Table 7

Grain yield, haulm yield, total dry matter yield and harvest index.

Treatments	Grain yield kg/ha	Haulm yield kg/ha	Total D.M. yield kg/ha	Harvest index
T1	688	1303	2245	.30
T2	978	1858	3193	.31
T3	1115	2054	3467	.33
T4	1257	2005	3748	.35
T5	1169	2163	3774	.31
T6	882	1299	2444	.36
T7	1154	2173	3695	.31
T8	1252	1866	3682	.35
T9	975	2202	3516	.32
T10	957	1678	2997	.33
T11	841	1343	2434	.35
T12	1036	1797	3100	.34
T13	1407	2284	3794	.38
T14	1631	2553	4742	.35
T15	1193	1719	3222	.40
F test	Sig.	N.S.	Sig.	N.S.
CD(.05)	276.51	...	1254.82	...

The effect of the treatments on haulm yield was not significant. However, the maximum value was recorded by T 14.

8. Total drymatter production:

The data are presented in table 7 and the analysis of variance in Appendix III.

The data showed that the drymatter yield vary significantly due to treatments. The maximum value was recorded by T 14 which was on par with T 13, T 7, T 8, T 9, T 12, T 15, and T 4. The lowest dry matter yield was given by T 1.

9. Harvest index:-

Data on harvest index is given in Table 7 and the analysis of variance in appendix III.

There was no significant change in harvest index due to treatments.

C. Chemical Studies:

a. Uptake studies:

1. Uptake of nitrogen:

Data on nitrogen uptake by plants are given in Table 8 and the analysis of variance in Appendix IV.

Nitrogen uptake by the plants varied significantly due to treatments. T 14 recorded maximum uptake and it was on par with T 13. The minimum value was given by T 1.

Table 8

Uptake of nitrogen, phosphorus and potash (Kg/ha)

Treatments	Uptake of N (Kg/ha)	Uptake of P_2O_5 (Kg/ha)	Uptake of K_2O (Kg/ha)
T1	44.49	5.32	11.77
T2	82.02	9.50	20.42
T3	95.02	9.50	22.62
T4	93.75	12.28	20.71
T5	96.71	11.35	25.33
T6	44.99	6.09	14.90
T7	88.64	11.71	28.52
T8	91.53	12.43	39.85
T9	101.36	10.72	22.43
T10	75.20	9.83	17.83
T11	52.59	6.34	12.20
T12	87.96	11.21	24.16
T13	121.69	13.86	34.85
T14	149.12	22.28	47.52
T15	90.93	13.08	22.25
F test	Sig.	Sig.	Sig.
C D (.05)	39.78	3.72	14.62

2. Uptake of phosphorus:

Data on phosphorus uptake by plants at harvest are given in Table 8 and the analysis of variance in Appendix IV.

The treatments differed significantly in their effects on phsophorus uptake. Maximum uptake was by T 14. T 1 recorded the minimum uptake value.

3. Uptake of potassium:

Data on potassium uptake at harvest are presented in Table 8 and the analysis of variance in Appendix IV.

With respect to potash uptake also the treatments varied significantly. T 14 recorded maximum uptake and it was on par with T 4, T 8 and T 13. T 1 gave the minimum value.

b. Soil analysis

1. Total nitrogen content of the soil after the experiement:

The mean values are furnished in Table 9 and the analysis of variance in Appendix IV.

There was no significant difference between the treatments in their effect on the total nitrogen content of the soil after the experiment. However, T 12 recorded the maximum value.

2. Available phosphorus content of the soil:

The data on available phosphorus content of soil after the experiment are presented in Table 9 and the analysis of variance in Appendix IV.

Table 9

Total nitrogen, available phosphorus and available potash contents of soil after the experiment

Treatment	Total N content (Kg/ha)	Available phosphorus content (Kg/ha)	Available potash content (Kg/ha)
T1	800	44.00	44.0
T2	1033	46.67	38.67
T3	1000	46.67	41.33
T4	1167	47.33	33.33
T5	800	44.67	49.33
T6	500	50.67	49.33
T7	700	53.0	34.0
T8	500	61.33	35.33
T9	600	58.0	34.67
T10	500	48.0	34.67
T11	767	46.0	36.0
T12	1467	50.0	36.0
T13	1100	57.33	34.00
T14	950	54.0	45.33
T15	950	52.67	46.67
F test	N.S.	Sig.	N.S.
C D (0.5)	..	9.85	...

The treatments varied significantly in their effect on the available phosphorus content of soil. The maximum value was recorded by T 8 which was on par with T 9, T 13, T 14, T 7, T 15 and T 6. The minimum value was given by T 1.

3. Available potassium content of the soil:

Data on available K content of the soil after the experiment are given in Table 9 and the analysis of variance in Appendix IV.

The effect of the treatments on available K content of the soil was not significant.

D. Quality characters:

1. Protein content of grain:

Data on protein content of grain are given in Table 10 and the analysis of variance in Appendix V.

There was significant difference between treatments in their effect on this quality character. Maximum protein content was recorded by T 14 which was significantly superior to all other treatments. T 13 gave the next value and it was on par with T 12, T 15, T 3, T 9, T 2, T 8, T 5, T 10, T 7, T 11. T 6 recorded the lowest value.

2. Grain protein yield:

Data on grain protein yield are furnished in Table 10 and the analysis of variance in Appendix V.

Table 10

Protein content of grain, grain protein yield and protein content of bhusa.

Treatment	Protein content of grain (percent)	Grain protein yield (Kg/ha)	Protein content of bhusa (percent)
T1	17.02	113.04	11.29
T2	24.17	237.14	12.88
T3	24.36	269.02	14.77
T4	24.85	312.46	16.13
T5	23.57	279.28	13.73
T6	14.94	134.72	10.98
T7	21.81	256.73	13.06
T8	23.92	298.31	13.83
T9	24.29	239.36	11.63
T10	23.19	222.35	11.64
T11	21.46	180.44	9.9
T12	25.11	259.33	14.84
T13	25.19	354.38	16.17
T14	29.90	481.91	15.5
T15	24.98	297.13	14.4
F test	Sig.	Sig.	N.S.
C D (.05)	4.69	66.22	...

Grain protein yield of the crop varied significantly due to treatments. T 14 was significantly superior to all other treatments. T 13 recorded the next higher value and was on par with T 4, T 8 and T 15. The minimum grain protein yield was recorded by T 1.

3. Protein content of bhusa:

Data on protein content of bhusa are given in Table 10 and the analysis of variance in Appendix V.

No significant difference between treatments was observed in their effect on this character.

Correlation Studies:-

Correlation study was conducted between yield and yield components protein content of grain and protein content of bhusa and also between total dry-matter yield and uptake of nitrogen, phosphorus and potash. The values of simple correlation coefficients are presented in Table 11.

Grain yield was significantly and positively correlated with yield components like number of pods per plant, number of seeds per pod, length of pod, seed yield per plant and the uptake of nitrogen, phosphorus and potash. The correlation co-efficients were 0.4853, 0.3438, 0.3345, 0.3845, 0.6603, 0.8637 and 0.6904 respectively.

Table 11

Values of simple correlation coefficients

Sl. No.	Characters correlated	Correlation coefficients
2.	Grain yield x Number of pods per plant	0.4853 *
2.	Grain yield x Number of seeds per pod	0.3438 *
3.	Grain yield x length of pod	0.3345 *
4.	Grain yield x seed yield per plant	0.3245 *
5.	Grain yield x N uptake	0.6603 *
6.	Grain yield x phosphorus uptake	0.8637 *
7.	Grain yield x potash uptake	0.6904 *
8.	Protein content of grain x protein content of bhusa	0.3117 *
9.	Dry matter yield x Nitrogen uptake	0.92 *
10.	Dry matter yield x phosphorus uptake	0.7266 *
11.	Dry matter yield x potash uptake	0.7891 *

Protein content of grain was positively and significantly correlated with protein content of bhusa with a correlation coefficient of 0.3117.

Total drymatter yield was also positively and significantly correlated with uptake of nitrogen, phosphorus and potash and the values of correlation coefficient are 0.92, 0.7266 and 0.7891 respectively.

Discussion

5. DISCUSSION

The results of the investigation to evaluate the comparative efficiency of soil and foliar application of nitrogen and phosphorus on the growth, yield and quality of blackgram are discussed below.

A. Growth characters

1. Height of plants

An appraisal of Table 2 showed that the plant height varied significantly due to treatments in all the stages of growth except the first ie, 20 days after sowing. On 20th day there was no significant difference in plant height by the application of either nitrogen or phosphorus alone or both nitrogen and phosphorus either as a single basal dose or partly through soil and partly through foliage. But as the season progressed application of small doses of nitrogen alone and combined application of nitrogen and phosphorus, through the leaves at various stages of growth enhanced plant height. But the application of phosphorus, even through the leaves had no significant effect on plant height. Similar nonsignificant effect of phosphorus application was noticed by Gill and Cheema (1976) in summer mung.

In general, plants which received both nitrogen and phosphorus were superior to those which received either nitrogen or phosphorus alone. This is in agreement with the findings of Shukla (1964).

Regarding the method of application, combined application of nitrogen and phosphorus in three equal split doses -- at sowing as a basal dose, through the foliage at the vegetative phase and at flowering - ie, (T14) was found to be the best treatment. However there was no significant difference between this treatment and application of nitrogen alone in two (at sowing and at flowering) or three (at sowing, at the vegetative phase and at flowering) equal split dressings. Here top dressings were given through the foliage. The nitrogen applied through the leaves at the vegetative phase and at flowering might have increased the nitrogen content in the vegetative parts resulting in increased plant height. Reddy et al (1981) also obtained similar results.

Plants which received the full amount of nitrogen or phosphorus or both in a single dose at sowing were comparatively shorter. This may be due to the reduced activity of the nitrogen fixing bacteria in the root nodules resulting in reduced nitrogen fixation.

But applying a small quantity of nitrogen and phosphorus was found to be beneficial in the early stages of crop growth. Sij et al (1979) also obtained similar results in soybean.

2. Number of leaves per plant

It can be seen from Table 3 that the treatments had significant effect on the leaf number only at one stage, ie, 60 days after sowing. Combined application of nitrogen and phosphorus resulted in more leafy plants compared to the application of nitrogen of phosphorus alone. However even the combination was insignificant in its effect on this character, in the early stages of crop growth. Regarding the method of fertilizer application, applying the nutrients partly through soil and partly through foliage was found to be more effective.

Maximum number of leaves was found in the treatment T 13 where nitrogen and phosphorus were given half through soil as a basal dose and the remaining half in two equal split dressings -- at the vegetative phase and at flowering -- through the foliage. However there was no significant difference between this treatment and treatment T14 where the application of nitrogen and phosphorus in three equal split doses - the first through soil as basal and the remaining through foliage at the vegetative phase and at flowering and also when nitrogen alone was applied half through soil + half through foliage in two equal split dressing ie, T3 treatment or 1/3 through soil and 2/3 in two equal split dressing through the foliage ie, T4 treatment. This might be due to the fact that nitrogen applied to the foliage might have been immediately absorbed and utilised for leaf production. Similar beneficial affects of nitrogen application on leaf number was noticed by Minchin et al (1981) in cowpea.

It was also observed that phosphorus when applied alone did not have much influence on leaf number but when applied along with nitrogen it increased the number of leaves per plant significantly. This is in agreement with the findings of Ezedinma (1965) in cowpea and Annamma George (1980) in blackgram.

In all the treatments tried, the leaf number was found to be less at the maturity stage compared to the other stages. This might be due to the increased senescence of leaves at this stages as a result of the mobilisation of nutrients to the developing pods. However the treatments which received a foliar spray of nitrogen at flowering retained more leaves compared to the others.

3. Leaf area index

The table 4 revealed that the leaf area indices varied significantly due to treatments only on the 60th day after sowing, ie, pod development stage. Thomas George (1981) also obtained similar results in cowpea.

Here also combined application of nitrogen and phosphorus was better than applying each nutrient individually. Regarding the method of nutrient application - applying nitrogen and phosphorus in three equal split doses. -- first as a basal dose and the subsequent dressings as foliar spray was the best one. Maximum leaf area index was recorded by the treatment T14 (Nitrogen and phosphorus 1/3 as basal + 2/3 in two equal split dressings through the foliage, at the vegetative phase and at flowering). This is due to the higher number of leaves they possessed. Similar results were obtained by Thomas George (1981) in cowpea.

Although the combination effect alone was significant, application of nitrogen alone partly through soil and partly through foliage also recorded comparatively higher values of leaf area indices. This is due to the higher number of leaves recorded by these treatments.

But the application of phosphorus alone either through soil or through soil and foliage did not have any favourable influence on leaf area index. While studying the response of soil and foliar application of phosphorus on peas Kherde and Yawalkar (1966) also obtained similar nonsignificant effects of phosphorus on leaf area index. According to Duraiswamy Reddy and Palaniappan (1979) leaf area index of greengram was not influenced by phosphorus application.

4. Number of branches per plant

It was evident from Table 5 that the application of either nitrogen or phosphorus alone or both nitrogen and phosphorus did not have any significant effect on this growth character. The method of fertilizer application too was insignificant in its effect on branch number.

Shukla (1964) and Bhattacharya (1971) found no significant variation in branch number due to nitrogen application in gram. Annamma George (1980) observed no significant difference in branch number due to the application of different levels of phosphorus in blackgram.

5. Number of nodules per plant

Data presented in Table 5 showed that the number of nodules per plant varied significantly due to treatments. Here also combined application of nitrogen and phosphorus was found to be better than applying nitrogen or phosphorus alone. As far as method of application was concerned, applying a portion of the nutrients through soil and the remaining part through foliage was more effective when compared with the soil application of the entire quantity of nutrients.

Maximum number of nodules was noticed in the treatment T12 where nitrogen and phosphorus were given 1/2 through soil as basal dose and 1/2 through foliage in two equal split dressings at the vegetative phase and at flowering. The nitrogen applied along with phosphorus might have enhanced the development of nodular tissue resulting in better nodulation and nitrogen fixation.

The results also pointed out that application of phosphorus alone (Half through soil and the remaining 1/2 in two equal split dressings through the foliage or 1/3 through soil and 2/3 in two equal split dressing through the foliage) was as effective as the treatment T12. This is in line with the findings of Nair et al (1970), Sinha (1971), Jones et al (1977), Singh (1977) and Haque et al (1980)

Table 6 also showed that nitrogen application either through soil or through both soil and foliage did not have any significant effect on the number of nodules per plant. This is in agreement with the findings of Singh (1968) and Saadati et al (1978) in soyabean, Sundaram et al (1979) in bengalgran and Annamma George (1980) in blackgram. Nitrogen applied to the plants in the early stages of growth might have retarded the activity of nodule bacteria thus reducing the number of nodules per plant.

6. Dry weight of nodules per plant

It was evident from Table 5 that the treatments differed significantly in their effect on the dry weight of nodules. Maximum value was recorded by T12 (nitrogen and phosphorus 1/2 through soil + 1/2 through foliage at flowering). Here also combination of nitrogen and phosphorus was superior to the individual effects of either nitrogen or phosphorus alone. The favourable effect of the combination on nodule number might have contributed to the increased nodule dry weight also.

Regarding the method of fertilizer application applying the fertilisers in a single dose through the soil at sowing time recorded the minimum dry weight of nodules. But nutrient application partly through soil and partly through foliage was the best method tried.

Application of phosphorus alone partly through soil and partly through foliage (T8 and T9) increased the dry weight of nodules significantly. Despande and Bathkal (1965) observed no significant difference between 20 lb P_2O_5 supplied through soil and 10 lbP_2O_5 supplied through foliage in their effect on nodules dry weight.

In the case of nitrogen, Table 6 indicated that, applying a meagre quantity through soil at the time of sowing and the remaining portion through the foliage at the vegetative phase and at flowering when there was peak demand for nitrogen, increased the nodule dry weight significantly. The quantity supplied in the initial stages might have helped in better plant establishment and the foliar applications were done when there was much demand for this nutrient. Minchin et al (1981) obtained similar results in cowpea.

B. Yield and yield attributes

1. Number of pods per plant

It was evident from Table 6 that the treatment had significant effect on the number of pods per plant. Combined application of nitrogen and phosphorus was more effective than applying either nitrogen or phosphorus alone. This is in agreement with the findings of Ramaswamy and Ramaiah (1981). Regarding the method of applications, applying 1/3 of the nutrients through soil and the remaining 2/3 in two equal split doses through the foliage at the vegetative phase and at flowering was the best method.

Maximum number of pods was recorded by the treatment T14 (Nitrogen and phosphorus 1/3 through soil + 2/3 in two equal split applications through the foliage at the vegetative phase and at flowering). But the treatment T13 (nitrogen and phosphorus 1/2 through soil + 1/2 in two equal split dressings through the foliage at the vegetative phase and at flowering), T8 (phosphorus 1/2 through soil + 1/2 in two equal split dressings through the foliage) and T7 (phosphorus 1/2 through soil + 1/2 through foliage at flowering) were on par with T14.

The result showed that even though N and P combinations recorded maximum value in pod number, application of phosphorus alone (partly through soil and partly through foliage) also had significant influence on number of pods per plant. This may be due to the indirect effect of phosphorus on pod development by increasing the number of nodules per plant which in turn might have fixed adequate quantity of atmospheric nitrogen. The observation in the present study was in agreement with the findings of Jones et al (1977) in Soybean and Singh et al (1980) in field pea.

Fig.3 Number of pods per plant

Treatments

	Basal (Soil)	Vegetative Phase (Foliar)	Flowering (foliar)
T_1	N full (20kgN/ha)	..	..
T_2	½ N	..	½ N
T_3	½ N	¼ N	¼ N
T_4	1/3 N	1/3 N	1/3 N
T_5	½ N	..	¼ N
T_6	P full (30kg P_2O_5/ha)	..	..
T_7	½ P	..	½ P
T_8	½ P	¼ P	¼ P
T_9	1/3 P	1/3 P	1/3 P
T_{19}	½ P	..	¼ P
T_{10}	N + P full (20 Kg N + 30kg/P_2O_5/ha)	..	..
T_{12}	½ N+½ P	..	½ N + ½ P
T_{13}	½ N + ½ P	¼ N + ¼ P	¼ N + ¼ P
T_{14}	1/3 N + 1/3 P	1/3 N + 1/3 P	1/3 N + 1/3 P
T_{15}	½ N + ½ P	..	¼ N + ¼ P

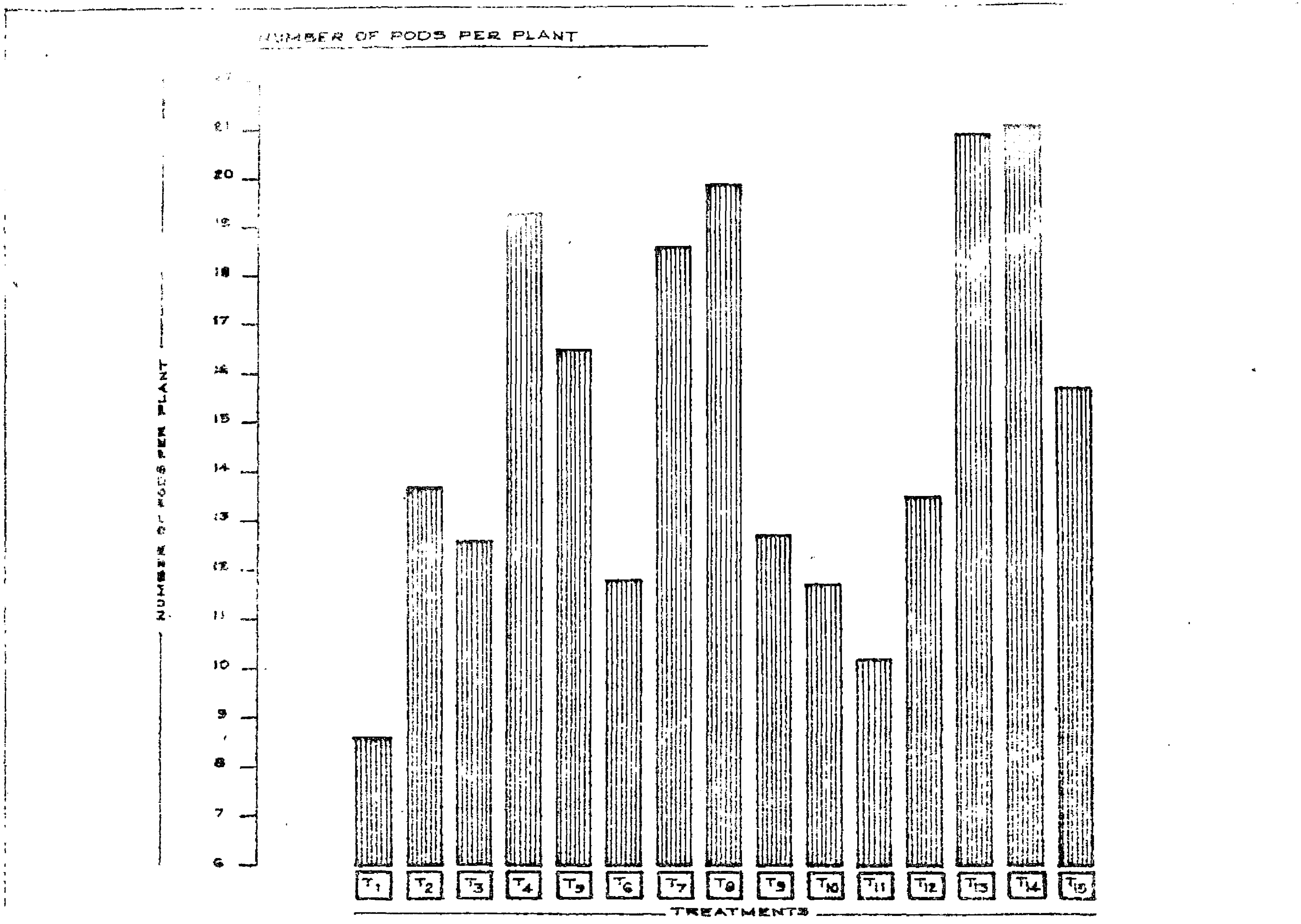

NUMBER OF PODS PER PLANT
NUMBER OF PODS PER PLANT
20
18
17
15
14
13
10
9
8
7
6
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
T13
T14
T15
TREATMENTS

Table 6 also showed that T1 (nitrogen full dose as basal)recorded the minimum value. But T4 (nitrogen 1/3 through soil as basal + 2/3 in two equal split dressings through foliage) was on par with T14, This may be due to the fact that in T4 only a meagre quantity of nitrogen was given at the time of sowing just enough for plant establishment, and the remaining portions were given at stages when there was peak demand for nitrogen for the formation and development of reproductive structures. This is in line with the findings of Patra (1974), Summerfield (1975), Rabie et al (1979) and Minchin et al (1981)

2. Length of pod

It was evident from Table 6 that the application of nitrogen or phosphorus or their combination either completely through soil or partly through soil and partly through foliage had no significant effect on the length of pods. Thus it was evident that the combination effect of nitrogen and phosphorus was equal to that of their individual effects. Applying the nutrients completely through soil and partly through soil and partly through foliage also had similar influence on this yield attribute. This is in confirmity with the findings of Reddy and Palaniappan (1979) in greengram and

Annamma George (1980) in blackgram.

3. Number of seeds per pod

An appraisal of Table 6 showed that all the treatments under trial were uniform in their effect on the number of seeds per pod. So there was no significant differencebetween treatments in their effect on this yield attribute.

Application of nitrogen and phosphorus either alone or in combinationwere equal in their effects on the number of seeds per pod. Regarding the method of application, applying the nutrients either fully through soil or partly through soil and partly through foliage were equally effective in increasing the number of seeds per pod. Since there was no significant difference between treatments in their effect on the length of pod the number of seeds per pod was also unaffected by the treatments. Similar results were obtained by Annamma George (1980) in blackgram.

4. Seed yield per plant

Data presented in Table 6 revealed that the treatments had significant effect on the seed yield per plant. The treatment T14 (nitrogen and phosphorus 1/3 through soil + 2/3 through foliage in two equal split dressings at the vegetative phase and at flowering) recorded the maximum value. Since maximum number of pods was recorded by this treatment, highest seed yield noted could be justified. This result showed the superiority of combined application of nitrogen and phosphorus over their individual effects. The split application of nutrients partly through soil as basal and partly through foliage at different growth stages was found to be better than applying the entire quantity as basal dose.

However the treatments T13 (nitrogen and phosphorus 1/2 through soil + 1/2 through foliage in two equal split dressings at the vegetative phase and at flowering) and T12 (nitrogen and phosphorus 1/2 through soil + 1/2 through foliage at flowering) were equally effective. This is in line with the findings of Panda (1972).

However treatment T7 (phosphorus 1/2 through soil + 1/2 through foliage at flowering), T8 (phosphorus 1/2 through soil + 1/2 through foliage in two equal split dressings at the vegetative phase and at flowering) and T4 (nitrogen 1/3 through soil + 2/3 in two equal split dressings at the vegetative phase and at flowering) were on par with T14. These results indicated the favourable effect of split application of nutrients through soil and foliage at different growth stages compared to their soil application in a single dose. Similar results were obtained by Peeran et al (1970)

These results also emphasised that the application of phosphorus or nitrogen partly through soil and partly through foliage also gave singnficantly, higher seed yield although their combination recorded the maximum value. Small amounts of nitrogen and phosphorus given might have enhanced the nodulation and nitrogen fixation resulting in higher seed yield. It was shown by Subramonian and Palaniappan (1980) that in blackgram foliar application of 12.5 Kg phosphorus per hectare was as effective as the combined foliar application of 10 Kg. nitrogen and 12.5 Kg phosphorus per hectare. Iswaran and Sen (1973) also obtained similar results.

5. Hundred seed weight

Table 6 showed that the hundred seed weight varied significantly due to treatments. T7 (phosphorus 1/2 through soil + 1/2 through foliage at flowering) recorded the maximum value. This is in agreement with the findings of Ahlawat (1979) in cowpea. Other treatments like T14 (nitrogen and phosphorus 1/3 through soil as basal + 2/3 in two equal split doses through foliage), T13 (nitrogen and phosphorus 1/2 through soil as basal + 1/2 through foliage in 2 equal split dressings), T15 (nitrogen and phosphorus 1/2 through soil as basal + 1/4 through foliage at flowering), T8 (phosphorus 1/2 through soil as basal + 1/2 in two equal split doses through foliage), T10 (phosphorus 1/2 through soil as basal + 1/4 through foliage at flowering), T4 (nitrogen 1/3 through soil + 2/3 in two equal split doses through foliage) and T2 (nitrogen 1/2 through soil as basal + 1/2 through foliage at flowering) were on par with it. These results showed that the application of nutrients either alone or in combination through the foliage at the later stages of crop growth is effective in increasing the hundred seed weight.

6. Grain yield

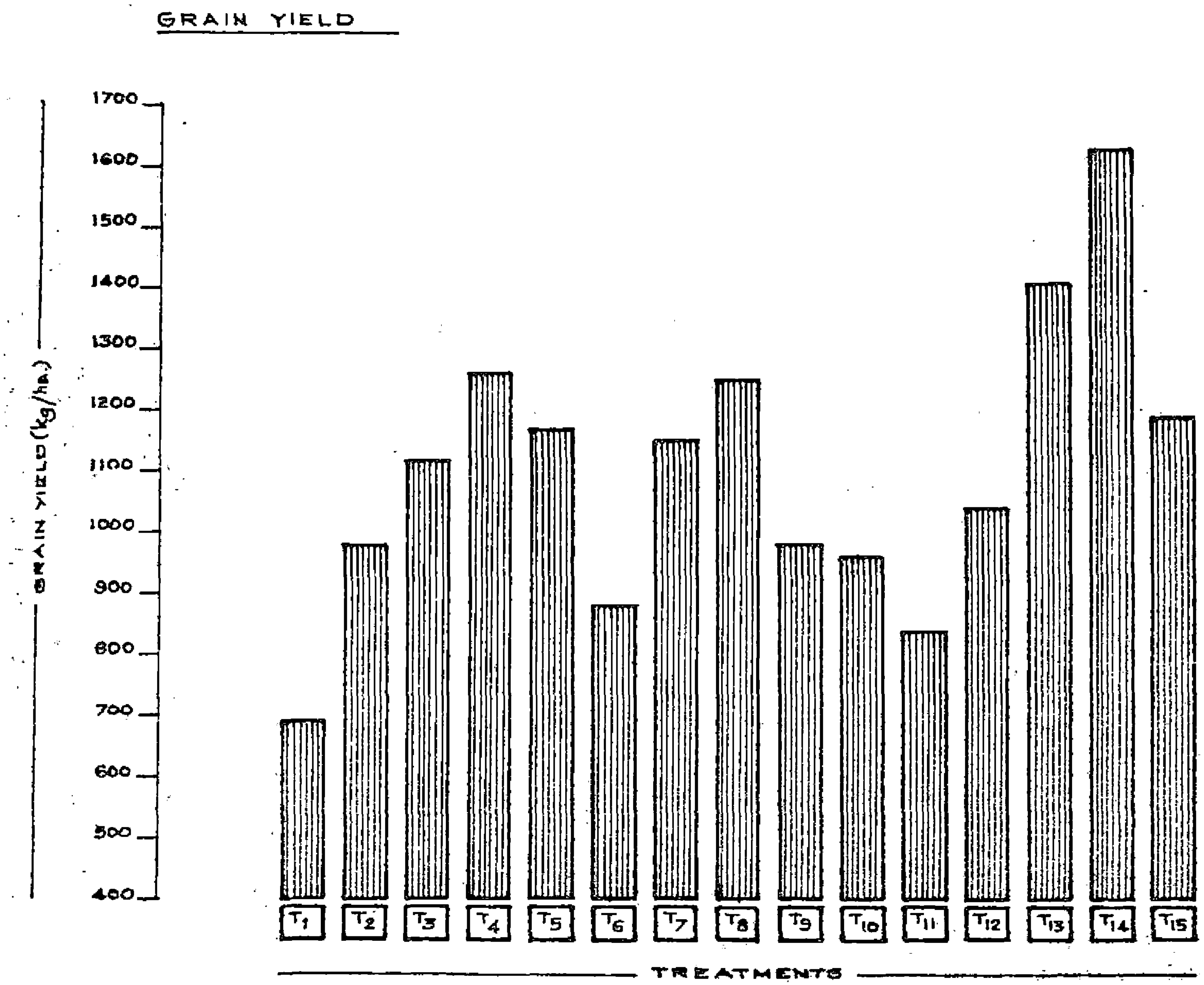
Data presented in Table 7 revealed that the treatments differed significantly in their effects on grain yield. Here also combination of nitrogen and phosphorus was superior to their individual effects. Regarding the method of fertilizer application, applying a small quantity of nutrients through the soil at the time of sowing and the remaining portion in split doses through the foliage at later stages was found to be the best method.

Maximum grain yield was recorded by T14 (nitrogen and phosphorus 1/3 through soil + 2/3 in two equal split doses through the foliage) and it was on par with T13

Fig. 4 Grain yield (Kg/ha)

Treatments

	Basal (Soil)	Vegetativepphase (Foliar)	Flowering (Foliar)
T1	N full (20 kgN/ha)	..	..
T2	½ N	..	½ N
T3	½ N	¼ N	¼ N
T4	1/3 N	1/3 N	1/3 N
T5	½ N	..	¼ N
T6	P full (30 kg P_2O_5/ha)	..	..
T7	½ P7	..	½ P
T8	½ P	¼ P	¼ P
T9	1/3 P	1/3 P	1/3 P
T10	½ P	..	¼ P
T11	N and P full (20kg N + 30 kg P_2O_5/ha)	..	..
T12	½ N + ½ P	..	½ N + ½ P
T13	½ N + ½ P	¼ N + ¼ P	¼ N + ¼ P
T14	1/3 N + ½ P	1/3 N + 1/3 P	1/3 N + 1/3 P
T15	½ N + ½ P	..	¼ N + ¼ P



GRAIN YIELD
GRAIN YIELD (kg/ha.)
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
T13
T14
T15
TREATMENTS

(nitrogen and phosphorus 1/2 through soil + 1/2 in two equal split doses through the foliage). Yield contributing factors like number of pods per plant, seed yield per plant, hundred seed weight etc, were also higher for these treatments which might have led to the higher seed yields in them. Similar significant effects of combined application of nitrogen and phosphorus on grain yield was noted by Shukla (1964), Pillai et al (1980), Ramaswamy and Ramaiah (1980) and Subramonian and Palaniappan (1980).

7. Bhusa yield

The nonsignificant effect of the treatments on bhusa yield was evident from Table 7. This may be due to the nonsignificant effect of the treatments on most of the growth characters studied, at the time of harvest. However, T14 (applying nitrogen and phosphorus together partly through soil and partly through foliage) recorded comparatively higher bhusa yield than applying either nitrogen or phosphorus alone.

8. Total drymatter production

An appraisal of Table 7 indicated that total drymatter yield varied significantly due to treatments. Combination of nitrogen and phosphorus was superior to the individual effects of either nitrogen or phosphorus alone. As far as method of application is concerned, applying a part of the nutrients through soil as basal dose and the remaining part through the foliage in two equal split dressings at the vegetative phase and at flowering was found to be the best method.

The treatment T14 (nitrogen and phosphorus 1/3 through soil + 2/3 in two equal split dressings through the foliage) recorded the maximum drymatter yield. This may be because of the significant influence of this treatment on grain yield and yield promoting characters.

9. <u>Harvest index</u>

Data presented in Table 7 indicated the non-significant effect of the treatments on harvest index. This result explains the unfavourable influence of the treatments on the economic yield of the crop. However T15 (nitrogen and phosphorus 1/2 through soil as a basal dose + 1/4 through foliage at flowering) and T13 (nitrogen and phosphorus 1/2 through soil + 1/2 through foliage in two equal split dressings at the vegetative phase and at flowering) showed a slight increase in the ratio though it did not reach the level of significance.

C. Chemical studies

a. Uptake studies

1. <u>Uptake of nitrogen</u>

Nitrogen uptake by the plants varied significantly due to treatments. Combined application of nitrogen and phosphorus resulted in better nitrogen uptake compared to the application of each nutrient independently. T14 (nitrogen and phosphorus 1/3 through soil as basal + 2/3 in two equal split dressings through the foliage) recorded maximum nitrogen uptake. Enhanced drymatter production might be the reason for better uptake. This is in accordance with the findings of Yadava and Chokhey Singh (1978) in greengram who observed increased uptake of nitrogen due to the combined application of nitrogen and phosphorus.

T1 (nitrogen alone completely given as a basal dose) and T6 (phosphorus alone given in a single basal dose) recorded the minimum values of uptake of nitrogen. But the application of nitrogen alone, partly through soil and partly through foliage also recorded relatively higher values of nitrogen uptake. These results emphasised the favourable effect of split application of nutrients through soil and foliage on nitrogen uptake.

2. Uptake of phosphorus

The treatments differed significantly in their effect on phosphorus uptake (Table 8). Among the treatments T14 recorded maximum uptake and it was significantly superior to all other treatments. This may be due to the significant influence of this treatment on total drymatter yield. Table 11 showed the positive and significant correlation between total drymatter yield and phosphorus uptake. This is in line with the findings of Annamma George (1980)

3. Uptake of potassium

The Table 8 revealed that the treatments varied significantly in their effect on potassium uptake. Maximum uptake was by T14 and it was on par with T4, T8 and T13. As shown in Table 11 there was positive and significant correlation between potassium uptake and total drymatter yield. The higher uptake of potassium by these treatments may be due to their significant influence on the drymatter yield. Annamma George (1980) also obtained similar results in blackgram.

b. Soil analysis

1. Total nitrogen content of soil after the experiment

The result on the content of nitrogen in the soil after the experiment indicate that the treatments have not significantly affected the residual nitrogen in the post harvest soil samples. This might be due to the insufficiency of the kjeldahl nitrogen determinating method to monitor the small differences in total nitrogen content of soil and also due to the difference between treatments in their effect on symbiotic fixation and excretion of nitrogen into the soil.

2. Available phosphorus content of soil

An appraisal of Table 9 showed that the available phosphorus content of soil was significantly influenced by the treatments. T8 (phosphorus 1/2 through soil as basal + 1/2 through foliage in two equal split dressings) recorded maximum value. Since nitrogen was not given in this treatment, in the absence of nitrogen phosphorus might not have been completely utilized resulting in increased phosphorus content of soil.

3. Available potassium content of soil

The available potassium content of soil was not influenced by the treatments. The available potassium status of the soil remained uniform showing the nonsignificant effect of the various treatments on this character. Potassium was supplied uniformly in all the plots. Being a mobile cation, a major portion of applied

K might have been lost through leaching. The crop also removed sufficient quantities of this nutrient. So the relatively small quantity of applied potassium could not produce any significant effect on its content in the soil. Similar results were obtained by Annamma George (1980).

D. Quality characters

1. <u>Protein content of grain</u>

Data presented in Table 10 revealed the significant influence of the treatments on the protein content of grain. In this case also combination of nitrogen and phosphorus was superior to the individual effects of each nutrient. Regarding the method of application, applying the nutrients partly through soil and partly through foliage was the best one. T14 (nitrogen and phosphorus 1/3 through soil as basal + 2/3 through foliage in two equal split doses) recorded maximum protein content of grain and it was superior to all other treatments. The higher protein content in grain was attributed to the higher nitrogen content in them. Similar results were obtained by Tej Singh <u>et al</u> (1975) and Agarwal and Narang (1975).

2. <u>Grain protein yield</u>

An appraisal of Table 10 showed that grain protein yield varied significantly due to treatments.

Protein content of grain was influenced by the treatments and hence the grain protein yield also showed the same trend. Maximum value was recorded by T14 which was significantly superior to all other treatments. T13 (nitrogen and phosphorus 1/2 through soil + 1/2 through foliage in two equal split dressings) gave the next lower value. These results indicated the favourable effect of combination of nitrogen and phosphorus on grain protein yield compared to their individual effects. Also the favourable effect of nutrient application partly through soil and partly through foliage was shown here.

3. Protein content of bhusa

The table 10 on protein content of bhusa pointed out that this quality character was not influenced by the treatments under trial. This may probably be due to the nonsignificant effect of the treatments on nitrogen content of bhusa as the nitrogen and protein content are directly related.

Economics of production

A maximum net profit of Rs.3247.80 per hectare was obtained by the treatment which received both nitrogen and phosphorus 1/3 through soil as a basal dose + 2/3 in two equal split doses through the foliage at the vegetative phase and at flowering.

The next lower values of the Rs.2905.60. Rs.2537.90 and Rs.2243.52 per hectare were recorded by T15, T13 an T4 respectively. The treatments which received either nitrogen or phosphorus alone or both nitrogen and phosphorus through soil in a single dose ie, T1, T6 and T11 obtained the lowest net profits thus emphasising the favourable effect of applying the nutrients partly through soil and partly through foliage (Table 12).

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Summary

6. SUMMARY

An experiment was conducted in the rice follows of the Rice Research Station, Kayamkulam during the summer season of 1981-'82 (30.1.1982 to 19.4.1982) to find out the influence of the method of application of N and P on the growth, yield and quality of blackgram. The experiment was laid out in Randomised Block Design with fifteen treatments, replicated thrice. The results of the study are summarised below.

1. The plant height was not significantly influenced by the treatments at the first stage ie, 20th day after sowing. But during the subsequent stages ie, 40th day after sowing, 60th day after sowing and at harvest, plant height showed significant difference due to treatments. Combined application of nitrogen and phosphorus 1/3 through soil as a basal dose + 2/3 in two equal split dressings through the foliage at the vegetative phase and at flowering recorded the maximum plant height.

2. Significant influence of the treatments on the number of leaves per plant was noticed only on the 60th day after sowing. Here also combination of nitrogen and phosphorus was the best treatment, compared to their individual effects, recording maximum leaf number.

3. The treatments had significant influence on the leaf area index only on the 60th day after sowing. Combined application of nitrogen and phosphorus 1/3 through soil as basal + 2/3 in two equal split dressings through the foliage, recorded the maximum value.

4. Neither the individual effects of nitrogen and phosphorus nor their interation were significant in increasing the number of branches per plant.

5. The number of nodules also varied significantly due to treatments. Maximum number was recorded by the treatment given both nitrogen and phosphorus 1/2 through soil as a basal dose + 1/2 through foliage at flowering. Application of phosphorus alone partly through soil and partly through foliage (T8 and T9) also favourably influenced this character.

6. In the dry weight of nodules per plant also, combined application of nitrogen and phosphorus 1/2 through soil as a basal dose + 1/2 through foliage at flowering recorded the maximum value and it had significant effect on this character.

7. Yield attributing characters like length of pod and number of seeds per pod were not significantly influenced by either nitrogen or phosphorus or both. But the number of pods per plant, seed yield per plant and hundred seed weight were significantly affected by the treatments. In the case of number of pods and seed yield per plant combined application of nitrogen and phosphorus 1/3 through soil as a basal dose + 2/3 in two equal split dressings through the foliage recorded the maximum value. But regarding hundred seed weight, application of phosphorus alone 1/2 through soil + 1/2 through foliage at flowering recorded the highest value.

8. Grain yield was significantly influenced by the treatments. Here also combined application of nitrogen and phosphorus partly through soil as basal and partly through foliage at different growth stages gave the highest value.

9. Neither the individual effects of nitrogen and phosphorus nor their interaction had any significant influence on haulm yield.

10. Total drymatter production varied significantly due to the treatments and the maximum drymatter yield was recorded by the treatment given both nitrogen and phosphorus 1/3 through soil as basal + 2/3 in two equal split doses through the foliage.

11. Harvest index was not significantly affected by the treatments.

12. Combined application of nitrogen and phosphorus either 1/2 or 1/3 through soil as basal and the remaining portion in two equal split doses through the foliage, alone were significant in increasing the uptake of nitrogen by the plants.

13. Phosphorus uptake also varied significantly due to treatments. Combined application of nitrogen and phosphorus 1/3 through soil as basal + 2/3 in two equal split dressings through the foliage recorded the maximum uptake.

14. Individual effect of nitrogen and phosphorus as well as their combinations were significant in increasing the uptake of potash when the nutrients were supplied partly through soil as basal and partyly through foliage at different growth stages.

15. The total nitrogen content of soil after the experiment was not influenced significantly by the treatments.

16. Available phosphorus content of the soil differed significantly due to treatments and maximum content was recorded by the treatment which was given phosphorus alone 1/2 through soil as basal + 1/2 through foliage in two equal splits.

17. Available potassium content of the soil was not significantly influenced by any of the treatment.

18. Combined application of nitrogen and phosphorus 1/3 through soil as basal + 2/3 in two equal split doses through the foliage alone was significant in increasing the protein content of grain.

19. Grain protein yield followed the same pattern as that of the protein content of grain.

20. Neither the individual effects of nitrogen and phosphorus nor their combination were significant in increasing the protein content of bhusa.

21. Grain yield was significantly and positively correlated with the yield attributes, nitrogen uptake phosphorus uptake and potash uptake.

Drymatter yield was also positively and significantly correlated with the uptake of nitrogen, phosphorus and potash.

22. The maximum net profit of Rs.3254.80 per hectare was obtained with the application of both nitrogen and phosphorus 1/3 through soil as basal + 2/3 in two equal split doses through the foliage at the vegetative phase and at flowering.

The present investigation indicated that blackgram requires combined application of nitrogen and phosphorus 1/3 through soil as a basal dose and 2/3 in two equal split doses through the foliage at the vegetative phase and at flowering for giving higher yield in the rice follows of Onattukara tract.

Future line of work:-

The present study shows that blackgram requires combined application of nitrogen and phosphorus partly through soil and partly through foliage at vegetative phase and at flowering for better growth and yield. This can be tested in other pulse crops like greengram, cowpea, horsegram etc. The influence of nutrient spray application at pod filling stage also needs investigation.

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*Originals not seen.

Appendices

APPENDIX I

Weather data during the crop period and the average for the last five years

Standard weeks (No.)	period	Temperature (°C) Maximum 1982	Avg.	Minimum 1982	Avg.	Relative Humidity % 1982	Avg.	Sunshine hours 1982	Avg.	Rainfall (mm) 1982	Avg.
5	29th Janu -- 4th Feb.	33.4	33.3	21.3	21.9	88	87	10.6	10.2	..	0.08
6	5th -- 11th Feb.	32.8	33.8	21.6	22.3	93	91	10.8	9.4		5.3
7	12th -- 18th Feb.	33.4	33.3	21.0	22.2	92	88	10.9	10.1		1.16
8	19th -- 25th Feb.	33.6	33.5	22.1	22.4	90	91	10.5	9.8		2.04
9	26th -- 4th Mar.	34.4	34.2	22.4	22.8	93	92	10.6	10.5		1.96
10	5th -- 11th Mar.	34.2	34.3	23.2	23.6	93	92	10.3	9.1		9.28
11	12th -- 18th Mar.	34.3	34.3	23.0	24.3	93	92	9.5	9.5		1.92
12	19th -- 25th Mar.	33.7	34.4	23.5	24.3	94	94	9.6	9.3	84.2	10.6
13	26th Mar. -- 1st April	33.6	35.1	23.5	24.6	94	91	9.2	9.7	33.2	3.4
14	2nd -- 8th April	34.4	34.4	25.0	25.3	91	91	10.0	8.4	..	22.64
15	9th -- 15th April	34.6	34.3	25.0	25.7	89	92	9.6	8.2	..	10.92
16	16th -- 22nd April	34.1	34.3	23.6	25.2	91	92	9.9	9.4	40	21.65

APPENDIX II

Abstract of analysis of variance table for growth characters

Sl. No.	Growth character	Mean squares		
		Block (2)	Treatment (14)	Error (28)
1	Height of plants (cms.)			
	20 days after sowing	0.55	0.55	0.48
	40 days after sowing	9.075	16.62**	3.06
	60 days after sowing	3.26	51.40**	3.48
	At harvest	6.76	31.12**	5.96
2	Number of leaves per plant			
	20 days after sowing	.132	0.06	4.06
	40 days after sowing	11.779*	1.858	1.449
	60 days after sowing	1.99	12.33**	1.14
	At harvest	2.50	10.85	10.57
3	Leaf area index			
	20 days after sowing	0.0032	0.0032	0.002
	40 days after sowing	0.33	0.156	0.133
	60 days after sowing	2.08**	0.603*	0.273
	At harvest	0.326	0.39	0.344
4	Number of branches per plant	2.63	0.56	0.798
5	Number of nodules per plant	1.85	23.95**	5.45
6.	Dry weight of nodules per plant	88.97	73.47*	27.03

Figure in paranthesis indicates degrees of freedom.
** Significant at 0.01 level.
* Significant at 0.05 level.

APPENDIX III

Abstract of analysis of variance table for yield components and yield.

Sl. No.		Mean squares Block (2)	Treatment (14)	Error (28)
1.	Yield components			
i)	No. of pods per plant	109.49**	49.15*	18.25
ii)	No. of seeds per pod	0.882*	2.50	2.22
iii)	Length of pod (cm)	0.38*	0.11	0.072
iv)	Seed yield per plant (g)	6.50**	2.99*	.874
v)	Hundred seed weight (g)	0.016	0.054*	0.022
2.	Grain yield (Kg/ha)	218991.36**	166863.78**	27343.62
3.	Bhusa yield (Kg/ha)	514436.42	451334.51	457455.11
4.	Total drymatter yield (Kg/ha)	1245438.95	1270158.45*	563107.48
5.	Harvest Index	0.01	0.002	0.007

Figure in paranthesis indicates degrees of freedom.

** Significant at 0.01 level

* Significant at 0.05 level.

APPENDIX IV

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

Sl. No.		Mean squares		
		Block (2)	Treatment (14)	Error (28)
1.	Uptake of nitrogen (Kg/ha)	1944.44*	2235.26**	566.04
2.	Uptake of phosphorus (Kg/ha)	10.09	48.81**	4.94
3.	Potash uptake (Kg/ha)	45.09	339.10**	76.42
4.	Total nitrogen content of the soil after the experiment (Kg/ha)	80888.89	232103.17	76246.03
5.	Available phosphorus content of the after the experiment (Kg/ha)	58.69	82.59	34.64
6.	Available K content of the soil after the experiment (Kg/ha)	45.87	106.51	174.44

Figure in paranthesis indicates degree of freedom.

** Significant at 0.01 level

* Significant at 0.05 level

APPENDIX V

Abstract of analysis of variance table for quality characters

Sl. No.		Mean squares		
		Block (2)	Treatment (14)	Error (28)
1.	Protein content of grain (%)	13.21	37.24 **	7.88
2.	Grain protein yield (Kg/ha)	21395.90**	23596.41	1567.99
3.	Protein content of bhusa (%)	0.951	11.43	8.67

Figure in paranthesis indicates degrees of freedom.

** Significant at 0.01 level.

INFLUENCE OF THE METHOD OF APPLICATION OF N AND P ON THE GROWTH, YIELD AND QUALITY OF BLACKGRAM [*Vigna mungo* (L.) *Hepper*]

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ABSTRACT OF A THESIS
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A B S T R A C T

An experiment was conducted in the rice follows of the Rice Research Station, Kayamkulam during the summer season of 1981-82 to study the influence of the method of application (soil and foliar) of N and P on the growth, yield and quality of blackgram.

The experiment was laid out in Randomised Block Design with fifteen treatments replicated thrice.

The study revealed that the height of the plant at the last three stages of crop growth was significantly influenced by the combined application of N and P, partly through soil and partly through foliage. At one stage alone the number of leaves per plant and leaf area index were significantly affected by the application of N and P combination partly through soil and partly through foliage. The maximum values were recorded by the treatment given both N and P 1/3 through soil as a basal dose + 2/3 in two equal split doses through the foliage. None of the treatments had any singi significant influence on the number of branches per plant. Nodule number and dryweight of nodules per plant were significantly influenced by the application of phosphorus alone 1/2 through soil as a basal dose and 1/2 through foliage at flowering.

Yield and yield attributes were significantly influenced by the combined application of N and P partly through soil and partly through foliage. Maximum grain yield of 1631 kg per hectare was recorded by the treatment given N and P 1/3 through soil as basal + 2/3 in two equal split doses through the foliage. The total drymatter production also significantly varied due to the combination effect.

Combined application of N and P partly through soil and partly through foliage alone was significant in increasing nitrogen uptake and in the case of phosphorus and potash uptake also this treatment recorded the maximum value.

Combined application of N and P 1/3 through soil and 2/3 in two equal split doses through the foliage alone, was significant in increasing the protein content of grain and grain protein yield. But none of the treatments had any significant effect on the protein content of bhusa.

Positive and significant correlation between grain yield and yield attributes like number of pods per plant, number of seeds per pod, length of pod and seed yield per plant and also between grain yield and the uptake of nitrogen, phosphorus and potash were noted