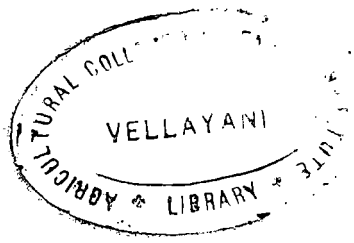
STUDIES ON THE PERFORMANCE OF FIVE VARIETIES OF COWPEA (*Vigna sinensis* Savi.) AND THEIR RESPONSE TO NITROGEN AND PHOSPHATE FERTILIZATION

BY

R. RAVINDRAN NAIR, B. Sc. (Ag.)/



THESIS

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CERTIFICATE

This is to certify that the thesis herewith submitted contains the results of bona fide research work carried out by Sri R. Ravindran Nair under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

(C.K.N. NAIR)
Principal and Additional Director of Agriculture (Research)

(C.M. GEORGE)
Professor of Agronomy

Agricultural College and Research Institute, Vellayani, Trivandrum.

8th August, 1966.

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(R. Ravindran Nair)

C O N T E N T S

LIST OF ILLUSTRATIONS

INTRODUCTION

I N T R O D U C T I O N

Pulses occupy a unique position among the subsidiary food crops of India. These grain legumes form one of the most important sources of protein.

The nutritional standard of the food consumed by the people of this country is far below that of other countries in the world. In terms of calories, the per capita consumption of food energy per day is only 1970 in India, while the world average is 2420. The consumption of fruits, vegetables, pulses, egg, fish, and meat is deplorably inadequate, the protein equivalent being 51 for India, 60 for the other under developed countries and 90 for the developed countries (Sukhatme, 1958-60). The requirement of pulses per day per adult is three ounces, to make the diet a balanced one (Aykroyd). According to this standard, 13.70 million tonnes of pulses would be required in India per annum. But the present production is only 9.87 million tonnes, the deficit being 38.7%. This emphasises the necessity for increasing the production of pulses.

Among the cultivated pulses, cowpea occupies an important position in Kerala because of its adaptibility to varied soil and climatic conditions, short duration, and its high content of protein. It is cultivated mainly in the Khariff season and occupies an area of approximately 14,600 hectares, out of the total area of 43,800 hectares under pulses. The yield of cowpea per unit area is rather low in Kerala when compared to other states, the per hectare yield being only 250 Kg. This low yield may be due to the poor yielding nature of the varieties cultivated and also to inadequate manuring.

Preliminary studies conducted in the Agricultural College, Vellayani in 1963 with 20 new exotic varieties gave an indication that some of the varieties like New Era, M.S.9314, and C_4 could be successfully cultivated under the local conditions (unpublished). But no detailed field trials to study their relative performance were carried out in the locality.

Cowpea is not usually manured except perhaps with a little farm yard manure. It has been universally recognized that yield of legumes can be increased by judicious manuring, especially with phosphorus. Many of the previous Indian workers have pointed out the

necessity of applying phosphorus to pulses in India. But no systematic trials have been conducted in Kerala to study the requirement of nitrogen and phosphorus for a most suitable variety of cowpea. Therefore it was felt necessary to take up a varietal-cum-manurial study on cowpea with the following objectives:

(1) to compare the performance of four improved varieties of cowpea with the common local variety and to find out the best variety suited to the local conditions;

(2) to study the response of these varieties to different levels of nitrogen and phosphate manuring.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Influence of Nitrogen and Phosphorus on Nodulation, Growth, Yield and Quality of Leguminous Crops

1. Effect of nitrogen on nodulation

It was generally believed that a high basal level of nitrogen caused considerable reduction in the formation of root nodules in leguminous plants, until Lipman and Blair (1914, 1915) reported that nodulation in soyabean was not depressed by the application of nitrogenous fertilizers.

Investigations conducted by Pate and Dart (1961) by means of pot culture experiments on the nodulation in cowpeas revealed that nodulation of the primary roots was stimulated by the lower levels of nitrogen (5 to 20 mg. N/pot) applied at sowing, while the higher levels (upto 125 mg. N/pot) decreased nodule formation but increased the nodule size. Kumar and Pande (1962) also reported increase in the number of nodules produced in the roots of gram by the application of inorganic nitrogen.

There are also several findings against the beneficial results of added nitrogen on nodulation. Studies

conducted by Wilson (1917) and Fellers (1918) on soybean, Truesdell (1917) and Hills (1918) on alfalfa brought to light that inorganic nitrogen exerted a depressing influence on nodulation and nitrogen fixation.

Young (1958) reported that nitrogen applied to white clover at the rate of 80 to 100 pounds per acre had no effect on the number of nodules per gramme of root, but nitrogen at 200 lb. per acre caused a significant decrease in the number of large nodules per gramme of root. Nowotny and Zinkiewicz (1959), Gowling (1961), and Mckee (1961) also observed that nitrogen application depressed nodulation in red and white clover. Waber (1966) found similar results in soybeans.

2. Effect of nitrogen on growth

Albrecht (1920), Giobel (1926), Waber (1930) and Schanderl (1943) held the view that small quantities of nitrogen were beneficial to encourage early growth of legumes and that the practice of adding nitrogen did not endanger the capacity of legumes to fix atmospheric nitrogen.

Young (1958) reported that 36 lb. per acre nitrogen applied to white clover in early spring resulted in increased top growth. Kumar and Pande (1962) had also found similar results on gram with nitrogen at 15 lb. per acre.

Russel (1961) opined that nitrogen supply was beneficial for rapid establishment of leguminous crops, particularly, if the seed was small and if the land was worn out.

Ezedinma (1964) found that cowpea seedlings grown in sterile sand inoculated with Rhizobium strains responded well to light dressings of nitrogen. He concluded that light dressings of nitrogen were preferable to seed inoculation owing to the short growing period of the crop.

While studying the response of gram to nitrogen and phosphorus fertilization, Shukla (1964) observed that the rate of elongation of the shoot was in the linear order to the application of nitrogen at 10 and 20 lb. per acre.

3. Effect of nitrogen on the yield and quality

Several workers have reported the beneficial effect of applying nitrogen on the yield and quality

of legumes. Fellers (1918) obtained increased seed yield and protein content in soybeans by the application of sodium nitrate.

Results of experiments conducted by Thronton (1956), Mitchell and Contnoir (1959) and Martin (1959) on red and sweet clover showed that fodder yield and protein content of fodder were increased by nitrogen manuring.

Singh and Sahasrabudhe (1957) studied the response of groundnut to nitrogen at 20 lb. per acre and reported that nitrogen increased the per acre pod yield by 137 lb. in the first season (1951-52) but in the following seasons in 1952-53 and 1953-54, the increase was only moderate, being 93 and 70 lb. per acre respectively, which was not statistically significant.

Khan (1957) observed significant increase in the fodder yield of berseem due to the application of nitrogen at 30 lb. per acre.

There are also reports contrary to the above findings.

Lipman and Blair (1914) found that there was little difference in the seed yield and nitrogen content of soybeans by the application of sodium nitrate.

MacTaggart (1921) reported that when applied singly nitrogen could hardly be said to benefit the plants with respect to seed yield and nitrogen content.

Studies of Sharma and Misra (1961) on the nitrogen manuring of peas at 0, 10 and 20 lb. per acre, indicated no significant difference in seed yield between the levels. In fact, nitrogen at 20 lb. per acre depressed the grain yield, when compared to the no manure treatment.

Singh and Sahasrabudhe (1957) observed slight decrease in yield of redgram with the application of nitrogen at 20 lb. per acre but the decrease in yield was not statistically significant.

Investigations conducted by Shukla (1964) on the nitrogen manuring of gram at the rate of 10 and 20 lb. per acre revealed that nitrogen alone did not effect significant increase in yield in any of the two levels, but the fodder yield was increased by 80.36 and 244.36 lb. per acre by the respective doses of nitrogen. The tendency of applied nitrogen to depress yield was also reported by Moolani and Jana (1965). They found that nitrogen at 25 kg. per hectare caused 5 per cent reduction in the number of pods produced and the quantity of grain yielded by gram, compared to the no manure treatment

4. Effect of phosphorus on nodulation and nitrogen fixation

Phosphorus is one of the most essential nutrients for the growth of all plants. It has a definite stimulatory effect on the multiplication of Rhizobia which in association with leguminous plants fix atmospheric nitrogen. According to Mercer (1948), "the cheapest method of supplying nitrogen is by stimulating the growth of legumes with phosphatic fertilizers.". Robert and Olsen (1944) and Parr and Sen (1948) observed that the uptake of nitrogen by leguminous crops depended on phosphorus supply.

Investigations on the nodule formation and nitrogen fixation of leguminous plants conducted by Moore (1912), Truesdell (1917) and Fellers (1918) brought to light that the presence of phosphates in the soil stimulated the rapid multiplication and nitrogen fixing activity of the microflora and thereby increased the efficiency of the legumes in fixing nitrogen. MacTaggart (1921) found that field peas, alfalfa and soybeans fixed more nitrogen when supplied with phosphorus. Ludecke (1941) and James et al (1944) also reported increase in nodulation and greater fixation of nitrogen in soybeans supplied with phosphorus.

Studies of Vyas and Desai (1953) on the phosphate manuring of peas revealed that application of P_2O_5 at 60 and 120 lb. per acre increased the number and weight of root nodules, and the quantity of nitrogen fixed.

Sen and Bains (1955) in field trials involving treatments with superphosphate to give 16 to 64 lb. P_2O_5 per acre found that increasing rates of phosphorus increased the nodulation in berseem and cowpea. Nair et al (1957) observed significant increase in the number of nodules produced in sesbania raised on laterite soils of Kerala, when supplied with 30 lb. of phosphorus per acre. Similar results were also reported by Izawa and Okomoto (1959) and Lin (1959) in red clover and white clover supplied with phosphorus.

Deshpande and Bathkal (1965) studied the effect of phosphorus at the rate of 20, 40, and 60 lb. per acre on the nodulation of greengram and reported that application of phosphorus at increasing levels increased significantly the number of nodules produced.

While investigating on the nitrogen fixation by clusterbeans in relation to the uptake of phosphorus from the soil, Rewari, Sen and Sen (1965) noticed that

the amount of nitrogen fixed by the crop was positively and significantly related to its phosphorus uptake from the soil. The plants under treatment with superphosphate contained the highest amount of nitrogen as well as phosphorus. They also observed that response was greater in poor soils, than in soils which were fertile.

5. Effect of phosphorus on growth

Rao (1923) and Parr and Bose (1945) found that growth of leguminous plants like dhaincha, cowpea and berseem was significantly increased by phosphate application.

Investigations conducted by Vyas and Desai (1953) on the phosphate manuring of peas revealed that phosphate application at 60 and 120 lb. per acre increased the vegetative growth considerably which resulted in higher straw yield, the percentage of increase being 82.2 and 37.5 for the higher and lower doses over the control. Sen and Saine (1955) observed similar significant results with varying doses of phosphorus from 16 to 64 lb. per acre in cowpea. Chandani and Oberoi (1956) also noticed increase in vegetative growth of cowpea manured with phosphorus at

80 lb. per acre. Johri (1956) studying the effect of application of superphosphate to the green manure crop dhaincha in laterite soils noticed that in phosphate manured plots with 25 lb. P_2O_5 per acre, the average height of plants and the total dry matter yield were 6 and 12 times respectively more than that in the no manure plot. Nair et al (1957) obtained significant increase in height of sesbania with phosphorus at 30 lb. per acre in the laterite soils of Kerala.

According to Jackson and McDermid (1963) phosphate application resulted in greater absorption of nitrogen, increased seedling vigour and stand of alfalfa. Similar observations were reported by Sharma and Nichharia (1962) with the application of 40 lb. of P_2O_5 per acre to gram. Deshpande and Bathkal (1965) also observed highly significant linear increase in the growth of greengram due to the application of phosphorus at 20, 40, and 60 lb. per acre.

Contrary to these findings, Shukla (1964) found that application of phosphorus at 30 and 60 lb. per acre did not increase significantly the height of gram over the no manure treatment. But these levels did

increase significantly the number of productive branches on the main stem.

6. Effect of phosphorus on the seed and green matter yield and quality

Investigations conducted by Fellers (1918) and Graul and Fred (1922) brought to light that yield and nitrogen content of legumes increased, when soils were treated with phosphates. Similar observations were reported in the case of white clover by Vinall and Wilkins (1936), of hairy vetch by Rogers and Sturkie (1939) and of red clover by Powers (1942).

Studies of Parr and Bose (1944, 1945) revealed that cowpea responded highly to phosphate manuring. They claimed that application of P_2O_5 at the rate of 132 lb., 198 lb. and 264 lb. per acre increased the fodder yield in the linear order, the percentage of increase being 18, 24 and 30 for the respective doses of the manure.

Baur and Trembly (1948) observed that 60 lb. of phosphorus per acre properly placed in bands sufficed to produce good yields of canary peas.

Results of experiments conducted by Greaves and Pittman (1945), Larsen et al (1952), and

Jones et al (1953) on lucerne brought out that hay yield could be enhanced significantly by phosphate manuring with doses varying from 30 to 240 lb. P_2O_5. Similarly, highly significant increase in fodder yield of berseem was reported by Sen and Bains (1952) and Rao et al (1954). Among the various levels of phosphorus tried by Rao et al, increased fodder and seed yield was obtained only upto 66 lb. per acre. They claimed that at higher rates, response per unit decreased, and no significant differences were seen in seed yield.

Bhide (1952) reported spectacular increase in yield of cowpea and groundnut with the application of superphosphate to supply 30 lb. P_2O_5 per acre. Similar results were also reported by Rao and Govindarajan (1952) on beans and cowpea.

Ballal and Natu (1959) reported significant increase in the yield of gram by the application of phosphorus at 40 lb. per acre.

Kolhe (1960) tried different levels of phosphorus varying from 50 to 100 lb. per acre on Indianbean and found that the yield of grains increased by 34.5 per cent and that of straw by 14 per cent with the application of P_2O_5 at 50 lb. per acre over no manure.

This dose was found to be economic also.

Deshpande and Bathkal (1965) studied the response of greengram to different levels of phosphorus and reported that the number of pods per plant and weight of pods per acre were significantly increased by 40 and 60 lb. P_2O_5. They also reported that the response of greengram to the different levels of phosphorus was linear, indicating that pulse yield and green weight (haulm) increased with the increasing doses of phosphorus, the percentages of increase being 20.6, 75.6 and 85.6 for grain yield and 14.8, 27.9 and 46.9 for haulm yield over the control for the respective doses of P_2O_5 at 20, 40 and 60 lb. per acre. Moolani and Sana (1965) also obtained significant increase in grain yield of greengram with the application of P_2O_5 at 50 and 100 lb. per acre.

Mann (1965) summerising the results of simple fertilizer trials conducted on groundnut and bengalgram, concluded that both the crops responded significantly to phosphate manuring at doses ranging from 33.6 kg. to 67.2 kg. per hectare.

Contrary to these findings in favour of the phosphate manuring of legumes, Desai et al (1957)

obtained no significant difference in the yield of leguminous green manure crops on sandy loam soils fertilised with phosphates. They arrived at the conclusion that phosphate application to green manure crops in sandy loams with an available P_2O_5 content of 50 lb. per acre and above, had no beneficial effect in increasing the production of green matter. Rao et al (1962) reported similar results in pillipesara, sannhemp and badabada raised on the sandy loam soils of Andhra Pradesh with P_2O_5 at 22.5 lb. per acre.

7. Effect of combination of nitrogen and phosphorus on yield and quality

According to Breazeale (1928), absorption of phosphorus by all crops was stimulated in the presence of nitrogen, whereas absorption of nitrogen was not influenced by other elements. But, MacTaggart (1921) found that nitrogen in combination with phosphorus, potash and sulphur promoted no better response in the legumes like fieldpeas, soybeans and alfalfa, than when it was employed alone.

Sen (1958) observed that the uptake of nitrogen by redgram was greatly enhanced by the application of nitrogen and phosphorus. Similarly, Cullier (1956) obtained 20 to 50 per cent more yield by applying

40 to 70 kg./ha. of ammonium sulphate and 40 to 75 kg. per hectare of calcium phosphate to groundnut. Singh and Sahasrabudhe (1957) have also reported increase in yield of groundnut with the application of phosphorus in combination with nitrogen. Highly significant and beneficial results were also reported by Satyanarayana and Rao (1962) with nitrogen and phosphorus at 20 and 40 lb. per acre respectively on groundnut. But, Wahhab and Mohammad (1958) claimed that nitrogen when applied in combination with phosphorus, reduced the beneficial effect of phosphorus on groundnut.

Studying on the response of peas to different combinations of nitrogen and phosphorus at 40 and 120 lb. per acre respectively, Sen, Bains and Mathur (1962) reported that the $N_{40}P_{120}$ dose gave significantly higher yield over the control, but the effect of phosphorus alone at 120 lb. per acre was superior to the $N_{40}P_{120}$ treatment. Sharma and Misra (1961) also reported similar results in peas. The treatment giving nitrogen at 10 lb. per acre together with phosphorus at 60 lb. per acre yielded significantly more yield over no manure. But, phosphorus applied

alone at 60 lb. per acre was far superior to the combination of 10 lb. nitrogen and 60 lb. P_2O_5 per acre.

Shukla (1964) conducted investigations on the manuring of gram and reported that increasing doses of nitrogen in the absence of phosphorus depressed grain yield, although in combination with phosphorus, nitrogen, particularly the 20 lb. per acre dose, had a positive relationship with pod and grain yield. He also noted that the straw yield increased with increase in nitrogen supply, especially when it was used in combination with phosphorus at 60 lb. per acre.

Moolani and Jana (1965) studied the effect of nitrogen and phosphate manuring of greengram and found that 25 kg. nitrogen with 100 kg. P_2O_5 per hectare produced highly significant yield compared to the no manure treatment. But this dose was not statistically superior in seed yield to phosphorus applied alone at 100 kg./ha.

Singh and Singh Virk (1965) also reported increase in the yield of blackgram and greengram to the application of 40 kg. nitrogen and 60 kg. P_2O_5 together per hectare. The application of 60 kg.

P_2O_5 with and without 40 kg. nitrogen produced average response of 110.1 and 50.1 per cent in the case of blackgram and 102.3 and 46.4 per cent in the case of greengram over the control. They concluded that both the doses were economical in blackgram but uneconomical in greengram.

MATERIALS AND METHODS

MATERIALS AND METHODS

The present investigation was undertaken to study the effect of nitrogen and phosphate manuring on five varieties of cowpea and to determine the best variety suited to the soil and climatic conditions of Vellayani.

I. Experimental site

The experiment was conducted in the red loam soils of the farm attached to the Agricultural College and Research Institute, Vellayani. The soil was analysed for its nutrient contents and the results are furnished below:-

Total Nitrogen	..	0.0890	per cent
Total P_2O_5	..	0.0403	,,
Available P_2O_5	..	0.0019	,,
Total K_2O	..	0.0810	,,
Available K_2O	..	0.0008	,,

II. Season

The experiment was conducted during the period from July to September 1965. The meteorological observations recorded during this period are given in Appendix I.

III. Materials

1. Seed Material.

Five varieties of short duration cowpea were selected for the investigation. Of these five varieties, New Era, M.S.9314, African and G_4 were obtained from the Pulses' Specialist, Agricultural College and Research Institute, Coimbatore and the fifth, 'Kozhinjil payar', the local variety, from the Pulses' Research Station, Sasthamkotta. All these varieties were of approximately 70 days' duration.

The varietal characters are described below:-

a) New Era: This is a North Rhodesian variety. It is a bushy plant with light green medium sized leaves and purple petals and light green calyx. Pods are medium sized, having purple tips. Seeds are chocolate in colour.

b) M.S. 9314: This is also called as "De John France". The plants are bushy and erect with pink coloured stems of medium thickness. Leaves are small and dark green coloured. Flowers are medium sized with purple coloured calyx and petals. The pods are green with purple tips. When mature, the pods become completely purple coloured. Seeds are deep chocolate in colour with red mottling.

c) African: This is an African variety with bushy stature and thin stem. Leaves are small and dark green in colour. Flowers have green calyx and purple petals. Pods are medium sized with green tips. Seeds are yellow in colour.

d) C_4: This is a pure line selection from Coimbatore local, released from the Pulses' Research Station, Coimbatore. Plants are bushy in habit, with dark green leaves. Flowers have green calyx and violet petals. Seeds are red in colour.

e) Local - "Kozhinjil payar": This is a local type, grown extensively in the southern parts of Kerala. Plants are bushy and profusely branching. Leaves are small and pale green. Flowers are yellow in colour. Pods are small in size. Seeds are red coloured.

2. Manures and Fertilizers

A uniform dose of cattle manure was given to all the plots.

Nitrogen, phosphorus and potash were applied in the form of Ammonium sulphate, Superphosphate and Muriate of Potash respectively. Lime was given in the form of Calcium hydroxide.

The chemical analyses of the manures and the fertilizers used are given below:-

Ammonium sulphate	..	20.20 % N
Superphosphate	..	16.31 % P_2O_5
Muriate of potash	..	58.24 % K_2O
Lime	..	55.00 % CaO
Cattle manure	..	0.54 % N
		0.31 % P_2O_5
		0.48 % K_2O

IV. Methods

1. Treatments.

The treatment combinations comprised of two levels of nitrogen, four levels of phosphorus and five varieties. The fertilizer combinations were tried in the whole plots and the varieties in the sub-plots.

Levels of nitrogen : 1. n_0 - No nitrogen
2. n_1 - 20 kg./ha.

Levels of phosphorus : 1. p_0 - No phosphorus
2. p_1 - P_2O_5 at 30 kg./ha.
3. p_2 - P_2O_5 at 60 ,,
4. p_3 - P_2O_5 at 90 ,,

The whole plot combinations were the following:-

1. n_0p_0
2. n_0p_1
3. n_0p_2
4. n_0p_3
5. n_1p_0
6. n_1p_1
7. n_1p_2
8. n_1p_3

The sub-plot treatments were:-

1. V_1 .. New Era
2. V_2 .. M.S.9314
3. V_3 .. African
4. V_4 .. G_4
5. V_5 .. Local

There were forty treatment combinations with the eight whole plot and the 5 sub-plot treatments mentioned above.

2. Layout and design.

The experiment was laid out as a split plot experiment in Randomized Block Design and was replicated

thrice. The layout plan given in fig. 1.

3. Size of plots.

Whole plot	..	Gross:	23.70 metres	x 4.50	metres
Sub plot	..	Gross:	4.50 ,,	x 4.50	,,
		Net:	3.90 ,,	x 3.90	,,

4. Spacing.

A spacing of 30 cm. either way as recommended by

Krishnaswamy et al (1945) and

Dungan and Ross (1957) was adopted.

5. Number of plants in the sub plots

Gross	..	225
Net	..	169

V. Cultivation

1. Preparatory cultivation.

The experimental site was ploughed and dug twice. The plots were then laid out as per the design.

2. Manures and manuring.

Calcium hydroxide at the rate of 1680 kg. per hectare was applied broadcast just before the preparatory cultivation was started. Cattle manure at the rate of 5600 kg. per hectare was also applied uniformly to all

$n_0p_1v_3$	$n_0p_1v_1$	$n_0p_1v_2$	$n_0p_1v_4$	$n_0p_1v_5$	$n_1p_2v_3$	$n_1p_2v_2$	$n_1p_2v_4$	$n_1p_2v_5$	$n_1p_2v_1$
$n_0p_3v_3$	$n_0p_3v_4$	$n_0p_3v_1$	$n_0p_3v_2$	$n_0p_3v_5$	$n_1p_3v_1$	$n_1p_3v_2$	$n_1p_3v_5$	$n_1p_3v_3$	$n_1p_3v_4$
$n_0p_2v_1$	$n_0p_2v_3$	$n_0p_2v_5$	$n_0p_2v_2$	$n_0p_2v_4$	$n_1p_0v_3$	$n_1p_0v_5$	$n_1p_0v_2$	$n_1p_0v_1$	$n_1p_0v_4$
$n_0p_0v_4$	$n_0p_0v_1$	$n_0p_0v_2$	$n_0p_0v_5$	$n_0p_0v_3$	$n_1p_1v_5$	$n_1p_1v_3$	$n_1p_1v_4$	$n_1p_1v_1$	$n_1p_1v_2$

REP: I.

$n_1p_1v_3$	$n_1p_1v_2$	$n_1p_1v_1$	$n_1p_1v_5$	$n_1p_1v_4$	$n_1p_0v_3$	$n_1p_0v_5$	$n_1p_0v_2$	$n_1p_0v_1$	$n_1p_0v_4$
$n_0p_1v_4$	$n_0p_1v_3$	$n_0p_1v_5$	$n_0p_1v_2$	$n_0p_1v_1$	$n_1p_2v_3$	$n_1p_2v_4$	$n_1p_2v_3$	$n_1p_2v_1$	$n_1p_2v_2$
$n_0p_0v_3$	$n_0p_0v_4$	$n_0p_0v_5$	$n_0p_0v_1$	$n_0p_2v_2$	$n_0p_2v_4$	$n_0p_2v_3$	$n_0p_2v_5$	$n_0p_2v_2$	$n_0p_2v_1$
$n_0p_3v_2$	$n_0p_3v_5$	$n_0p_3v_1$	$n_0p_3v_3$	$n_0p_3v_4$	$n_1p_3v_4$	$n_1p_3v_1$	$n_1p_3v_5$	$n_1p_3v_2$	$n_1p_3v_3$

REP: II

$n_0p_3v_5$	$n_0p_3v_4$	$n_0p_3v_1$	$n_0p_3v_2$	$n_0p_3v_3$	$n_0p_1v_1$	$n_0p_1v_3$	$n_0p_1v_4$	$n_0p_1v_2$	$n_0p_1v_5$
$n_1p_3v_3$	$n_1p_3v_2$	$n_1p_3v_4$	$n_1p_3v_5$	$n_1p_3v_1$	$n_1p_0v_2$	$n_1p_0v_4$	$n_1p_0v_5$	$n_1p_0v_1$	$n_1p_0v_3$
$n_1p_2v_3$	$n_1p_2v_5$	$n_1p_2v_4$	$n_1p_2v_1$	$n_1p_2v_2$	$n_0p_2v_4$	$n_0p_2v_3$	$n_0p_2v_2$	$n_0p_2v_5$	$n_0p_2v_1$
$n_1p_1v_4$	$n_1p_1v_2$	$n_1p_1v_3$	$n_1p_1v_1$	$n_1p_1v_5$	$n_0p_0v_2$	$n_0p_0v_1$	$n_0p_0v_3$	$n_0p_0v_4$	$n_0p_0v_5$

REP: III

N

LAY OUT

SPLIT-PLOT EXPERIMENT

IN RANDOMISED BLOCK DESIGN

WHOLE PLOT: 23.70 m x 4.50 m.

SUB PLOT : 4.50 m x 4.50 m.

TREATMENTS:-

WHOLE PLOT: 8 FERTILIZER COMBINATIONS.

SUB PLOT : 5 VARIETIES.

FIG: 1.

the plots as a basal dose, 14 days after the application of lime. These two doses were recommended by Nair et al (1957) for leguminous crops grown in Kerala soils.

The fertilizers were applied as basal dose a day before sowing. Ammonium sulphate and muriate of potash were applied broadcast, while superphosphate was placed in bands 10 cm. deep and 30 cm. apart.

3. Sowing.

The seeds were dibbled in lines 30 cm. apart both ways at the rate of one seed per hole on 3-7-1965.

4. General condition of the crop.

There was good rain on the day of sowing. Seeds started germination from the third day onwards and germination was completed by the sixth day.

The general condition of the crop was normal.

5. Weeding.

One weeding was given on 16-7-1965. The plots were kept free from weeds althrough.

6. Plant protection.

A mild attack of aphids was noticed on 16-7-'65.

Follidol E_{605} was sprayed against the aphids on 17-7-1965. The pest was completely controlled by that spraying. Two prophylactic sprayings were given with Follidol E_{605} on 29-7-1965 and 5-8-1965.

7. Harvest.

The local variety was partially harvested on 3-9-1965. All the other varieties and the left over from the local variety were harvested on 13-9-1965. The border rows were harvested separately. The selected plants for biometric studies in the net sub plots were separately harvested and threshed after drying. The grain yield for the total harvest was recorded at 12% moisture. Haulms were pulled out and the weight recorded immediately after the harvest of pods.

VI. Observations taken

Leaving one border row on all the four sides, eight plants were selected from each sub-plot by random method. These plants were studied for the following characters:-

1. Height of plants at maturity: The height of each plant was measured in cm. individually and the average height was calculated. The height was measured from the cotyledonary node to the terminal node.

2. Number of nodules: All the nodules on the roots of the selected plants were counted and the average worked out.

3. Number of pods per plant: These were grouped under two categories -

a) number of pods with seeds.

b) number of pods without seeds - barren pods.

The average was then worked out.

4. Length of pods and number of seeds per pod: The length of 20 pods taken at random out of the pods collected from the selected plants were measured in centimetres. These were then threshed separately and the number of seeds present in each pod was counted. The average length and the number of seeds per pod were recorded.

Other observations

5. Weight of pods: Weight of pods in each sub plot after harvest was recorded.

6. Weight of dry seeds: The pods harvested from each sub plot were dried, threshed and the weight was recorded at 12% moisture.

7. Weight of haulm: Immediately after harvest of pods, haulms in each sub plot were pulled out and their weight recorded.

8. Weight of 100 seeds: 100 seeds from each treatment were drawn at random after thoroughly mixing the seeds and the weight was recorded using a physical balance.

RESULTS

R E S U L T S

The data relating to the various biometric observations taken were statistically analysed. The results are furnished below:

The following notations are used to represent the levels of fertilizers and the names of varieties:-

Fertilizers

n_0 = Nitrogen at 0 kg. per hectare.
n_1 = " at 20 kg. " "
P_0 = P_2O_5 at 0 kg. per hectare
P_1 = " at 30 kg. " "
P_2 = " at 60 kg. " "
P_3 = " at 90 kg. " "

Varieties

V_1 = New Era
V_2 = M.S. 9314
V_3 = African
V_4 = G_4
V_5 = Local

1. Height of plants at maturity

The analysis of variance for the height of plants at maturity is given in Appendix II. It is seen that

the height of plants increased significantly due to the addition of nitrogen. But phosphorus did not effect significant influence on the height. Further, the varietal differences were significant.

The mean height of plants under the various treatments is given in Table I.

Among the varieties, the maximum height of 53.01 cm. was recorded for the variety V_3 which was closely followed by V_4 and V_1. The varieties V_2 and V_5 recorded the minimum mean heights. Eventhough the effect of phosphorus was not significant in general, it was found that the variety V_3 responded significantly to phosphorus at the lower level of nitrogen, whereas, at the higher level of nitrogen, the effect of phosphorus seemed to be depressing. This variety recorded the maximum height in the treatment combination n_1P_0.

2. Number of nodules

The data relating to the number of nodules produced were statistically analysed and the analysis of variance is presented in Appendix III. It is seen that nitrogen at the higher level exerted negative influence on nodulation while phosphorus showed significant linear increase. The interaction between nitrogen and phosphorus

TABLE I

Mean height of plants (in cm.) at maturity

Variety	n_0				n_1				Varietal means
	p_0	p_1	p_2	p_3	p_0	p_1	p_2	p_3	
V_1	29.21	34.00	35.63	35.46	38.79	41.54	40.13	41.58	37.04
V_2	22.00	29.83	24.96	25.38	28.08	23.92	27.33	25.58	25.88
V_3	43.79	48.96	50.29	56.17	64.25	54.83	51.42	54.38	53.01
V_4	45.29	51.83	45.67	51.79	52.50	45.46	53.92	57.08	50.44
V_5	19.96	24.42	27.50	23.17	29.21	23.88	24.54	27.42	25.01
Mean	32.05	37.01	36.81	38.39	42.57	37.93	39.47	41.21	38.27

Mean height (in cm.) of plants corresponding to the levels of N and P

n_0	n_1	p_0	p_1	p_2	p_3
36.26	40.28	37.29	37.86	38.13	39.80

C.D. (5%) for comparison between	fertilizer means	6.80
C.D. " " " "	levels of nitrogen	3.38
C.D. " " " "	" " phosphorus	4.80
C.D. " " " "	varietal means	3.41
C.D. " " " "	varieties in the same fertilizer	9.61
C.D. " " " "	fertilizers in the same variety	10.91

was also significant but the effect was negative. The varieties showed significant difference in nodulation.

The mean number of nodules produced under different treatments are given in Table II.

As evidenced by Table II, maximum nodulation was shown by V_4, closely followed by V_3. The varieties V_1, V_5 and V_2 followed these two and differed significantly from them. But V_5 and V_2 did not show significant difference. All the improved varieties except V_2 produced significantly more nodules than the local V_5.

All the varieties responded positively to phosphorus. Maximum nodulation was seen in variety V_3 with P_2O_5 at 90 kg. per hectare, followed by V_4, V_1, V_5 and V_2 at the same level.

All the varieties exhibited depression in nodulation due to the application of nitrogen. The interactional effect of nitrogen and phosphorus was negative on nodulation.

3. Number of pods

The number of pods produced per plant was statistically analysed and the analysis of variance is presented in Appendix IV. It is seen that application of nitrogen did not influence the production of pods. But, phosphorus

TABLE II

Mean number of nodules produced

Variety	n_0				n_1				Varietal means
	P_0	P_1	P_2	P_3	P_0	P_1	P_2	P_3	
V_1	10.66	15.11	17.20	17.20	8.99	10.79	13.33	15.49	13.59
V_2	6.91	7.83	10.16	11.41	5.95	7.58	9.33	11.08	8.78
V_3	11.37	18.70	20.58	27.83	9.74	13.70	13.87	16.13	16.49
V_4	11.83	18.95	20.66	25.24	9.28	14.58	16.20	17.74	16.81
V_5	8.16	10.58	10.45	11.02	7.20	8.37	9.64	11.33	9.69
Mean	9.79	14.23	15.81	18.70	8.23	11.00	12.47	14.35	13.07

Mean number of nodules corresponding to the levels of N and P

n_0	n_1	P_0	P_1	P_2	P_3
14.63	11.52	9.01	12.61	14.14	16.53

C.D. (5%) for comparison between fertilizer means	:	0.27
C.D. " " " " levels of nitrogen	:	0.47
C.D. " " " " " " phosphorus	:	0.66
C.D. " " " " varietal means	:	0.74
C.D. " " " " fertilizer means in the same variety	:	2.09
C.D. " " " " varietal means under the same fertilizer	:	2.10

did increase pod formation significantly. The varietal differences were also significant.

The mean number of pods produced under the various treatments are given in Table III.

The variety V_5 produced the maximum number of pods of 15.77 per plant followed by V_2, V_1, V_3 and V_4. The variety V_4 did not significantly differ from V_3. Similarly, V_2 and V_1 also did not differ significantly. All the varieties showed response to phosphate application. The highest number of pods was produced by V_5 (17.25 per plant) in the treatment n_0p_1 while V_2 and V_4 produced the maximum numbers under n_1p_3. V_1 and V_3 showed highest response under the treatment n_0p_3 and n_0p_2 respectively.

4. Number of barren pods

The analysis of variance for the number of barren pods produced per plant is furnished in Appendix V. It is evident that application of phosphorus influenced significantly in the reduction of the number of barren pods produced. The influence of nitrogen in this character was not significant. The varieties showed significant difference in the production of barren pods.

The mean number of barren pods produced under the

TABLE III

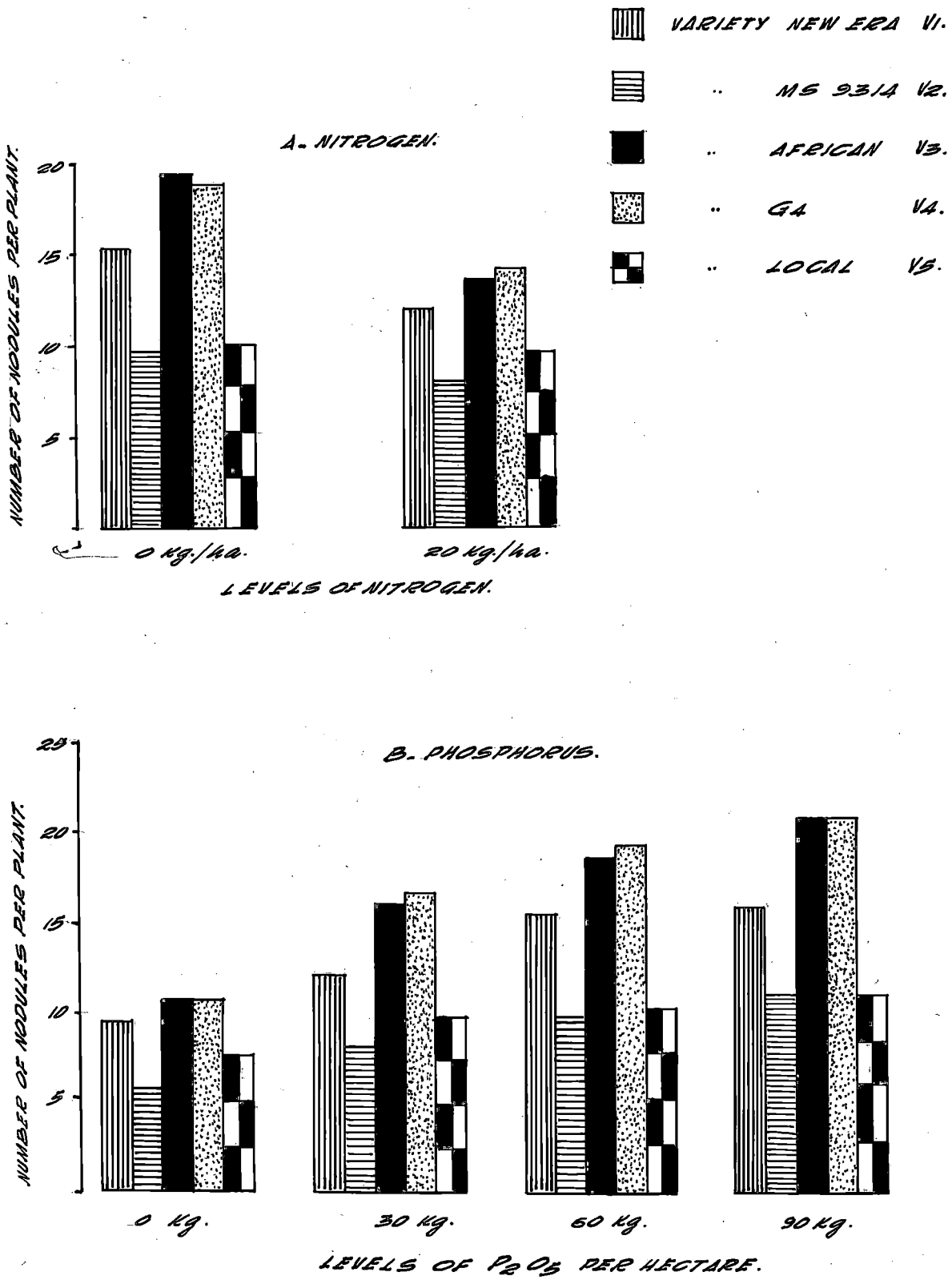
Mean number of pods per plant

Variety	n_0				n_1				Varietal means
	P_0	P_1	P_2	P_3	P_0	P_1	P_2	P_3	
V_1	8.46	9.87	11.33	12.29	9.21	10.50	10.91	10.75	10.41
V_2	8.69	13.12	12.71	9.58	8.04	9.63	13.21	13.58	11.06
V_3	6.42	9.20	9.50	9.40	7.16	8.21	8.71	8.46	8.38
V_4	5.99	8.58	8.87	8.25	7.25	8.33	7.50	8.95	7.96
V_5	16.12	17.25	16.46	15.54	14.08	15.62	15.21	15.87	15.77
Mean	9.12	11.60	11.77	11.01	9.15	10.46	11.11	11.52	10.71

Mean number of pods per plant corresponding to the levels of N and P

n_0	n_1	P_0	P_1	P_2	P_3
10.87	10.56	9.13	11.03	11.44	11.27

C.D. (5%) for comparison between	fertilizer means	1.48
C.D. " " " "	levels of nitrogen	0.73
C.D. " " " "	" " phosphorus	1.03
C.D. " " " "	varietal means	1.48
C.D. " " " "	fertilizer means in the same variety	4.02
C.D. " " " "	varietal means in the same fertilizer	4.12



EFFECT OF NITROGEN AND PHOSPHORUS ON NODULATION.

FIG:2.

various treatments are given in Table IV.

The variety V_5 produced the highest number of barren pods with a mean value of 1.11, while V_3 and V_4 produced the least numbers with 0.15 per plant. V_5 and V_2 differed significantly from all the other varieties. V_1 and V_4 did not show significant difference. Similarly V_4 and V_3 also did not differ significantly. All the varieties showed a tendency to produce lesser number of barren pods with the application of phosphorus either alone or in combination with nitrogen. Nitrogen also tended to reduce the formation of barren pods though this treatment was not as effective as phosphorus.

5. Length of pods

The analysis of variance for the mean length of pods is presented in Appendix VI. It is seen that the application of phosphorus increased the length of pods up to 60 lb. P_2O_5 per hectare, but nitrogen did not. The combined effect of nitrogen and phosphorus was significant. The varieties exhibited significant difference in this character.

The mean length of pods under the various treatments is given in Table V.

TABLE IV

Mean number of barren pods per plant

Variety	n_0				n_1				Varietal means
	p_0	p_1	p_2	p_3	p_0	p_1	p_2	p_3	
V_1	0.54	0.16	0.21	0.25	0.50	0.37	0.12	0.50	0.33
V_2	1.37	0.62	0.54	0.41	0.83	0.41	0.66	0.50	0.67
V_3	0.25	0.04	0.08	0.04	0.37	0.12	0.25	0.08	0.15
V_4	0.33	0.25	0.17	0.08	0.04	0.12	0.08	0.16	0.15
V_5	2.62	1.00	0.87	0.42	2.16	0.75	0.50	0.54	1.11
Mean	1.02	0.41	0.37	0.24	0.78	0.36	0.32	0.36	0.48

Mean number of barren pods corresponding to the levels of N and P

n_0	n_1	p_0	p_1	p_2	p_3
0.17	0.16	0.31	0.13	0.12	0.10

C.D. (5%) for comparison between fertilizer means	: 2.46
C.D. " " " " levels of nitrogen	: 0.12
C.D. " " " " levels of phosphorus	: 0.17
C.D. " " " bet.varietal means	: 0.16
C.D. " " " between fertilizer means in the same variety	: 0.46
C.D. " " " " variotal means under the same fertilizer	: 0.45

TABLE V

Mean length of pod (in cm.)

Variety	n_0				n_1				Varietal means
	P_0	P_1	P_2	P_3	P_0	P_1	P_2	P_3	
V_1	14.05	16.20	16.20	15.93	15.43	15.93	15.39	15.25	15.55
V_2	13.35	14.32	15.16	15.00	14.39	13.82	14.32	14.06	14.30
V_3	13.71	14.89	15.61	14.80	14.62	15.15	15.03	15.35	14.89
V_4	13.47	14.48	15.91	14.37	12.98	15.33	14.18	15.23	14.49
V_5	7.50	9.01	9.52	8.72	8.08	8.76	8.52	9.23	8.66
Mean	12.41	13.78	14.48	13.76	13.10	13.78	13.49	13.82	13.56

Mean length (in cm.) corresponding to the levels of N and P

n_0	n_1	P_0	P_1	P_2	P_3
13.61	13.56	12.76	13.80	13.99	13.80

C.D. (5%) for comparison between	fertilizer means	0.15
C.D. " " " "	levels of nitrogen	0.08
C.D. " " " "	" " phosphorus	0.11
C.D. " " " "	varietal means	0.17
C.D. " " " "	fertilizer means in the same variety	0.45
C.D. " " " "	varietal means under the same fertilizer	0.47

The maximum mean length of 15.55 cm. was attained by the variety V_1 which was followed by V_3, V_4, V_2 and V_5. The variety V_5 had the minimum pod length of 8.66 cm. Eventhough the main effect of nitrogen was not statistically significant, it was found that application of nitrogen tended to increase the length of pods in all the varieties except V_4. The maximum response was shown by the variety V_1 to the treatments n_0p_1 and n_0p_2 which were on par.

6. Number of seeds per pod

The analysis of variance for the number of seeds per pod is given in Appendix VII. It is seen that the application of phosphorus exerted significant influence in seed formation, but nitrogen did not show any significant effect. The varietal difference and the variety manure interaction were also significant.

The mean number of seeds produced under various treatments are presented in Table VI.

The maximum number of seeds per pod was produced by the variety V_1 with 13.46 seeds, followed by V_4, V_3, V_2 and V_5 with 13.13, 13.11, 9.97 and 7.94 seeds respectively. But V_4 and V_3 did not differ significantly. All the varieties significantly responded to phosphorus

TABLE VI

Mean number of seeds per pod

Variety	n_0				n_1				Varietal means
	P_0	P_1	P_2	P_3	P_0	P_1	P_2	P_3	
V_1	12.54	14.93	14.41	14.47	12.59	13.10	12.79	12.84	13.46
V_2	7.86	8.79	11.56	10.22	8.85	10.49	11.74	10.28	9.97
V_3	11.88	14.03	13.29	13.62	12.25	14.24	12.03	13.30	13.11
V_4	11.78	13.54	13.15	13.07	11.82	14.98	12.63	14.09	13.13
V_5	6.78	7.89	8.18	8.09	7.57	7.60	8.61	8.81	7.94
Mean	10.17	11.84	12.12	11.93	10.62	12.08	11.56	11.86	11.52

Mean number of seeds per pod corresponding to the levels of N and P

n_0	n_1	P_0	P_1	P_2	P_3
11.51	11.53	10.39	11.96	11.84	11.90

C.D. (5%) for comparison between	fertiliser means	0.57
C.D. " " " "	levels of nitrogen	0.28
C.D. " " " "	levels of phosphorus	0.40
C.D. " " " "	varietal means	0.30
C.D. " " " "	fertiliser means in the same variety	0.95
C.D. " " " "	varietal means under the same fertiliser	0.84

application, but none responded favourably to nitrogen applied alone. V_1 produced the highest number of seeds per pod in the treatment n_0p_1; V_2 in n_1p_2; V_3 and V_4 in n_1p_1 and V_5 in n_1p_3.

7. Yield of pods per plot

The yield of dry pods under different treatments was calculated on per hectare basis. The analysis of variance is presented in Appendix VIII. It is evident that nitrogen application tended to reduce the pod yield over no nitrogen though not significantly, but phosphorus significantly increased the pod yield. The interaction between nitrogen and phosphorus was significant. The varietal differences were also significant.

The yield of pods per hectare under the various treatments is given in Table VII.

The maximum yield of pods of 995.07 kg. per hectare was produced by the variety V_1 followed by V_3, V_5, V_4 and V_2. The last two varieties did not show significant difference. V_1 and V_3 gave 31.3 and 19.1 per cent more yield of pods than the local variety V_5. But V_4 and V_2 produced 9.6 and 14.8 per cent less than the local. V_1 recorded the highest yield

TABLE VII

Yield of pods in kg. per hectare

Variety	n_0				n_1				Varietal means
	P_0	P_1	P_2	P_3	P_0	P_1	P_2	P_3	
V_1	718.60	1130.83	1132.80	1157.13	919.79	977.64	928.99	994.73	995.07
V_2	556.87	795.53	598.29	639.71	545.69	782.38	598.29	650.89	645.95
V_3	714.66	971.07	973.04	981.59	854.70	819.85	961.86	964.49	905.16
V_4	517.42	721.23	800.13	703.48	600.26	657.46	690.33	802.10	686.55
V_5	464.82	797.50	804.07	865.87	740.96	786.98	749.50	852.73	757.80
Mean	594.48	883.23	861.67	869.56	732.28	804.86	785.80	852.99	798.10

Yield of pods (in kg.) per hectare corresponding to the levels of N and P

n_0	n_1	P_0	P_1	P_2	P_3
801.94	793.72	663.38	844.04	823.73	861.27

C.D. (5%) for comparison between	fertilizer means	57.79
C.D. " " " "	levels of nitrogen	28.20
C.D. " " " "	" " phosphorus	42.27
C.D. " " " "	varietal means	52.83
C.D. " " " "	fertilizer means in the same variety	133.07
C.D. " " " "	varietalmeans under the same fertilizer	155.88

of 1157.63 kg. per hectare under the treatment n_0p_3 which was not significantly superior to the next best viz. n_0p_2. The effect of phosphorus was seen slightly reduced when nitrogen was also applied in combination.

8. Yield of seed per hectare

The analysis of variance for the yield of seed per hectare is presented in Appendix IX. It is seen that the application of phosphorus exerted significant influence in yield whereas, nitrogen failed to show significant effect. The interaction between nitrogen and phosphorus was negative and it was significant. The varieties showed significant difference. The interaction between varieties and manures was also significant.

The mean yield per plot under different treatments calculated on per hectare basis is given in Table VIII.

Among the varieties, V_1 gave the maximum yield, followed by V_3, V_5, V_4 and V_2. The last two varieties did not differ significantly. While V_1 and V_3 produced 21.2 and 10.2 per cent more yield than the local variety V_5, the varieties V_4 and V_2 yielded 15.3 and 15.5 per cent respectively less than the local (V_5). The highest response for fertilizer was shown by the

TABLE VIII

Yield of seed in kg. per hectare

Variety	n_0				n_1				Varietal means
	P_0	P_1	P_2	P_3	P_0	P_1	P_2	P_3	
V_1	491.12	808.67	828.40	859.30	642.34	681.79	681.79	729.78	715.40
V_2	379.35	532.54	486.52	521.36	401.05	646.28	491.12	532.54	498.85
V_3	493.09	703.48	705.45	705.45	591.71	604.86	703.48	696.90	650.56
V_4	355.03	527.94	583.17	530.57	440.50	488.49	497.70	583.16	500.90
V_5	359.63	639.70	639.71	685.73	499.67	576.59	633.13	685.73	589.90
Mean	415.64	642.46	648.65	660.48	515.05	599.60	601.44	645.62	591.12

Yield of seed (in kg.) per hectare corresponding to the levels of -- N and P

n_0	n_1	P_0	P_1	P_2	P_3
591.60	590.23	465.15	621.07	624.59	652.86

C.D. (5%) for comparison between fertilizer means	: 42.28
C.D. " " " " levels of nitrogen	: 21.15
C.D. " " " " " " phosphorus	: 29.62
C.D. " " " " varietal means	: 34.78
C.D. " " " " fertilizer in the same variety	: 97.96
C.D. " " " " varieties in the same fertilizer	: 99.21

variety V_1 followed by V_3 and V_5. All the varieties produced higher yields in the treatments having phosphorus alone except V_2 which recorded maximum yield under the treatment combination n_1p_1. Though V_1 produced the maximum seed yield of 859.30 kg. per hectare with the treatment combination n_0p_3, the increase due to the highest level of phosphorus was not significant over the lower levels i.e. n_0p_1 and n_0p_2.

9. Yield of haulm

The analysis of variance on the yield of haulm per plot calculated on per hectare basis is presented in Appendix X. It is seen that nitrogen effected significant increase in the yield of haulm. But phosphorus did not show significant influence beyond 30 kg. P_2O_5 per hectare. The varietal differences were significant.

Table IX relates to the yield of haulm per hectare under the various treatments. The maximum haulm yield of 8399.05 kg. per hectare was recorded by the variety V_4, followed by V_3, V_1, V_5 and V_2. But V_5 and V_2 did not exhibit significant difference. V_4 produced the highest quantity of haulm corresponding to the treatment n_1p_1.

TABLE IX

Yield of haulm (in kg.) per hectare

Variety	n_0				n_1				Varietal means
	P_0	P_1	P_2	P_3	P_0	P_1	P_2	P_3	
V_1	2892.82	4602.22	3616.03	4339.23	6706.09	6048.63	4207.74	5522.66	4741.93
V_2	1051.93	2432.60	1643.65	1775.14	1512.15	1512.15	1643.65	1577.90	1643.64
V_3	5325.42	6311.61	6706.09	6180.12	5851.39	7692.28	5982.88	9138.69	6648.56
V_4	6443.10	8612.72	8086.75	7232.06	9204.44	10256.37	7429.29	9927.64	8399.05
V_5	1446.41	1906.63	1512.15	1775.14	1972.38	1975.48	1709.39	1840.88	1767.31
Mean	3431.93	4773.15	4312.93	4260.14	5049.29	5496.98	4194.59	5601.55	4640.10

Yield of haulm in kg. per hectare corresponding to the levels of -- N and P

n_0	n_1	P_0	P_1	P_2	P_3
4215.96	5083.80	4263.62	5164.34	4217.60	4953.95

C.D. (5%) for comparison between	fertilizer means	1114.07
C.D. " " " "	levels of nitrogen	560.81
C.D. " " " "	" " phosphorus	793.55
C.D. " " " "	varietal means	821.83
C.D. " " " "	fertilizer means in the same variety	2361.60
C.D. " " " "	varietal means under the same fertilizer	2325.44

10. 100-seed weight

The analysis of variance on the weight of 100 seeds is presented in Appendix XI. It is seen that application of nitrogen did slightly reduce the test weight, though not significantly. The influence of phosphorus on this character was significant. The effect of interaction between nitrogen and phosphorus was also significant, but the effect was negative. The varieties showed significant difference. The variety manure interaction was also significant.

Table X represents the 100-seed weights under the different treatments.

The maximum weight was recorded by the variety V_3, which was closely followed by V_1. The local variety V_5 showed the lowest test weight. V_2 and V_4 occupied positions intermediate between V_1 and V_5. All the varieties exhibited significantly superior response to the application of phosphorus alone compared to the combinations of nitrogen and phosphorus at the different higher levels. The variety V_1 showed the maximum test weight in the treatment n_0p_1, V_2 in n_0p_2, V_3 and V_4 in n_0p_3 and the local variety V_5 in n_1p_2.

TABLE X

100-seed weight in gramme

Variety	n_0				n_1				Varietal means
	P_0	P_1	P_2	P_3	P_0	P_1	P_2	P_3	
V_1	10.37	12.91	11.26	11.03	10.93	12.34	11.44	11.38	11.50
V_2	9.06	9.71	9.89	9.28	9.70	9.19	9.53	9.47	9.46
V_3	10.91	11.70	11.28	11.96	11.27	11.72	11.57	11.69	11.51
V_4	9.36	9.95	9.78	10.07	9.00	9.07	9.29	9.27	9.47
V_5	5.85	6.04	6.24	6.14	6.17	6.23	6.34	6.01	6.13
Mean	9.11	10.06	9.69	9.77	9.41	9.71	9.63	9.56	9.62

100-seed weight corresponding to the levels of N and P

n_0	n_1	P_0	P_1	P_2	P_3
9.66	9.58	9.26	9.89	9.66	9.67

C.D. (5%) for comparison between fertilizer means	:	0.23
C.D. " " " " levels of nitrogen	:	0.11
C.D. " " " " " " phosphorus	:	0.17
C.D. " " " " varietal means	:	0.17
C.D. " " " " fertilizer means in the same variety	:	0.50
C.D. " " " " varietal means under the same fertilizer	:	0.40

DISCUSSION

D I S C U S S I O N

An investigation was carried out at the Agricultural College and Research Institute, Vellayani, to study the effect of nitrogen and phosphate manuring on five varieties of cowpea and to find out the best variety suited to the soil and climatic conditions of Vellayani.

The data recorded on the height of plants, the number of branches, the number of nodules produced on the roots, length of pods, the number of seeds per pod, the number of filled and barren pods, yield of pod, seed and haulm per plot and the weight of hundred seeds were statistically analysed. The results are discussed in the following pages.

1. Height of plants at maturity

As evident from Table I, the varieties differed significantly in their heights. The plants of V_3 were taller than those of the other varieties, recording on an average 53.01 cm. per plant. The varieties V_4, V_1, V_2 and V_5 ranked in the descending order. The differences in heights between the varieties V_3 and V_4 and also between V_2 and V_5 were not significant.

The varieties showed difference in their response

to the fertilizer treatments. The maximum vegetative growth was seen in the variety V_3, V_2 and V_5 in the treatment 20 kg. nitrogen per hectare, while V_4 and V_1 produced the maximum mean heights in the treatment combination of 20 kg. nitrogen and 90 kg P_2O_5 per hectare.

It is seen from the observations that nitrogen at 20 kg. per hectare effected in general highly significant increase in the height of plants, but the different levels of phosphorus did not show marked effect, though it showed a tendency to increase the height of plants in the linear order. Shukla (1964) reported similar results in gram. The presence of available nitrogen given in the form of ammonium sulphate seems to have promoted rapid vegetative growth. According to Giobel (1926), Schander1 (1943) and Russel (1961), small quantities of nitrogen are desirable for the early growth of legumes. Findings of Young (1958) in white clover, Kumar and Pande (1962) and Shukla (1964) in gram and Ezedinma (1964) in cowpea are in agreement with the results of this investigation.

2. Number of nodules

As seen from Table II, nitrogen applied at the rate of 20 kg. per hectare produced the least number of

nodules in all the varieties tried. On the other hand, the effect of phosphorus on nodulation was in the linear order, phosphorus at 90 kg. per hectare producing the maximum nodulation in all the 5 varieties. V_3 showed the maximum response to phosphate application and produced on an average 27.83 nodules per plant with P_2O_5 at 90 kg. per hectare. V_3 was closely followed by V_4 in this character producing 25.24 nodules per plant at the same level of phosphorus. These varieties were followed by V_1, V_5 and V_2, but the last two varieties did not exhibit significant difference in nodulation. The response of V_1 and V_2 to phosphorus at 60 and 90 kg. per hectare was on par.

All the five varieties showed depression in nodulation in the nitrogen phosphorus interaction, but the negative influence of nitrogen is seen reduced by phosphorus at the higher levels, especially at 90 kg. per hectare.

The depression in nodulation due to the application of nitrogenous fertiliser may probably be due to the fact that nitrogen fixing bacteria when provided with readily assimilable nitrogen become less active in fixing atmospheric nitrogen thus retarding the formation of nodules. Hills (1918), Cowling (1961) and

Mckee (1961) and Weber (1966) obtained identical results. According to Gibson (1951) optimum conditions for nodule formation and nitrogen fixation are obtained when the nutrient and other needs of the legumes are satisfied and the supply of nitrates in the soil is restricted.

The reduction in nodulation may also be due to the fact that the application of 20 kg. of nitrogen per hectare might have resulted in too low a carbohydrate nitrogen ratio in the plant leading to inadequate carbohydrate supply to the roots. Allison and Ludwing (1935) and Wilson (1935) expressed similar views.

Contrary to the effect of nitrogen, the effect of phosphorus on nodulation was positive. The number and density of nodules are greatly stimulated by phosphorus (Wilson 1917). The presence of phosphates in the soil stimulate the rapid multiplication of rhizobia which leads to the formation of more nodules (Truesdell, 1917, and James et al, 1944). Desai et al (1953), Nair et al (1957) Sen and Bains (1955) and Deshpande and Bathkal (1965) have also reported favourable effects of phosphorus on nodulation.

3. Number of pods

The varieties differed significantly in their capacity to produce pods (Table III). The local variety V_5 ranked first with 15.77 pods per plant, followed by V_2, V_1, V_3 and V_4 with 11.06, 10.41, 8.38, and 7.96 pods respectively. All the varieties responded significantly to phosphate application.

V_5 and V_2 produced the highest number of pods with P_2O_5 at 30 kg. per hectare producing 17.25 and 13.12 pods per plant respectively, whereas V_1 produced on an average 12.29 pods with P_2O_5 at 90 kg. per hectare and V_3 and V_4 with P_2O_5 at 60 kg. per hectare. V_5 and V_2 yielded comparitively more pods per unit dose of phosphorus. The response of V_1 to phosphorus was in the linear order. V_1 excelled significantly from the other varieties in its response to phosphorus which may be attributed to the inherent capacity of the variety itself. Inorganic nitrogen applied at 20 kg. per hectare showed a tendency to depress the number of pods in general, though its effect was not significant over the no nitrogen treatment. This may be due to the increase in vegetative growth caused by the easily available nitrogen. This indicates that applied nitrogen has not contributed to the yield of pods but has only helped to increase the vegitative

growth. Similar findings have been reported by Shukla (1964) and Moolani and Jana (1965) in gram.

An adequate supply of phosphorus early in the life of the plant is important in laying down the primordia for the reproductive parts of plants. Phosphorus is considered essential in the formation of fruits and seeds. The presence of easily available applied phosphorus seems to have stimulated the plants to produce more pods, though the levels of P_2O_5 at 30, 60 and 90 kg. per hectare did not differ significantly in their effect on pod formation. The results of investigations conducted by Shukla (1964) in gram and Deshpande and Bathkal (1965) in greengram are in agreement with the above findings.

4. Number of barren pods

As evidenced by Table IV, nitrogen at 20 kg. per hectare applied in the form of ammonium sulphate did not seem to influence the number of barren pods significantly. But application of phosphorus tended to reduce the number of such pods. The highest level of phosphorus (90 kg. P_2O_5 per hectare) produced the least number (0.10) of barren pods per plant but P_2O_5 at 30, 60 and 90 kg. per hectare levels did not

show significant difference. The essentiality of phosphorus for seed setting is quite evident in these results.

The variety V_5 produced the maximum number of barren pods with an average of 1.11, followed by V_2, V_1, V_3 and V_4 with mean values of 0.67, 0.33, 0.15, and 0.15 respectively. The reason for the large number of barren pods in the local variety V_5 may be attributed to the inherent character of the variety itself. All the improved varieties showed significant difference in this character which may be considered as the inherent superiority of these varieties over the local.

5. Length of pods

Among the varieties, V_1 showed the maximum pod length of 15.55 cm. (Table V) followed by V_3, V_4, V_2 and V_5 having 14.89, 14.49, 14.30 and 8.66 cm. per pod respectively. The varieties showed significant difference in this character. The pod length of all the varieties were seen influenced significantly due to the application of the different fertilizer combinations.

In all these varieties, the maximum pod length was observed with P_2O_5 at 60 kg. per hectare. The

highest response to phosphate manuring was shown by the variety V_1 and the least response by the local variety V_5.

In general, nitrogen applied at 20 kg. per hectare did not significantly increase pod length, but the effect of phosphorus was significant. The interactional effect of nitrogen and phosphorus was significant and was negative.

It is evident from the above observations that pod length is a character which mainly depends on the genetical make up of the variety concerned but to some extent it is influenced by the application of phosphorus either alone or in combination with nitrogen.

6. Number of seeds per pod

From the Table VI, it is evident that the varieties differed significantly in the production of seeds per pod. V_1 produced the maximum number of seeds per pod with 13.46 followed by V_4, V_3, V_2 and V_5 with 13.13, 13.11, 9.97 and 7.94 seeds respectively per pod. The varieties V_4 and V_3 did not exhibit significant difference.

Significant response is shown by the varieties to Superphosphate applied to give P_2O_5 at 30, 60 and 90 kg. per hectare over no manure, though these levels did not differ among themselves in their effect. The response of V_1 for phosphorus was significantly superior, compared to the other varieties. None of the varieties responded significantly to the application of nitrogen at 20 kg. per hectare. The interactional effect of nitrogen and phosphorus on these varieties was negative and significant. The higher level of nitrogen in combination with phosphorus tended to reduce the beneficial effects of phosphorus in variety V_1 but not in the other varieties.

It is evident from the results that phosphorus has got significant influence on seed formation. During the time of seed formation, phosphorus and nitrogen are transferred by plants into the seeds which helps to increase seed setting. This is clearly indicated from the results of this investigation.

7. Yield of pods

From the data presented in Table VII, it is found that the varieties showed significant difference

in the total pod yield. The maximum yield was obtained from the variety V_1. While V_1 and V_3 yielded 31.3 and 19.1 per cent more pod yield compared to the local V_5 variety, V_4 and V_2 produced 9.6 and 14.8 per cent less than the local. Though V_5 produced the largest number of pods per plot, the weight of the final yield was less compared to V_1 and V_3.

All the varieties showed significant response to phosphorus at 30 kg. P_2O_5 per hectare. The variety V_1 exhibited the highest response compared to the other varieties. It yielded the maximum quantity of pods of 1157.13 kg. per hectare with P_2O_5 at 90 kg. per hectare. But there was no significant difference in the yields at 30, 60 and 90 kg. P_2O_5 per hectare.

The varieties V_1, V_3 and V_5 showed significant response to nitrogen at 20 kg. per hectare over no nitrogen but their response to phosphorus was more conspicuous than to nitrogen.

The influence of phosphorus in enhancing the yield of legumes is clearly evident in these results. Application of superphosphate to give P_2O_5 at 30, 60 and 90 kg. per hectare gave 28.5, 24.3 and

30.3 per cent respectively more yield compared to the no phosphorus treatment. But nitrogen applied at 20 kg. per hectare did not exert any significant influence on yield.

Leguminous plants are economic in their use of nitrogen and naturally applied nitrogen is not as essential as phosphorus (MacLaggart 1921). Studies of Sharma and Misra (1961) on the nitrogen manuring of peas at 10 and 20 lb. per acre indicated no significant difference in yield. As a matter of fact nitrogen at 20 kg. per hectare tended to depress yield in the present study. Singh and Sahasrabudhe (1957) and Shukla (1964) also reported similar results in redgram and gram respectively.

Application of phosphorus is seen to increase the number of nodules and pods and the total pod yield. Phosphorus applied might have resulted in the greater absorption of nutrients from the soil and also increased fixation of atmospheric nitrogen which contributed to the overall beneficial results. Such beneficial results have been reported by Baur and Trembly (1948) in canary peas, Bhide (1952) in cowpea, Bellal and Natu (1959)

in gram and Deshpande and Bathkal (1965) in greengram.

The interactional effect of nitrogen and phosphorus is significant with respect to pod yield, but the effect of phosphorus is far superior to the combinations of fertilizers. Similar results have been reported by Wahhab and Mohammed (1958) in groundnut, Sen, Bains and Mathur (1962) and Sharma and Misra (1961) in peas and Moolani and Jana (1965) in greengram.

8. Yield of seed

It is seen from Table VIII that the varieties V_1 and V_3 produced 21.2 and 10.2 per cent respectively more yield than the local variety V_5, while V_4 and V_2 yielded 15.3 and 15.15 per cent respectively less than the local. V_1 showed the highest significant response to fertilizers at all levels, followed by V_3, V_5, V_4 and V_2.

Nitrogen applied at 20 kg. per hectare did not have any significant effect. The response of all the varieties to phosphorus was highly significant over no phosphorus, but there was no significant difference between the levels at

30, 60 and 90 kg. P_2O_5 per hectare. The interactional effect of nitrogen and phosphorus was significant and was negative.

The absence of significant response to the application of 20 kg. nitrogen per hectare may be due to thefact that the presence of large amount of nitrogen stimulated excess vegetative growth with the result the grain yield was reduced especially in the absence of phosphorus. Similar results have been reported by Sharma and Misra (1961) in peas, Shukla (1964) and Moolani and Jana (1965) in gram.

The increase in seed yield obtained with the application of phosphorus can be attributed to the beneficial effect of phosphorus on root growth, flowering, pod formation and seed setting. Moreover, phosphorus might have stimulated the rhizobial activity in the root nodules leading to larger fixation of atmospheric nitrogen (Mercer, 1948). Phosphorus might have also helped in the uptake of nitrogen and other nutrients from the soil (Robert and Olsen, 1944). Corroboratory results have been obtained by Bhide (1952) and Rao et al (1964) in cowpea.

Kolhe (1965) and Deshpande and Bathkal (1965) have also found similar results in Indianbean and greengram respectively.

In the present study the effect of phosphorus applied alone was found superior to the different combinations of nitrogen and phosphorus at the higher levels. This is in conformity with the findings of Sharma and Misra (1961) in peas and Moolani and Jana (1965) in greengram.

9. Yield of haulm

Among the varieties, V_4 was found significantly superior to the others (Table IX) in haulm yield. All the varieties except V_2 produced significantly more quantity of haulm than the local variety V_5, the percentages of increase being 374.5, 275.8 and 167.7 for V_4, V_3 and V_1 respectively. V_2 yielded 7.0 per cent less than the local variety.

Highly significant increase in the weight of haulm was seen in all the varieties due to the application of 20 kg. nitrogen per hectare. Phosphorus tended to increase the production of haulm, but its effect was not significant beyond 30 kg. per hectare level.

The interactional effect of nitrogen and phosphorus was significant.

The variety V_4 yielded the highest quantity of (10256.37 kg.) haulm under the treatment combination of 20 kg. nitrogen and 30 kg. P_2O_5 per hectare, but this response was not significantly superior compared to the response under 20 kg. of nitrogen given alone.

Nitrogen fertilizer alone and in combination with phosphatic fertilizer was found to increase significantly the haulm yield in general. This may be due to the excessive vegetative growth induced by the readily available nitrogen. This finding is in conformity with the results obtained by Singh and Sahasrabudhe (1957) in groundnut, Khan (1957) in berseem and Shukla (1964) in gram. Phosphorus applied at 30 kg. P_2O_5 per hectare also resulted in significant increase in haulm yield. The stimulatory effect of phosphorus on the nitrogen fixing bacteria, as indicated by Truesdell (1917) may be the reason for this beneficial result. Corroboratory results have been reported by Parr and Dose (1945) in cowpea, Jones et al (1953) in lucerne, Sen and Saina (1952) and Rao et al (1954)

in berseem.

The variation in the yield of haulm shown by the varieties under identical conditions may be due to the inherent character of the varieties.

10. 100-seed weight

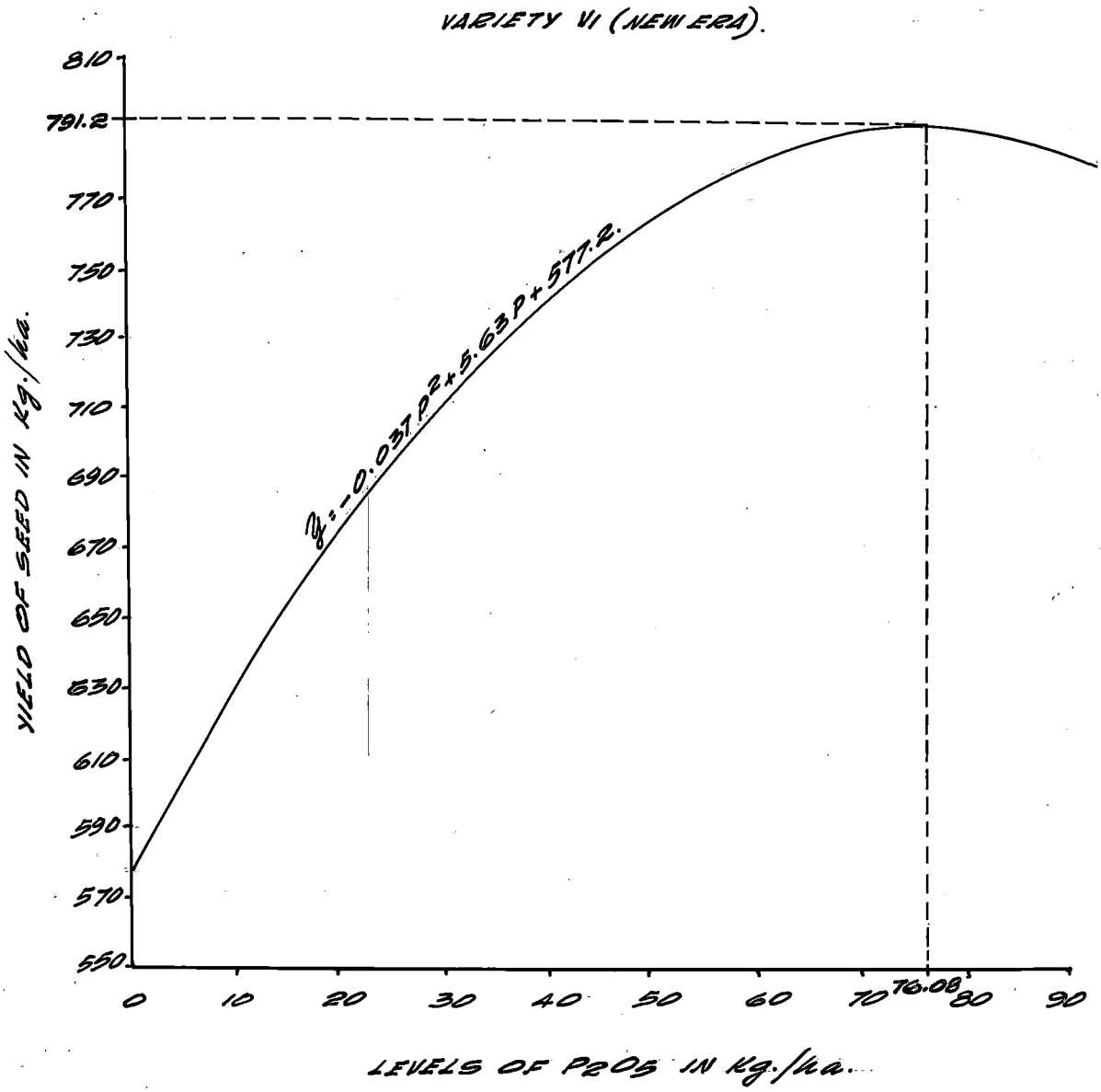
The varieties showed significant difference in the 100-seed weight under the various treatment combinations. (Table X). The variety V_3 ranked first with 11.51 g. per 100 seeds followed by V_1, V_4, V_2 and V_5 with 11.50 g., 9.47 g., 9.46 g., and 6.13 g. respectively. V_3 and V_1 were on par.

The 100-seed weight was seen increased due to the application of P_2O_5 at the rate of 30, 60 and 90 kg. per hectare but between 60 and 90 kg. P_2O_5 per hectare there was no significant difference. Among the varieties, the highest response to P_2O_5 was shown by the variety V_1 with P_2O_5 at 30 kg. per hectare and it recorded the maximum weight of 12.91 g. Nitrogen in general did not significantly affect the 100-seed weight. The interactional effect of nitrogen and phosphorus was significant with respect to the test weight of seeds. The increase in weight may be attributed to the effect

of phosphorus on the plumpiness of seeds which reflected on the yield of the varieties.

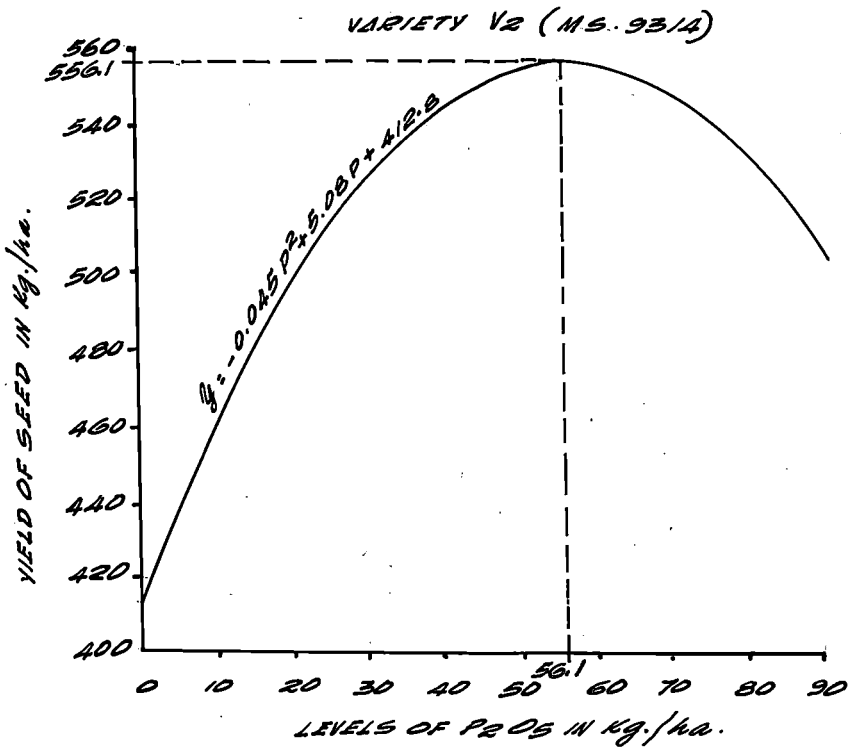
11. Optimum and Economic Levels of Phosphorus

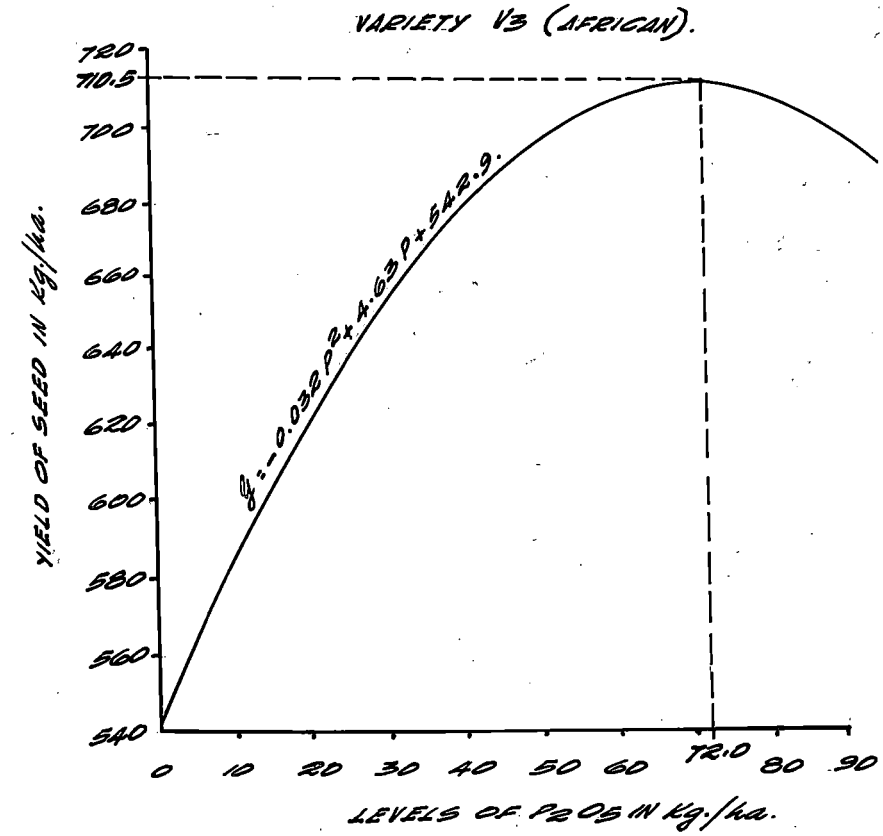
All the varieties tried have responded remarkably to phosphate manuring. The varieties V_1 and V_3 recorded the highest yields. The effect of phosphorus applied alone seemed far superior to the effect of nitrogen applied alone and in combination with phosphorus. The ready response of leguminous crops to phosphatic fertilizers is clearly evident in the results of the present investigation. The response curves fitted for the five varieties tried are presented in Figs. 3, 4 and 5. The optimum dose of P_2O_5 is found to be 76.05, 56.10, 72.00, 66.25 and 69.70 kg. per hectare for the varieties V_1, V_2, V_3, V_4 and V_5 respectively. The economic doses of P_2O_5 in kg. per hectare are seen to be 55.80 for V_1, 39.70 for V_2, 48.90 for V_3, 47.50 for V_4 and 48.10 for V_5.



RESPONSE CURVE FOR YIELD OF SEED FOR DIFFERENT LEVELS OF PHOSPHORUS.

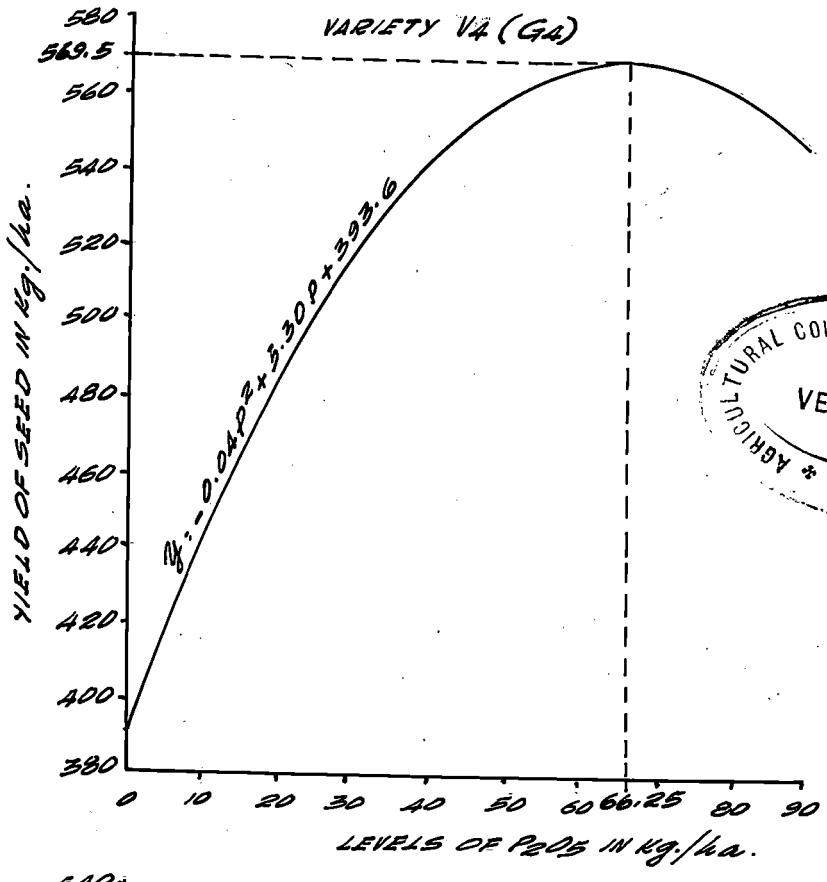
FIG: 3

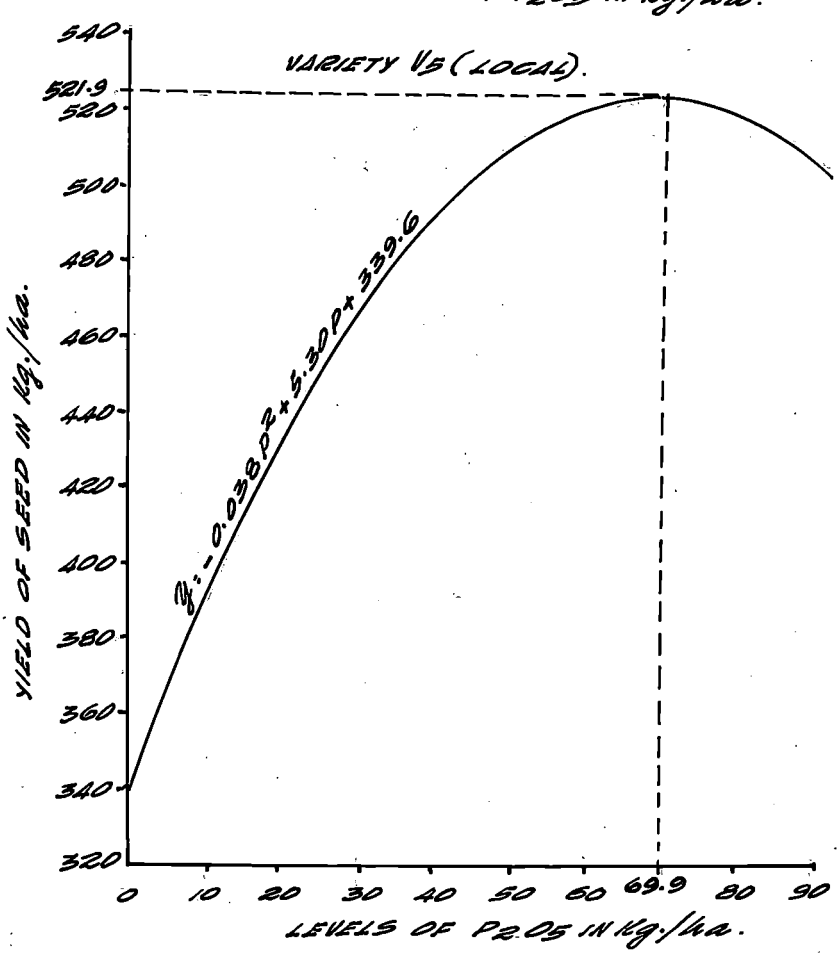




RESPONSE CURVES FOR YIELD OF SEED FOR DIFFERENT LEVELS OF PHOSPHORUS.

FIG: 4.





RESPONSE CURVES FOR YIELD OF SEED FOR DIFFERENT LEVELS OF PHOSPHORUS.

FIG:5

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

A field experiment was laid out in the farm attached to the Agricultural College and Research Institute, Vellayani, during 1965-66 to study the effect of nitrogen and phosphate fertilization on five varieties of cowpea and to determine the best variety, suited to the local conditions. The varieties tried were, New Era, M.S.9314, African, G_4 and the local. The fertilizer treatments comprised two levels of nitrogen, viz. 0 and 20 kg./ha. and four levels of P_2O_5, viz. 0, 30, 60 and 90 kg./ha. The main findings are summarised below:

1. (a) Variety 'African' recorded the maximum mean height of plants, followed by G_4.

(b) Application of nitrogen at 20 kg./ha. increased the height of plants. Phosphorus had no significant effect on this character.

2. (a) Maximum nodulation was observed in the variety 'African' with P_2O_5 at 90 kg. per hectare.

(b) A significant linear increase in nodulation was obtained with phosphate application. All the

varieties showed negative response to addition of nitrogen.

3. (a) The local variety produced the maximum number of pods per plant.

(b) Application of phosphorus resulted in a significant increase in the number of pods. The maximum number was produced with P_2O_5 at 60 kg./ha.

4. Application of phosphorus significantly reduced the number of barren pods.

5. (a) Variety New Era was found to be superior to the other varieties in the length of pods and the number of seeds per pod.

(b) Phosphorus tended to increase the pod length as well as the number of seeds per pod.

6. (a) Variety New Era gave the highest yield, followed by African, local, G_4 and M.S.9314.

(b) There was no significant increase in the yield of seed beyond 30 kg. P_2O_5 per hectare. Nitrogen at 20 kg. per hectare had no effect on the yield.

7. (a) Variety G_4 was found superior to the other varieties in the yield of haulm, followed by African,

New Era, Local and M.S.9314.

(b) Nitrogen at 20 kg./ha. in combination with P_2O_5 at 30 kg./ha. had a significant effect on haulm yield.

6. (a) The 100-seed weight was found to be maximum in the variety African, closely followed by New Era.

(b) P_2O_5 at 30 kg./ha. significantly increased the 100-seed weight.

Of the different varieties studied, New Era was found to be the best suited to the soil and climatic conditions of Vellayani, followed by African, local, G_4 and M.S.9314.

Variety New Era also showed the highest response to phosphate manuring. It showed response up to 76.05 kg. P_2O_5/ha. but the economic dose was found to be 59.80 kg./ha.

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APPENDICES

APPENDIX I

METEOROLOGICAL DATA RECORDED AT THE AGRICULTURAL COLLEGE FARM DURING THE CROP PERIOD

Period	Weekly Reports	Rainfall in m.m.	Temperature °F		Relative humidity %
			Maximum	Minimum	
	Days				
July	1 - 7	54	84.0	76.8	90.1
	8 - 14	-	86.0	77.8	89.7
	15 - 21	28	85.0	78.0	89.0
	22 - 28	-	84.8	76.8	89.4
	29 to Aug.4	55	84.0	76.6	90.0
Aug.	5 - 11	-	83.1	77.7	90.1
	12 - 18	63	83.1	77.4	90.3
	19 - 25	10	85.4	77.4	87.4
	26 to Sept.1	-	84.8	77.4	86.5
Sept.	2 - 8	27	85.4	77.7	86.0
	9 - 15	-	86.3	78.0	88.7

APPENDIX II

(Analysis of variance)

HEIGHT OF PLANTS

Source	S.S.	D.F.	Variance	F
Total	37952.000	119		
Block	16017.610	2	8008.800	105.990++
N	486.500	1	486.500	6.400+
P	98.110	3	32.700	<1
N x P	466.350	3	155.450	2.050
Error 1	1057.910	14	75.565	
Variety	16607.660	4	4176.910	144.230++
Interaction	810.910	28	28.960	<1
Error 2	2306.950	64	36.040	

++ Significant at 1 per cent level

+ Significant at 5 per cent level

APPENDIX III

(Analysis of variance)

NUMBER OF NODULES

Source	S.S.	D.F.	Variance	F
Total	3074.905	119		
Block	10.145	2	5.072	3.549
N	291.408	1	291.408	203.924++
P	893.542	3	297.847	208.430++
N x P	30.198	3	10.066	7.044++
Error 1	20.004	14	1.429	
Variety	1338.164	4	334.541	192.260++
Interaction	380.007	28	13.571	7.790++
Error 2	111.437	64	1.740	

++ Significant at 1 per cent level

APPENDIX IV

(Analysis of variance)

NUMBER OF PODS

Source	S.S.	D.F.	Variance	F
Total	2738.756	119		
Block	1119.214	2	559.607	157.100++
N	0.195	1	0.195	<1
P	77.817	3	25.939	7.280++
N x P	10.065	3	3.355	<1
Error 1	49.880	14	3.560	
Variety	930.651	4	232.663	34.080++
Interaction	113.980	28	4.070	<1
Error 2	436.954	64	6.827	

++ Significant at 1 per cent level

APPENDIX V

(Analysis of variance)

NUMBER OF BARREN PODS

Source	S.S.	D.F.	Variance	F
Total	41.165	119		
Block	1.800	2	0.900	9.090++
N	0.046	1	0.046	<1
P	8.112	3	2.704	27.300++
N x P	0.310	3	0.103	1.040
Error 1	1.395	14	0.099	
Variety	15.166	4	3.791	27.070++
Interaction	5.245	28	0.187	1.280
Error 2	9.091	64	0.142	

++ Significant at 1 per cent level

APPENDIX VI

(Analysis of variance)

LENGTH OF POD

Source	S.S.	D.F.	Variance	F
Total	808.387	119		
Block	2.336	2	1.168	28.500++
N	0.099	1	0.099	2.410
P	27.867	3	9.289	226.500++
N x P	10.825	3	3.608	88.000++
Error 1	0.577	14	0.041	
Variety	746.265	4	186.566	2086.300++
Interaction	14.676	28	0.524	5.880++
Error 2	5.742	64	0.089	

++ Significant at 1 per cent level

APPENDIX VII

(Analysis of variance)

NUMBER OF SEEDS PER POD.

Source	S.S.	D.F.	Variance	F
Total	721.340	119		
Block	6.818	2	3.409	6.383++
N	0.009	1	0.009	< 1
P	51.391	3	17.130	32.080++
N x P	4.371	3	1.457	2.730
Error 1	7.480	14	0.534	
Variety	577.453	4	144.363	511.900++
Interaction	55.779	28	1.992	7.060++
Error 2	18.039	64	0.282	

++ Significant at 1 per cent level

APPENDIX VIII

(Analysis of variance)

YIELD OF PODS PER HECTARE.

Source	S.S.	D.F.	Variance	F
Total	12.212	119		
Block	2.674	2	1.337	102.800++
N	0.004	1	0.004	<1
P	1.732	3	0.577	44.380++
N x P	0.536	3	0.178	13.700++
Error 1	0.184	14	0.013	
Variety	4.854	4	1.213	58.000++
Interaction	0.908	28	0.032	1.550
Error 2	1.320	64	0.020	

++ Significant at 1 per cent level

APPENDIX IX

(Analysis of variance)

YIELD OF SEED PER HECTARE

Source	S.S.	D.F.	Variance	F
Total	6.530	119		
Block	1.610	2	0.805	115.000++
N	0.002	1	0.002	<1
P	1.495	3	0.498	72.143++
N x P	0.253	3	0.084	12.000++
Error 1	0.100	14	0.007	
Variety	1.980	4	0.495	51.030++
Interaction	0.470	28	0.017	1.750
Error 2	0.620	64	0.009	

++ Significant at 1 per cent level

APPENDIX X

(Analysis of variance)

YIELD OF HAULM PER HECTARE

Source	S.S.	D.F.	Variance	F
Total	3013.390	119		
Block	389.380	2	194.690	40.810++
N	55.855	1	55.855	11.709++
P	44.282	3	14.760	3.094
N x P	31.223	3	10.407	2.181
Error 1	68.870	14	4.770	
Variety	1961.650	4	490.410	100.300++
Interaction	151.070	28	5.390	1.102
Error 2	313.060	64	4.890	

++ Significant at 1 per cent level

APPENDIX XI

(Analysis of variance)

100 - SEED WEIGHT

Source	S.S.	D.F.	Variance	F
Total	494.088	119		
Block	0.489	2	0.244	2.910
N	0.182	1	0.182	2.160
P	6.099	3	2.030	24.200++
N x P	1.794	3	0.598	7.120++
Error 1	1.177	14	0.084	
Variety	465.070	4	116.267	1211.100++
Interaction	13.111	28	0.468	4.800++
Error 2	6.166	64	0.096	

++ Significant at 1 per cent level