STUDIES ON THE PERFORMANCE OF Co. 1 LAB-LAB *(Ottu mochai)* UNDER GRADED DOSES OF PHOSPHORUS AND POTASH AT DIFFERENT SPACINGS

By

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THESIS

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CERTIFICATE

This is to certify that the thesis herewith submitted contains the results of bonafide research work carried out by Shri V K. Sasidhar, under my supervision. No part of the work embodied in this thesis has been submitted earlier for the award of any degree.

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INTRODUCTION

INTRODUCTION

Traditionally pulses have been an important constituent of Indian diet. Rich in protein and essential amino acids, they are consumed in various ways depending on the culinary niceties of different regions.

The nutritional standard of the food consumed by the people of this country is far below, when compared to other countries in the world. In economically advanced countries, the average uptake of protein is generous and the protein of animal origin make up nearly half the total protein. In terms of calories, the per capita consumption of food energy per day is only 1970 in India, when compared to the world average of 2420. The consumption of fruits, vegetables, pulses, egg, fish and meat is deplorably inadequate in India. This has been clearly reflected in the protein equivalent being 51 for India, 60 for other under developed countries and 90 for developed countries.

Diet surveys carried out in India have shown that bulk of the food in Indian dietaries is formed by cereals, which supply about 80% of the total energy. But according to Aykroyd and Doughty (1964), a balanced diet should contain 3 oz of pulses per day per adult.

This is because of the fact that all pulses contain higher percentage of protein than cereals. But the present production of pulses is only 12 million tonnes which is not sufficient for consumption as per the above standard. This emphasises the necessity for increasing the production of pulses.

Pulses have the unique built in mechanism for directly using the inexhaustible stock of nitrogen in the atmosphere. Every year in India, these crops use some 12 lakh tonnes of atmospheric nitrogen worth Rs.250 crores free of any cost. In all our factories, we do not produce even half of this amount of fertilizer nitrogen. Even the crops that follow pulses benefit from the enriched soils to the extent of Rs 45 crores. The annual pulses production of about 1.2 crore tonnes itself is worth Rs.1,200 crores, equivalent in value to the best harvest of our most prized crop of wheat, grown on the best lands we have (Chowdhury, 1968). Thus pulses play an important role not only in improving the nutritional standard of the food that we consume, but in the whole economy of the country also.

In Kerala, Peas and beans occupy 9300 hectares with an annual production of 3700 tonnes. Cowpea occupies a larger area under pulses, eventhough lab-lab contains comparatively higher percentage of protein than others The reason being the spreading habit coupled with season bound nature of kitchen garden lab-lab which is being cultivated as a vegetable crop in Kerala. But the recently released Co.1 lab-lab is a non seasonbound, dual purpose variety with erect habit.

Co.1 lab-lab is a cross between field lab-lab (_Dolichos lab-lab_ var. _lignosus_) and kitchen garden lab-lab (_Dolichos lab-lab_ var. _typicus_) and can be cultivated throughout the year. Considering the high content of protein (29.7%) Co.1 lab-lab has been tried at Vellayani to ascertain its suitability to Kerala conditions. The preliminary trials were conducted at the Agricultural College Farm, Vellayani and in view of the encouraging results obtained, it was thought worthwhile to conduct systematic field trials to study the nutritional as well as spacing requirements of this crop under Kerala conditions.

Legumes have been reported to be heavy phosphate feeders and phosphate manuring of legumes has been found to increase the nitrogen fixation in soil, as well as the nutritive value of crops. Legume crops are capable of tapping the subsoil and utilising the native phosphorus and, therefore, it is likely that they may not give any good response for phosphorus application (Raheja, 1966). Similarly it has also been reported that addition of potash will increase the phosphorus absorption by plants (Raheja, 1966). However, reliable data are lacking on this aspect of manuring also.

Being a recently released variety, correct assessment has not been made of the requirement of Co.1 lab-lab. It is not known, how far this crop does well under our conditions.

With radical change in the plant type concept in food crops, it has now become apparent that plant population is one of the important factors that determines the yield of crops. As a crop newly introduced under our conditions, the spacing requirements of the crop under our agro-climatic conditions need investigation.

Thus, to get an idea on the phosphorus, potash and spacing requirements of Co. 1 lab-lab and also to get a clue on the behaviour of phosphorus in the soil, the present study was undertaken. Broadly, the objectives of the experiment can be laid down as follows:

1. The performance of hybrid Co.1 lab-lab under graded doses of phosphorus and potash.
2. Performance of crop as influenced by spacing.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

This review relates to the effects of different levels of phosphorus, potash and spacings on a recently introduced Co.1 lab-lab under Vellayani conditions. Since there is not much work on the above aspects of study on lab-lab, the related literature on the other crops, particularly legumes have been reviewed.

Effect of phosphorus on growth and yield

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

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

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

Rao (1923) observed that phosphorus application increased the growth of plants like daincha, cowpea and berseem significantly. The favourable response of legumes to phosphate application with regard to yield has been reported by Fred et al (1932). Increase in growth of plants like daincha, cowpea and berseem with phosphorus application has been observed by Parr and Bose (1945) also. Sen (1956) remarked that "it would pay to fertilise legumes with phosphate as it increases the yields of these crops and enrich the soil". Results of experiments conducted by Lin (1959) showed that phosphate fertilisation increased height of plants, number of tillers and leaves per plant, weight of tops and roots, and hay yield in yellow lupine. Marked increase in the herbage growth of white clover due to addition of phosphorus was reported by Templeton and Taylor (1966). The effect of phosphorus in increasing the seed yield of legume was reported by Raheja (1966) who noted that seed yield of legumes was substantially reduced when phosphate was deficient in soil. However, low phosphate response at high levels was also observed by Raheja (1966) in berseem crop. Application of phosphates was even reported to reduce yields under certain conditions by Pierre (1944).

The effect of different levels of phosphorus on the yield of different kinds of leguminous crops has also been recorded by several workers. The optimum requirement of phosphorus for some leguminous crops has also been worked out. Baur and Trembly (1948) observed that 60 lb. phosphorus per acre properly placed in bands sufficed to produce good yields of canning and freezing peas. Increases in yield of dry matter, nodule number and nitrogen content of peas were reported by Vyas and Desai (1953), when they applied 60 and 120 lb. of superphosphate per acre.

Bhide (1952) reported spectacular increase in yield of cowpea with 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. Chandani and Oberoi (1956) noticed increase in vegetative growth of cowpea manured with phosphorus at 80 lb. per acre. Significant increase in yield of cowpea was obtained by Sharma and Misra (1961) by application of 30 and 60 lb. phosphorus per acre. The response of cowpea to foliar application of superphosphate was studied by Panikkar (1963) who recorded 100 per cent increase in straw yield over control. The experiment of Nair (1966) in cowpea showed that phosphorus application at the rate of 30 kg. per hectare increased 100 seed weight. Phosphorus also tended to enhance the number of pods, length of pods as well as the number of seeds per pod. However, there was no significant increase in the yield of seed beyond 30 kg. P_2O_5 per hectare. Phosphorus had no significant effect on the height of plants also. Bains (1967) also found that phosphate application did not influence the yield in field beans.

Ballal and Natu (1959) reported significant increase in yield of gram by the application of phosphorus at 40 lb. per acre. Manu (1966) summarising the results of simple fertiliser trials conducted on groundnut and Bengal gram concluded that both the crops responded significantl to phosphate manuring at doses varying from 33.6 kg. to 67.2 kg. per hectare. The response of green gram to phosphorus application in an acid laterite soil with high fixation capacity was studied by Moolani and Jana (1965). They observed that 100 kg. P_2O_5 per hectare significantly increased yields of green gram, when applied with or without nitrogen. Deshpande and Bathkal (1965) compared the response of mung to foliar spray and soil treatment of phosphorus. They reported that 10 lb. P_2O_5 per acre as foliar spray and 20, 40 and 60 lb. per acre as soil treatments produced increase of 32.1, 20.6, 75.6 and 85.6% in seed yields and 8.5, 14.8, 27.9 and 46.2% in green matter yields respectively from mung They noted that 40 and 60 lb. P_2O_5 per acre significantly increased number of pods per plant and weight of pods per acre.

However, Shukla (1964) found that application of phosphorus at 30 and 60 lb. per acre did not increase significantly the height of gram over no manure treatment. Sekhon et al (1966) reported that response of guar (*Cyamopsis tetragonoloba*) and mash (*Phaseolus aureus*) to P_2O_5 at 0, 40 and 80 lb. per acre was negligible. Even in a soil with very low phosphorus content, there was no effect with phosphate application on various legumes (Raheja, 1966).

The effect of phosphorus on soybean was studied by many workers. Welch et al (1949) and Howell (1955) reported beneficial effects of phosphate fertilisation on the yield of soybean. Miyasaka et al (1966) obtained increased soybean yields from 267 kg. per hectare to 795 and 1373 kg. per hectare at 60 and 120 kg. P_2O_5 per hectare respectively over no phosphorus. According to Anthony (1967) application of at least 45 lb. P_2O_5 per acre was necessary to build up the phosphorus status of soil enough to increase soybean yields by 10 bu per acre from residual phosphorus.

Singleton (1945) and Par (1947) obtained increased yields of alfalfa and clover by the addition of phosphatic fertilizers. Par (1947) observed that increasing dose of phosphatic fertilizers, particularly superphosphate, enhanced fodder yield in clover. Larson et al (1952) and

James *et al* (1953) obtained significant increase in yield of lucerne by phosphate manuring with doses varying from 30 to 240 lb. of P_2O_5. From a long term trial with low doses of phosphorus at 18, 36 and 72 lb. of P_2O_5 per acre, Ambika Singh and Tirlok Singh (1953) obtained increased yield of berseem. An increased yield of 331.9 maunds of green matter by the application of 20 lb. phosphorus to berseem was recorded in New Delhi (Anon., 1962). Elgindi *et al* (1963) recorded 11.96% and 3.95% increased yields of berseem with 150 kg. superphosphate with and without 100 kg. calcium nitrate respectively. But in the case of Indian clover (*Melilotus parviflora*), phosphorus showed a tendency to increase the yield only to a slight degree, viz., 4 to 5% which was not significant (Gill and Batra, 1966).

Johri (1956), studying the effect of application of superphosphate to daincha in laterite soil 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 no manure plants. Nair *et al* (1957) obtained significant increase in height of sesbania with phosphorus application at the rate of 30 lb. per acre. From the results of experiments with different kinds of phosphatic fertilisers, Malathi Devi (1960) reported that superphosphate was the best in increasing the yield of green manures. According to Venkata Rao and Sadasivam (1968), increase in the yield of green matter in the case of sannhemp was the order of 50% at 40 lb. P_2O_5 level and the same was over 200 per cent at 320 lb. P_2O_5 level.

Contrary to the above findings, Agarwal and Verma (1951) could not get increased yield of green matter in sannhemp in Kanpur soils where the available P_2O_5 content was high. Desai et al (1957) also 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 the green manure crops in sandy loams with an available phosphorus content of 50 lb. per acre or above had no beneficial effect in increasing the production of green matter. Investigations carried out by Relwany and Ganguly (1959) on green manuring in conjunction with application of fertilisers indicated that though, daincha responded to the application of superphosphate by producing more yields, the difference in yield of green matter was not statistically significant. Rao et al (1962) obtained no significant difference in yield of pillipesara and sannhemp raised on sandy loam soils of Andhra Pradesh with phosphorus at 22.5 lb. per acre

Effect of phosphorus on the uptake of nutrients and quality

In addition to better growth in legumes the phosphate application is also found to increase the uptake of phosphorus, calcium and nitrogen. Increase in protein content of leguminous seeds indicating an increase in nitrogen content has been reported by Fellers (1018). Alexander Mactaggart (1921), from his trial with alfalfa concluded that the nitrogen content of roots showed an increase as a result of phosphorus fortilisation. He had also reported similar results on peas. According to Sirkar and Sen (1941) the protein synthesis is controlled by the supply of phosphorus in the plant. In fact, the uptake of nitrogen is very largely associated with the uptake of phosphorus. It was observed that in the phosphate manured series, phosphate and calcium content of berseem and cowpea fodders, phosphate content of wheat grain, and nitrogen and phosphate content of wheat straw were increased over no manure series (Parr and Bose, 1944 1945). Fuleky (1947) obtained an increase in protein content of soybean by the application of phosphatic fertilizers. Parr and Sen (1948) recorded better growth in legumes and increase in phosphorus, calcium, and protein content by phosphate application. Kiaro (1950) also recorded increase in protein content of soybean by phosphate fertilisation. Acharya et al (1953) found that the application of phosphatic fertilisers to legumes increased their nitrogen content. Increase in yield of dry matter, nodule number and nitrogen content of peas was reported by Vyas and Desai (1953) when they applied 60 and 120 lb. of superphosphate per acre. Kochlor and Moore (1957) found that phosphorus content of alfalfa plants increased with increasing rates of phosphate fertilisers. In an experiment conducted by Shende and Sen (1958) application of phosphorus increased the nitrogen content of guar as compared to plants grown in the control plots. Panos (1959) reported that protein content of certain winter legumes was increased as a result of phosphate fertilisation.

Sankaram et al (1963) studied the effect of 15, 30 and 45 lb. P_2O_5 per acre on the protein content of sannhemp crop and found that 15 lb. P_2O_5 was significantly superior to higher doses.

Elgindi et al (1963) obtained increased phosphorus content by 40.22% and 35.09% by the application of 150 kg. superphosphate with and without 100 kg. calcium nitrate respectively. Hamdi et al (1965) found that increase in phosphorus content of plant was proportionate to the phosphorus added. Daniel (1966) observed that phosphorus uptake was maximum in plants receiving 30 lb. phosphorus per acre. Trials at Kovilpatty on sannhemp showed maximum uptake of phosphorus at 30 lb. P_2O_5 per acre, in the form of superphosphate. The application of phosphate to guar crop at the rate of 60 lb P_2O_5 per acre increased the nitrogen content of plants as compared to the control (Raheja, 1966). Bains (1967) reported that 640 lb of P_2O_5 per acre increased phosphorus content of plant from 0.269% to 0.392% in field beans.

Though there is sufficient experimental evidence to prove the capacity of phosphorus to increase the nitrogen content of legumes, a few investigators have failed to observe the same effect. Chandani and Oberoi (1956) working on the value of certain legumes as green manures, concluded that application of phosphate to legumes like sannhemp, borseem, senji, peas, lentil, cluster beans, soybeans, cowpea and daincha did not increase nitrogen content. Maini and Bains (1965) reported that application of phosphorus at 50 lb. per acre did not increase the protein content in soybeans.

<u>Effect of phosphorus on nitrogen fixation</u>

The results of very large number of experiments conducted in various parts of the world substantiate the view that phosphorus exerts a stimulatory effect on nitrogen fixation in most the legumes. James *et al* (1944) reported that the nitrogen content of experimental plots on which a rotation including legumes was use, was higher, where phosphoric acid and potassic fertilisers were applied than where no fertilisers were applied, inspite of greater removal of nitrogen by crops from fertilised plots. Sen and Bains (1955) from field experiments with different levels of P_2O_5 ranging from 16 to 64 lb. per acre found that with graded doses of the nutrient, increased nodulation was observed in berseem and cowpea. In laterite soils of Kerala, Nair <u>et al</u> (1957) observed significant increase in the number of nodules in Sesbania, when supplied with 30 lb. of phosphorus per acre. Blume and Raychaudhuri (1957) observed that clovers, grams, vetches, etc., could utilise the nitrogen from atmosphere for their growth. According to Alles (1958) nitrogen fixation in legume was directly connected to the total dry matter production of the crop, which in turn was controlled by the phosphorus application. Sikka and Jain (1958) studying the effect of phosphate manuring on physical and chemical properties of soil observed that when guar (<u>Cyamopsis tetragonaloba</u>) was fertilised with phosphate, the nitrogen content of the soil was increased in comparison with the non-fertilised plots. Similar increase in nitrogen fixation with phosphorus application was also reported by Izawa and Okomoto (1959) and Lin (1959) in red clover and white clover respectively. Mudaliar (1960) also observed increased nitrogen fixation by legumes as a result of phosphorus application.

However, Horace et al (1928) stated that superphosphate and Muriate of potash applied in plots to a crop of soybean did not have any influence on the nitrogen fixation. Only slight increase in the nitrogen content of soil was recorded by Vyas and Desai (1953). Russel (1961) reported that legumes may not increase soil nitrogen under all conditions. In case of legumes like peas, beans, soybeans and groundnut, even if their roots are often well nodulated, a large portion of nitrogen fixed is removed by the seed, straw and other harvested portions of the crop.

Effect of legumes and applied phosphorus on the availability of nutrients

The value of legumes as soil improvers is recognised everywhere. The fact that some crops have a considerably greater power than others for utulising the less readily available sources of phosphates can be employed in converting some of the phosphates into more easily available form by growing them as green manure crops. Yawalkar and Agarwal (196 reported increased availability of certain plant nutrients like, phosphorus, calcium, potassium, magnesium and iron as beneficial effects of green manuring. Raheja (1966) reported that in most places the subsoil contains adequate quantities of phosphorus which the deep-rooted crops are able to tap and make use of in growth of the crops. The reason forvery small response to applied phosphate by gram and pigeon pea according to him was the deep root system present in these plants by which they are able to tap the subsoil phosphorus pretty effectively in mo t localities in India.

A still better method of building up the soil fertility which was receiving much attention in recent years in India is the phosphate fertilisation of legumes The analysis of soil samples from the permanent manurial and rotation experiments of Pusa in 1946-47 revealed that the plot in which sannhemp was fertilised with phosphate showed highest content of carbon and nitrogen (Sinha,1947). Desai and Parr (1949) reported that in addition to increase in the yield of legume, increase in organic matter and nitrogen contentswas also brought about by phosphate application. The soil analysis showed that plots where berseem had been grown in rotation with phosphate manuring had at the end of a ten year period about 17% higher nitrogen content and also higher organic matter content than the plots where berseem had been grown without phosphate manuring (Acharya et al,1953). The effect of continuous cropping of berseem with the addition of phosphate on the nutrient status of soil was studied by Sen and Bains (1955). They observed that cultivation of berseem for three years with the addition of phosphate increased the nitrogen content of soil. Bains (1967) concluded that under green house conditions, soil test values for available phosphorus and available potash were influenced by the application of respective fertiliser elements, particularly at higher levels of applied phosphate and potash which indicated build up of available nutrients in the soil Phosphorus application to green manure like sannhemp brought about mobilisation of nitrogen as stated by Venkata Rao and Sadasivam (1968), wherein they got an increase of 72 lb nitrogen in the soil by the application of 40 lb. phosphorus to sannhemp. An increasing trend in nitrogen level was noticed by them with increasing levels of P_2O_5, the maximum being 204 lb. of nitrogen at 320 lb. P_2O_5 application

<u>Effect of potash on growth and yield of legumes</u>

Comparatively very few studies seem to have been carried out on the effect of potassium on the yield of legumes.

Striking yield response by potash application to soybean has been reported by Collwell (1944) and Collins *et al* (1947). Rossiter (1947) reported that potassium chloride application at the rate of 1 cwt per acre increased the yield of subterranean clover significantly. Baur and Trombly (1948) indicated that canning and freezing peas in western Washington required 60 lb. K_2O per acre in most of the soils. Fedorov and Podjapoljasja (1950) reported that lesser doses of potassium in sand culture medium reduced yields and also reduced the weight of nodules formed in legumes. Experiments conducted by Dolver (1953) indicated that dwarf bean required comparatively lesser potassium than nitrogen and phosphorus. Vargans (1957) obtained the highest yield with 60 kg. potash per hectare in beans. Wu (1963) observed increased yields in soybean by the application of potassium both in plots treated with phosphorus or inoculated. Feng (1964) recorded higher yield responses to potash in sandy loams. He obtained an increased yield of 215 kg. per hectare by applying 60 kg. K_2O per hectare on a sandy loam. Reisr and Sherwood (1965) obtained increased seed weight by the application of potash alone in soybean. Significant yield increase of groundnut with 180 kg. K_2O per hectare in soil having an adequate supply of available potash has been reported by Hagin and Koyumjisky (1966). In addition to an increase in yield of lucern (<u>Medicago Sativa L.</u>) an increased height of plants, rate of leaf accumulation, leaf size, weight per unit area, stomatal number and aperture have also been recorded by Cooper *et al* (1967) by potash application. They found that net photosynthesis of excised leaves increased with potash application and leaves from plants with added potash and lower CO_2 compensation points.

However, lesser responses were reported by Cartter (1941) and by Prince et al (1941). Rossiter (1947) reported that potassium chloride application at the rate of 1 cwt. per acre did not have any positive effect on lupines and other pasture species. Potassium had no effect on the total yield of pasture for four years, when 200 and 400 lb. K_2O per acre added as either one initial or four equal annual application respectively (Doll et al.,1959). However, soil test showed a slight increase in potassium content where 200 lb. of potassium were applied annually. Fong (1964) could not get any increase on height of plants by application of potash, though he recorded increased branching. In an experiment with groundnut, Veeraraghavan (1964) reported that there was no significant difference in hay (dried shoot) yield by the different levels of potash. Tewari (1965) reported that addition of potassium had no effect on the formation of nodules in cowpea. Vijayakumar (1967) also reported that potassium had no effect on nodulation, number and length of pods, and yield of bhusa in cowpea.

Depression effect of potassium on yield attributes like height of plants, weight of tops and roots, number of leaves and tillers per plant has been noted by Lin (1959) in yellow lupine. Adverse effect of potassium on yield was also noted by Kataski and Banahatti (1965), when potassium sulphate at the rate of 100 lb. and 200 lb. K_2O per acre was applied to groundnut. Vijayakumar (1967) reported a reduction in the mean height of cowpea by the application of potassium.

Effect of potash on the uptake of nutrients

Albrecht et al (1948) found that potash was the major factor in making for a larger concentration of nitrogen in tops, while there was a lower concentration in the roots. Scheffer et al (1961) noticed that the crude protein content of green and ripe peas were favourably influenced by the application of phosphate and potash. The absorption of phosphorus increased with increasing potash in the soil. The application of large amounts of muriate of potash to the soil reduced absorption of nitrogen, sulphur and phosphorus and thereby protein synthesis is also reduced (Raheja, 1966). Klebesadel and Brinsmade (1966) found that potash did not significantly affect crude protein content of forage. Bains (1967) recorded an increase in potash content of field beans to an extent of 1.49% to 3.11% at the highest level of application (320 lb. K_2O per acre).

Spacing

Most of the spacing experiments with crop plants have shown that the yield per acre depended on the growth and yield per plant and the total number of plants per unit area. The limitation of any of the factors depressed total production. Vittum *et al* (1958) noted that the yield of pea was decreased when plant population was less or when spacing given was closer than the optimum. According to Riepma (1958) the duration as well as branching characteristics and facilities for irrigation of the crop determined the optimum plant population per unit area. Short statured early varieties of peas required a larger number of plants per unit area, whereas the reverse was true with well branching and long duration dry crops. Some authors, however, have remarked that spacing does not influence the level of protein (Goldin, 1966 and Singh and Singh, 1968).

<u>Effect of spacing on growth and yield of legumes</u>

Nagi and Dalal (1957) obtained 5.24% higher yield of groundnut with 12" x 9 spacing over the commonly adopted spacing of 12 x 24 in Punjab. Picard and Sigwalt (1960) reported that spacing requirement varied even with varieties of the same crop. According to him the optimum plant density of field beans (*V. faba*) was about 45 plants per m^2 for a large seeded variety and 50 to 55 plants per m^2 for a small seeded variety. Lohman and Lambert (1960) studying the specific effects of spacing between rows and plants within the same row, in the case of two varieties of soybeans in two different soil types found that the number of seeds per pod decreased irrespective of soil types, when the spacing between plants in the same row was reduced. But the weight of seed behaved differently. Although in wide spacing of 7 to 12 between plants in rows situated 30 to 36" apart increased the percentage of large pods, this was not conducive to heavy yield when compared to a spacing of 2" to 6" (Anon., 1961). In a study of the effect of spacing on protein content of plant, it was observed that protein content tended to be lower with closer spacing (Donovan et al, 1963). Reiss and Sherwood (1965) reported that rows 24 wide produce the highest seed yields in soybean followed by rows 16, 8, 32 and 40 inches wide Appadurai et al (1966) studied the effect of spacing and leaf area on pod yields of kidney bean (*Phaseolus vulgaris* I) and observed that a spacing of 7.5 cm within the row, with 30 5 cm between rows was superior to all other spacings. Ahmad et al (1966) obtained highest pod yields with 24" x 12" spacing in the case of four spreading type varieties of groundnut Molinyawe and Cao-Van-Nav (1966) reported that soybean plants performed well under closer spacings in the dry season and under wider spacings in the wet season. Crop growth in the dry season recorded a higher seed weight of 12.8 grams compared to 9.1 grams in the wet season. Suput et al (1967) observed that in soybean the highest population gave the highest average seed yield, especially with early varieties. Gray (1967) recorded higher yield of seeds when soybeans sown in rows 12 apart with 1 or 2 seeds per hill spaced 6 or 4 inch apart Tender crop snap beans (*Phaseolus vulgaris* L.) were seeded 2.5, 5.1, 7.6 and 10.2 cm. apart in rows spaced 76 cm. apart in three consecutive years. The 2.5 cm. spacing consistently gave the highest yield (Cultcliffe, 1967). In another trial conducted for three years in peas Shekhawat *et al* (1967) reported that highest average pod yield of 13216 kg. per hectare was obtained with an intra-row spacing of 45 72 cm., while 30.48 cm. and 60 96 cm. spacings gave only 11941 kg. and 10993 kg. respectively Gautam and Tonka (1968) noticed that closer row spacing and higher seed rate made the plant tall, reduced branching, and decreased yield because of increased inter and intra plant competition. They obtained negative correlation for per plant and per hectare yield under increased seed rates. Irrigated groundnut responded to broader spacings as evidenced by the result obtained by Govindadas *et al* (1968), which showed that 18" x 3" and 15" x 4" spacings resulted in more number of kernels per unit weight than the other treatments.

However, Sen and Jana (1960) obtained results which showed that different spacings had very little effect on the height of plants. But number of branches, pods, seeds, dry weight and yield per plant increased with wider spacings. Goldin (1966) and Singh and Singh (1968) were of the opinion that spacing does not influence the yields of pods and bhusa or protein content of grain

Interaction effects

Offutt *et al* (1966) concluded that phosphorus and potash increased hay yield when used together or in conjunction with lime, but not when either was used alone or without lime. Seed yields were not increased unless phosphorus and potash were used in conjunction
Gooring (1966) reported that a combination of 150 kg P_2O_5 plus 250 kg. K_2O per hectare gave optimum yield where soil phosphorus and potash were very low. While studying the effect of nitrogen, potash and phosphorus on beans, Bains (1967) reported that nitrogen application showed significant association with bean yields, whereas phosphorus and potash effects were nonsignificant.
Singh and Singh (1968) concluded that interaction of 80 kg. P 0 per hectare and 25 cm. spacing has considerably increased the straw yield.

MATERIAL AND METHODS

MATERIALS AND METHODS

The present investigation was undertaken to assess the phosphorus, potash and spacing requirements of Co.1 lab-lab (Ottumochai) under Vellayani conditions.

Experimental site

The experiment was laid out in the red loam soils of the farm attached to the Agricultural College and Research Institute, Vellayani. The analytical data on chemical composition of the soil are furnished in Appendix I.

Season

The experiment was conducted during the period from September, 1968 to January, 1969. The meteorological observations recorded during the above period are given in Appendix II.

Seed material

The variety used was Co.1 lab-lab (Ottumochai) The seeds were obtained from the Pulses Breeding Station, Agricultural College and Research Institute, Coimbatore.

Co 1 lab-lab is a high yielding improved strain released by the Pulses Breeding Station, Agricultural

College and Research Institute, Coimbatore. It is a non-season-bound dual purpose variety of 115-120 days duration and is reported to be suitable for growing round the year under irrigated and rainfed conditions.

The plants are short, bushy and erect. The inflorescences are born on stalks of medium length with white flowers. Flowering starts from 45th day after sowing and continues for about 90 to 100 days. The average number of flowers in each inflorescence ranges between 55 to 60 and about 50% of the flowers set pods. The green pods fit for use as vegetable can be harvested 10 to 12 days after flowering. Pods are light green, 6.5 to 7 cm. long and 1.5 to 2 cm. broad with protein and fat contents of 29.7% and 3.93% respectively.

<u>Manures and fertilisers</u>

A uniform basal dressing of cattle manure, lime and ammonium sulphate was given to all plots. Nitrogen as ammonium sulpaate, phosphorus as superphosphate and potassium as muriate of potash were applied. Lime was given in the form of calcium hydroxide.

Fertilisers and cattle manure used were analysed as follows:

Ammonium sulphate	:	20.6% N
Superphosphate	:	16.0% P_2O_5
Muriate of potash	:	50.0% K_2O
Lime	:	55.0% CaO
Cattle manure	:	0.54% N
		0.31% P_2O_5
		0.48% K_2O

Lay out of the experiment

(a) Treatments

The treatments consisted of 4 levels of phosphorus and three levels each of potash and spacing and their combinations. The following were the levels

Levels of phosphorus

P_0	:	No phosphorus
P_1	:	25 kg P_2O_5/ha
P_2	:	50 kg P_2O_5/ha
P_3	:	75 kg P_2O_5/ha

Levels of potash

K_0	:	No potash
K_1	:	15 kg K_2O/ha
K_2	:	30 kg K_2O/ha

Levels of spacing

S_0	:	40 cm x 15 cm
S_1	:	40 cm x 25 cm
S_2	:	40 cm x 35 cm

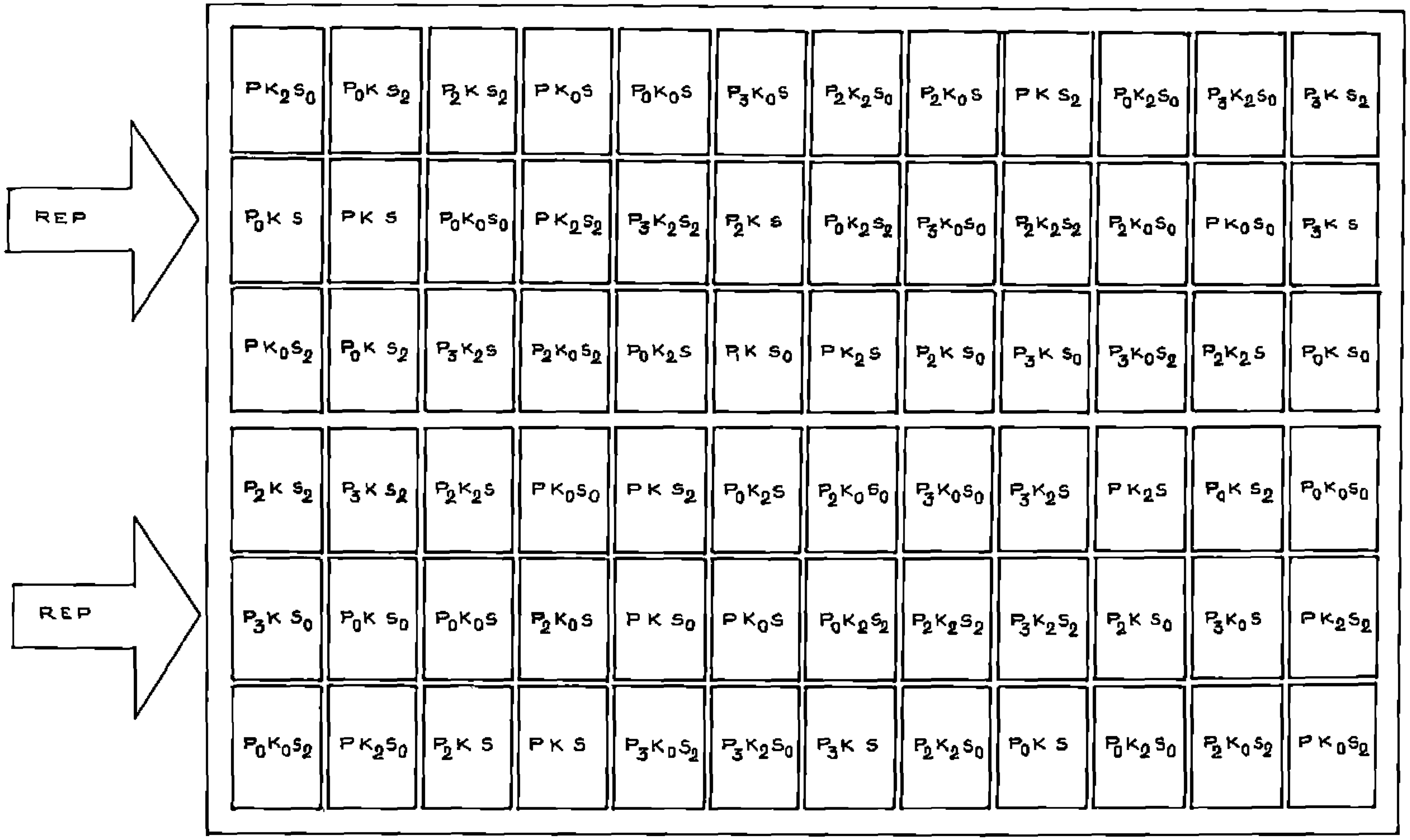
The different treatment combinations numbering 36 were as follows:

$P_0K_0S_0$	$P_1K_0S_0$	$P_2K_0S_0$	$P_3K_0S_0$
$P_0K_0S_1$	$P_1K_0S_1$	$P_2K_0S_1$	$P_3K_0S_1$
$P_0K_0S_2$	$P_1K_0S_2$	$P_2K_0S_2$	$P_3K_0S_2$
$P_0K_1S_0$	$P_1K_1S_0$	$P_2K_1S_0$	$P_3K_1S_0$
$P_0K_2S_1$	$P_1K_2S_1$	$P_2K_1S_1$	$P_3K_1S_1$
$P_0K_1S_2$	$P_1K_1S_2$	$P_2K_1S_2$	$P_3K_1S_2$
$P_0K_2S_0$	$P_1K_2S_0$	$P_2K_2S_0$	$P_3K_2S_0$
$P_0K_2S_1$	$P_1K_2S_1$	$P_2K_2S_1$	$P_3K_2S_1$
$P_0K_2S_2$	$P_1K_2S_2$	$P_2K_2S_2$	$P_3K_2S_2$

(b) Design

The design adopted for the experiment was a $4x3^2$ partially confounded factorial experiment with two replications The interactions KS and KS^2 were partially confounded in replications I and II respectively.

Number of treatments	:	36
Number of blocks	:	6 blocks of 12 plots each
Plot size	:	4 m x 5 25 m



LAY OUT

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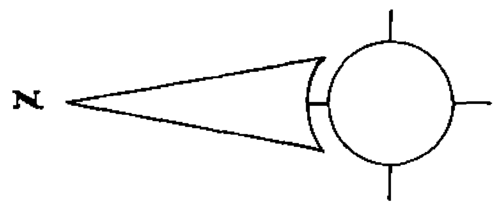

NUMBER OF REA MEN S	36
NUMBER OF REP A O S	2
NUMBER OF B O KS	6
NUMBER OF P O S N EACH B O K	12
P O S ZE	4 M X 5 25 M

FIG 1

Field culture

(i) Preparatory cultivation

The experimental plot received one ploughing with garden tractor one month before planting. The field was dug twice and stubbles, grasses and other weeds were removed. The blocks and plots were then laid out as per the design.

(ii) Manuring

The lime requirement of the soil was found and calcium hydroxide as per the lime requirement was applied broadcast and incorporated 10 days before starting the experiment. Cattle manure at the rate of 5600 kg per hectare was also applied and incorporated.

The fertilisers were applied as basal dressing, a day prior to sowing. Ammonium sulphate and muriate of potash were applied broadcast, while superphosphate was placed in bands 10 cm deep and 30 cm apart Ammonium sulphate was applied to supply a uniform dose of 10 kg N per hectare.

(iii) Sowing

The seeds were dibbled in lines at the rate of one seed per hole on 25-9-1968

(iv) <u>General condition of the crop</u>

Sprouts started appearing over the surface from 4th day onwards. Germination continued till 6-10-1968. The general condition of the crop was normal.

(v) <u>After cultivation and plant protection</u>

Weeding and intercultivation were systematically carried out whenever necessary. Altogether two hand weedings were given to keep the plots free of weeds.

Systematic prophylactic sprayings were given to control pests.

(vi) <u>Harvest</u>

The entire pods were harvested green for vegetable purpose. The first harvest started on 19-11-1968. Eight harvests were done to collect the entire green pods and the last harvest was conducted on 11-1-1969. The four plants selected from each plot for biometric observations were harvested separately. Haulms were pulled out and dried under the sun for three days and weight recorded.

<u>Characters studied</u>

Four plants were selected from each plot by random method for detailed observations.

A. Biometric observations

(i) Height of plants

The height of each selected plant was measured individually on 50th day after sowing. The height was measured from cotyledonary node to the terminal node.

(ii) Earliness in flowering

The number of days taken for the first flower opening was recorded and from this flowering duration was calculated.

(iii) Number of pods per plant

The number of pods on selected plants in each harvest was noted and average worked out.

(iv) Length of pods

The median length of green pods collected from the observation plant was measured in centimetres The average length was also worked out.

(v) Yield of green pods

The weight of green pods obtained in eight harvests was recorded separately. From this total yield of green pods in all the harvests was also calculated

(vi) Weight of dried haulm

On completion of harvest of pods, the plants were pulled out, dried uniformly and their weight recorded.

D Chemical analysis

(i) Total nitrogen content of the soil

Total nitrogen content of the soil taken on the 50th day and at the time of final harvest was estimated Kjeldahl's method was used for estimation of total nitrogen.

(ii) Available phosphorus

The available phosphorus content of the soil taken on the 50th day and at the time of final harvest of crop was determined Bray's method No.I was used to estimate available phosphorus (Bray and Kurtz, 1945).

(iii) Available potash

The available potash content of the soil taken on the 50th day and at the time of final harvest was estimated. Turbidimetric method (Datta et al, 1963) was used.

(iv) Nitrogen content of pods

Representative samples of green pods have been drawn from each harvest and pooled and nitrogen content was estimated after digestion of the dry powdered material by micro-Kjeldahl-Gunning method.

(v) Nitrogen content of haulm

Samples of bhusa were drawn from each plot and analysed for the nitrogen content using micro-Kjeldahl-Gunning method.

(vi) Phosphorus content of pods

Phosphorus content of pods (samples drawn from each harvest and pooled) was determined colorimetrically (Jackson, 1958).

(vii) Phosphorus content of haulm

Samples of haulm drawn from each plot were analysed for the phosphorus content colorimetrically as in the case of pods.

RESULTS

RESULTS

A. Biometric observations

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

1. Height of plants

The data on the height of plants taken on the 50th day were analysed and the analysis of variance table is given in Appendix III. The mean heights of plants under various treatments are presented in Table 1.

The results have indicated that there is no significant increase in height of plants due to different levels of phosphorus. The different levels of potash and spacing also have not significantly influenced the height of plants.

The interaction effects were also not significant.

2. Earliness in flowering

The analysis of variance table on the number of days required for the first flower opening in different treatments is given in Appendix IV. The mean values are presented in Table 2.

TABLE 1

Mean height of plants on 50th day in cm.

	P_0	P_1	P_2	P_3	Mean
S_0	106.25	115.96	112.25	111.75	111.55
S_1	106.87	119.83	110.87	119.46	114.26
S_2	108.96	109.91	123.64	113.62	114.01
K_0	102.50	114.87	111.67	114.00	110.76
K_1	113.46	113.08	119.58	113.62	114.94
K_2	106.12	117.75	115.42	117.21	114.13
Mean	107.36	116.23	115.55	114.94	--

	k_0	k_1	k_2	Mean
S_0	107.56	112.41	114.69	111.55
S_1	109.25	116.31	117.22	114.26
S_2	115.47	116.09	110.47	114.01
Mean	110.76	114.94	114.13	--

S.E. for levels of P = 2.86

S.E. for levels of K or S = 2.48

S.E. for combinations of P and K or combinations of P and S = 4.96

S.E. for combinations of K and S = 4.29

TABLE 2

Mean number of days for first flower opening

	p_0	p_1	p_2	p_3	Mean
s_0	36.83	37.33	36.83	36.67	36.91
s_1	37.50	36.83	37.00	36.50	36.96
s_2	37.67	36.50	36.17	36.33	36.66
k_0	37.67	37.33	37.00	36.67	37.16
k_1	37.67	36.67	36.17	36.67	36.79
k_2	36.67	36.67	36.83	36.17	36.58
Mean	37.33	36.89	36.67	36.50	--

	k_0	k_1	k_2	Mean
s_0	37.37	36.62	36.75	36.91
s_1	37.50	36.62	36.75	36.96
s_2	36.62	37.12	36.25	36.66
Mean	37.16	36.79	36.58	--

S.E. for levels of P = 0.261

S.E. for levels of K or S = 0.228

S.E. for combinations of P and K or combinations of P and S = 0.456

S.E. for combinations of K and S = 0.394

It is seen that the highest level of phosphorus could induce earliness only by 0.83 day which was not significant.

The effect of potash was also not singificant in this respect. Variation in spacing also did not affect flowering.

3. <u>Number of pods per plant</u>

The number of pods produced per plant was analysed and the analysis of variance table is given in Appendix V. The mean number of pods per plant under different treatments is given in Table 3.

It is seen that phosphorus and potash either alone or in combinations have not significantly increased the mean number of pods per plant. However, p_1, p_2 and p_3 have recorded 14.44, 22.48 and 14.85 per cent increase over p_0 level and k_1 and k_2 have recorded 12.29 and 11.68 per cent increase over k_0 level respectively.

Unlike phosphorus and potash spacing has recorded significant increase in the number of pods per plant, the increase being positive with increase in spacing. The difference brought about by s_2 spacing alone has been significant over s_0 and s_1.

TABLE 3

Mean number of pods per plant

	p_0	p_1	p_2	p_3	Mean
s_0	16.67	22.37	18.42	20.87	19.58
s_1	21.37	24.46	25.54	27.79	24.79
s_2	28.00	28.75	36.92	27.17	30.21
k_0	20.58	22.67	24.67	24.17	23.02
k_1	22.92	23.79	31.54	25.17	25.85
k_2	22.54	29.12	24.67	26.50	25.71
Mean	22.01	25.19	26.96	25.28	--

	k_0	k_1	k_2	Mean
s_0	17.12	20.87	20.75	19.58
s_1	22.41	27.37	24.59	24.79
s_2	29.53	29.31	31.78	30.21
Mean	23.02	25.85	25.71	--

C.D. (0.05) for levels of P = 6.1149

C.D. (0.05) for levels of K or S = 5.2938

C.D. (0.05) for combinations of P and K or combinations of P ans S = 10.5876

C.D. (0.05) for combinations of K and S = 9.1698

NUMBER OF PODS PER P ANT

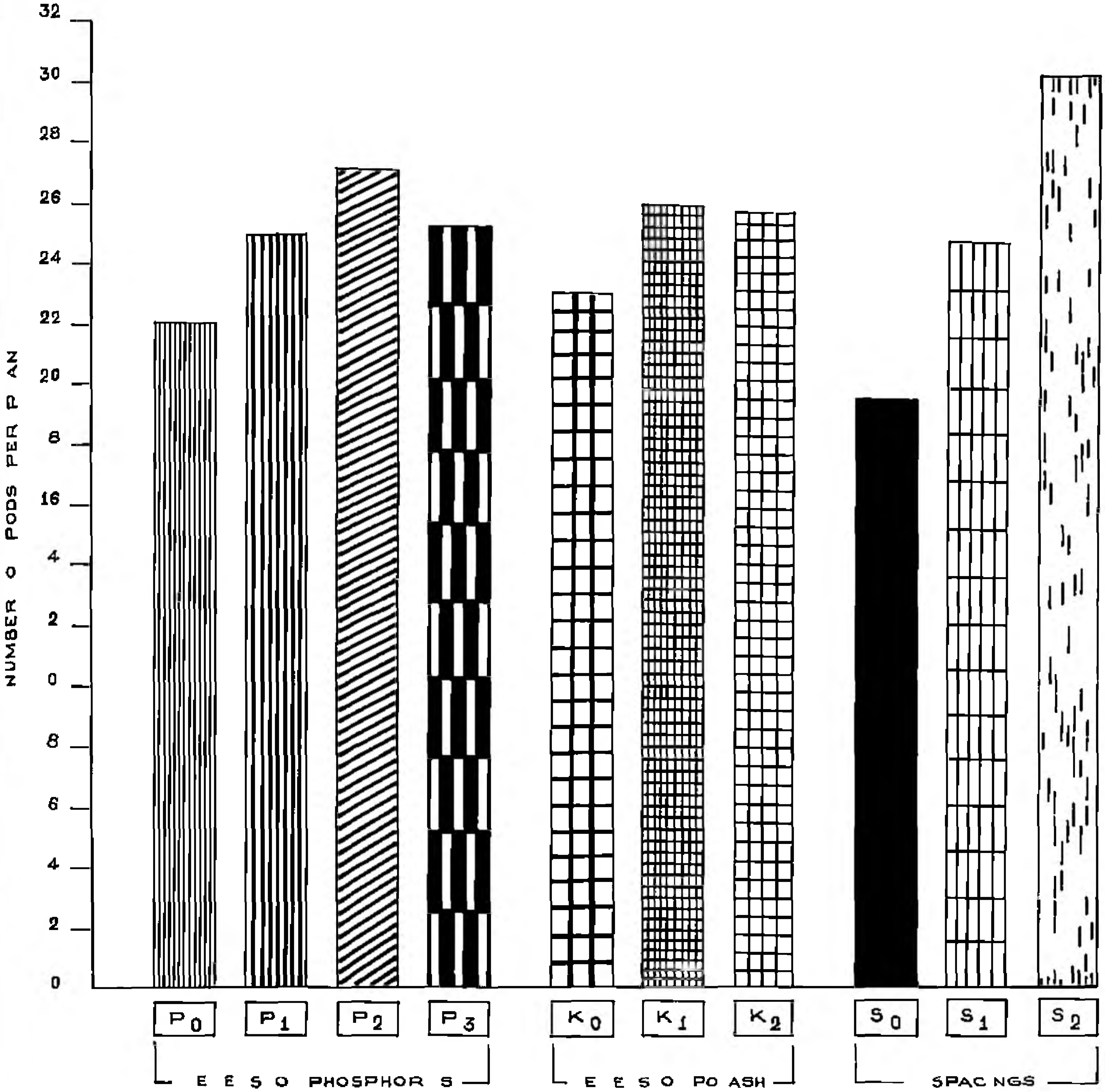

FIG 2

The interactions between, pk, ps and ks were not significant

4. Length of pods

The data regarding length of pods under various treatments were analysed and the analysis of variance table is given in Appendix VI. Mean length of pods corresponding to different treatments i given in Table 4.

It is seen that higher levels of pho phorus have significantly increased the length of pods Among the different levels, p_2 and p_3 have recorded significant increase over p_0, even though the difference between p_2 and p_3 was not significant. Increase in length of pods recorded by p_1 over p_0 was also not significant. The data also showed a slight increase in the length of pod at the higher level of potash (k_2).

With regard to spacing, significant increase in the length of pods was noticed for the widest spacing viz., s_2 over s_0 The differences between s_0 and s_1 as well as s_1 and s_2 were not significant.

Among the interactions, pk interaction was significant The maximum length of pod of 5.02 cm has been recorded by the combination p_2k_0

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TABLE 4

Mean length of pods in cm.

	p_0	p_1	p_2	p_3	Mean
s_0	4.59	4.63	4.77	4.64	4.66
s_1	4.58	4.61	4.88	4.80	4.72
s_2	4.73	4.78	4.83	4.87	4.80
k_0	4.51	4.58	5.02	4.67	4.70
k_1	4.68	4.71	4.78	4.67	4.71
k_2	4.71	4.72	4.68	4.97	4.77
Mean	4.63	4.67	4.83	4.77	--

	k_0	k_1	k_2	Mean
s_0	4.62	4.60	4.75	4.66
s_1	4.76	4.68	4.70	4.72
s_2	4.71	4.84	4.85	4.80
Mean	4.70	4.71	4.77	--

C.D. (0.05) for levels of P = 0.1046
C.D. (0.05) for levels of K or S = 0.0906
C.D. (0.05) for combinations of P and K or combinations of P and S = 0.1815
C.D. (0.05) for combinations of K and S = 0.1570

5. Yield of green pods

The data on the yield of green pods obtained in all the eight harvests were analysed separately and the analysis of variance tables are given in Appendices VII to XIV. The pooled data was also analysed and the analysis of variance table is presented in Appendix XV. The mean yields of pooled data calculated per hectare basis are given in Table 5.

The analysis of variance tables have shown that none of the treatments except the effect of spacing in the first harvest, was significant in their effects. The data on pooled analysis have also shown that the effect of neither phosphorus nor potash was significant in increasing the yield of green pods. The different spacings also did not significantly influence the yield but the highest yield was recorded by closest spacing (s_0).

The interaction effects were also not significant.

6. Yield of haulm

The analysis of variance table on the yield of haulm per plot is presented in Appendix XVI. The mean yield of haulm per plot calculated on a per hectare basis is given in Table 6.

TABLE 5

Mean yield of green pods in kg/ha (total of eight harvests)

	p_0	p_1	p_2	p_3	Mean
s_0	2343.012	2617.378	2354.679	2626.745	2485.454
s_1	2364.840	2461.426	2431.583	2448.092	2426.485
s_2	2058.726	2090.079	2501.269	2163.888	2203.490
k_0	2185.474	2233.174	2205.079	2313.174	2234.225
k_1	2286.269	2463.412	2818.649	2365.950	2483.570
k_2	2294.840	2472.297	2263.807	2569.602	2397.636
Mean	2255.527	2389.627	2429.177	2412.908	--

	k_0	k_1	k_2	Mean
s_0	2084.284	2671.664	2700.411	2485.454
s_1	2162.793	2636.007	2480 650	2426.485
s_2	2455.593	2143.031	2011 841	2203.490
Mean	2234.225	2483.570	2397.636	--

S.E. for levels of P = 139.009

S.E. for levels of K or S = 120.385

S.E. for combinations of P and K or combinations of P and S = 240.776

S.E. for combinations of K and S = 208.514

Y E D OF GREEN PODS PER HEC ARE

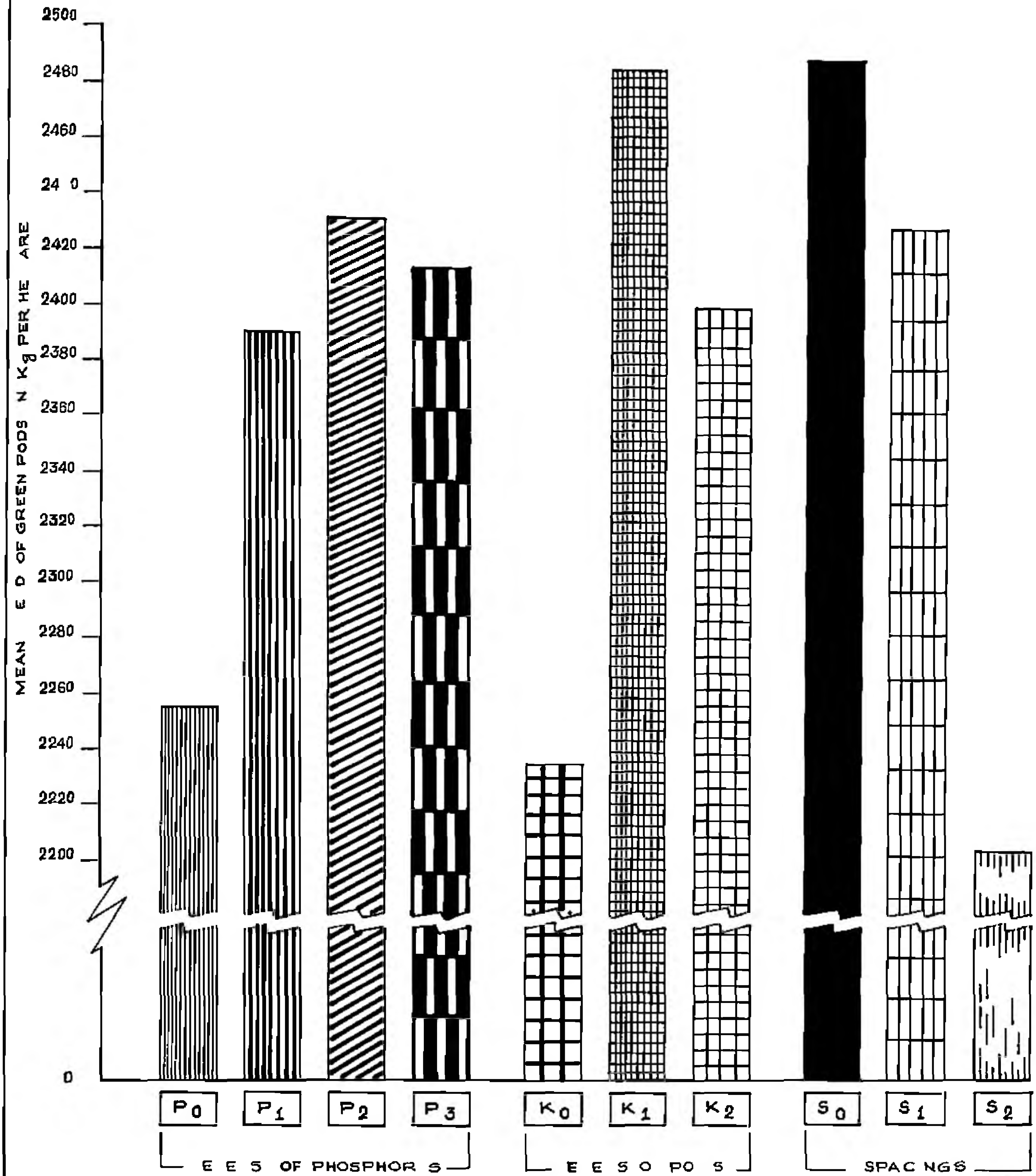


FIG 3

TABLE 6

Mean yield of haulm in kg/ha

	p_0	p_1	p_2	p_3	Mean
s_0	763.094	1121.826	1058.332	1084.918	1007 042
s_1	699.099	890.475	926.985	957.142	868.637
s_2	522.776	587.299	849.999	757.142	686.804
k_0	637.299	809.523	845.237	904.761	799.204
k_1	644.047	903.570	1119.842	891.270	889.670
k_2	734.523	886.509	870.237	1003.175	873.609
Mean	671.956	866.532	945.104	933.066	--

	k_0	k_1	k_2	Mean
s_0	888.389	1122.318	1010.413	1007.042
s_1	720.237	905.618	980.056	868.637
s_2	788.985	641.071	630.358	686.804
Mean	799.204	889.670	873.609	--

C.D. (0.05) for levels of P = 200.716

C.D. (0.05) for levels of K or S = 173.819

C.D. (0.05) for combinations of P and K or combinations of P and S = 347.647

C.D. (0.05) for combinations of K and S = 301.069

Y ELD OF HAULM PER HECTARE

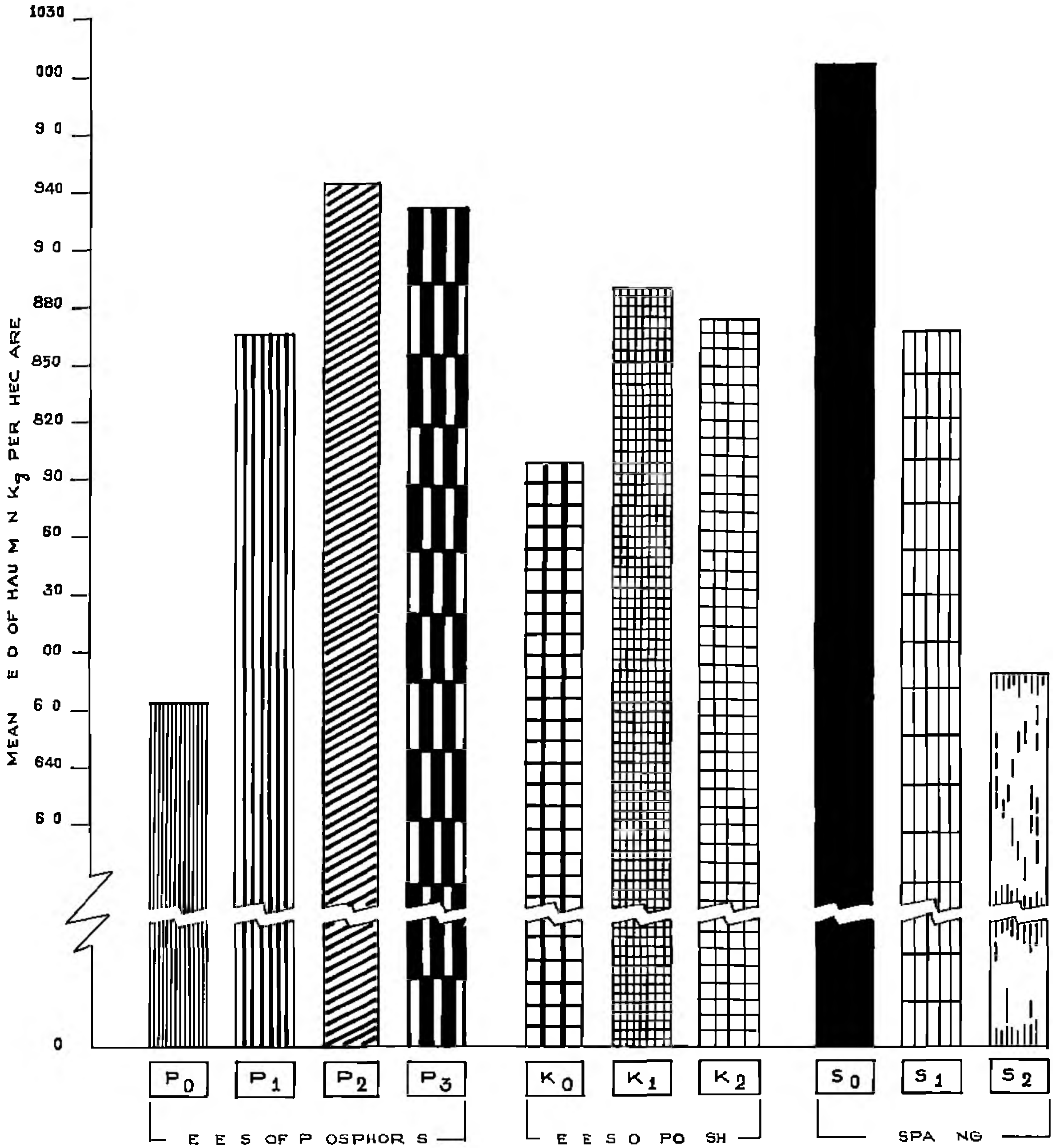


FIG 4

It is seen that the effect of phosphorus on the yield of haulm was not significant. The effect of potash was also not found to be significant. However, spacing has contributed to significant increase in the yield of haulm. It is seen that s_0 and s_1 have brought have brought about significant increase in the yield of haulm over s_2 eventhough s_0 and s_1 were on par. The interaction effects were also not found to be significant.

B. <u>Chemical analysis</u>

The data relating to chemical analysis of soil, pods and haulm were statistically analysed. The results are furnished below:

1. <u>Nitrogen content of soil</u>

The data on the nitrogen content of soil taken on the 60th day and at the time of final harvest were analysed and the analysis of variance tables are given in Appendices XVII and XVIII respectively. Mean values of nitrogen in percentage are given in Tables 7 and 8 respectively.

It is seen that the effect of phosphorus was significant in the samples collected on the 60th day.

TABLE 7

Nitrogen content of soil (in percentage) on 50th day

	p_0	p_1	p_2	p_3	Mean
s_0	0.0689	0.0720	0.0724	0.0722	0.0714
s_1	0.0683	0.0717	0.0722	0.0722	0.0711
s_2	0.0682	0.0716	0.0722	0.0722	0.0710
k_0	0.0674	0.0715	0.0722	0.0721	0.0708
k_1	0.0686	0.0719	0.0723	0.0724	0.0713
k_2	0.0695	0.0720	0.0723	0.0724	0.0715
Mean	0.0685	0.0718	0.0723	0.0723	--

	k_0	k_1	k_2	Mean
s_0	0.0710	0.0715	0.0718	0.0714
s_1	0.0707	0.0712	0.0714	0.0711
s_2	0.0706	0.0711	0.0714	0.0710
Mean	0.0708	0.0713	0.0715	0.0000

C.D. (0.05) for levels of P = 0.000938

C.D. (0.05) for levels of K or S = 0.000816

C.D. (0.05) for combinations of P and K or combinations of P and S = 0.00163

C.D. (0.05) for combinations of K and S = 0.00141

TABLE 8

Nitrogen content of soil (in percentage) at the time of final harvest

	p_0	p_1	p_2	p_3	Mean
s_0	0.0719	0.0720	0.0720	0.0721	0.0720
s_1	0.0720	0.0719	0.0719	0.0720	0.0719
s_2	0.0718	0.0719	0.0719	0.0719	0.0719
k_0	0.0718	0.0720	0.0720	0.0720	0.0719
k_1	0.0720	0.0720	0.0719	0.0720	0.0719
k_2	0.0719	0.0720	0.0719	0.0720	0.0719
Mean	0.0719	0.0720	0.0719	0.0720	--

	k_0	k_1	k_2	Mean
s_0	0.0720	0.0720	0.0720	0.0720
s_1	0.0720	0.0719	0.0719	0.0719
s_2	0.0718	0.0719	0.0719	0.0719
Mean	0.0719	0.0719	0.0719	--

C.D. (0.05) for levels of P = 0.0000999

C.D. (0.05) for levels of K or S = 0.0000856

C.D. (0.05) for combinations of P and K or combinations of P and S = 0.0001733

C.D. (0.05) for combinations of K and S = 0.0001509

Significant increase in the nitrogen content of soil was brought about by treatments p_1, p_2 and p_3 over no phosphorus treatment, eventhough the difference between the levels was not significant. The different levels of potash and spacings were not effective in making any significant change in this respect. However, a slight increase in nitrogen content has been recorded by s_0 spacing.

Regarding the data at the time of final harvest, it is seen that neither phosphorus nor potash has effected any significant change in the nitrogen content of soil.

Among spacings, s_0 alone has shown significant increase over s_1 and s_2, while s_1 and s_2 are on par.

None of the interactions was found to be significant.

2. Available phosphorus content of soil

Analysis of variance tables on the available phosphorus content of soil taken on 50th day and at the time of final harvest are given in Appendices XIX and XX respectively. Mean values are given in Tables 9 and 10.

It is seen that effects due to P, K, S and interactions were found to be significant. The data on

50th day indicate that incremental doses of phosphorus have shown highly significant progressive increase in available phosphorus content of soil. Mean values for different levels of phosphorus are 66.33, 80.00, 110.67 and 118.67 lb respectively for p_0, p_1, p_2 and p_3.

The effect of potash was also significant at all levels. Mean values for different levels are 74.83, 101.33 and 104.83 lb respectively for k_0, k_1 and k_2.

With regard to spacing, s_2, the widest spacing has significantly increased the available phosphorus content of soil over the other two spacings. There has been a significantly progressive increase from s_0 to s_2.

The different combinations and interactions were also found to be significant.

Regarding the available phosphorus content of soil at the time of final harvest, it is seen that different levels of phosphorus have effected significant increase in this respect except p_3, which has recorded a significant reduction in the available phosphorus content over p_2.

In respect of potash, k_1 has given significant increase over k_0, while k_2 has shown significant reduction from k_1.

TABLE 9

Available phosphorus content of soil (P lb/acre) on 50th day

	p_0	p_1	p_2	p_3	Mean
s_0	64.67	87.33	84.00	92.67	82.17
s_1	51.33	83.33	138.67	116.00	97.33
s_2	80.00	69.33	109.33	147.33	101.50
k_0	71.33	73.33	102.67	52.00	74.83
k_1	44.00	91.33	131.33	138.67	101.33
k_2	80.67	75.33	98.00	165.33	104.83
Mean	65.33	80.00	110.67	118.67	--

	k_0	k_1	k_2	Mean
s_0	44.00	92.50	110.00	82.17
s_1	103.50	124.00	64.50	97.33
s_2	77.00	87.50	140.00	101.50
Mean	74.83	101.33	104.83	--

C.D. (0.05) for levels of P = 3.447

C.D. (0.05) for levels of K or S - 2.978

C.D. (0.05) for combinations of P and K or combinations of P and S = 5.977

C.D. (0.05) for combinations of K and S 5.161

TABLE 10

Available phosphorus content of soil (P lb/acre) at the time of final harvest

	p_0	p_1	p_2	p_3	Mean
s_0	84.00	106.67	91.33	158.00	110.04
s_1	82.67	79.33	134.00	78.00	93.50
s_2	77.33	108.67	183.33	112.67	120.50
k_0	88.67	115.33	162.00	84 67	112.67
k_1	76.00	118.67	122.67	195.33	128.17
k_2	79.33	60.67	124.00	68.67	83.17
Mean	81.33	98.22	136.22	116.22	--

	k_0	k_1	k_2	Mean
s_0	78.00	179.00	73.00	110.00
s_1	135 00	75.50	70.00	93.50
s_2	125.00	130.00	106.50	120.50
Mean	112.67	128.17	83.17	--

C.D. (0.05) for levels of P = 7.425

C D. (0 05) for levels of K or S = 6.446

C.D. (0.05) for combinations of P and K or co binations of P and S - 12.892

C.D. (0.05) for combinations of K and S = 11.158

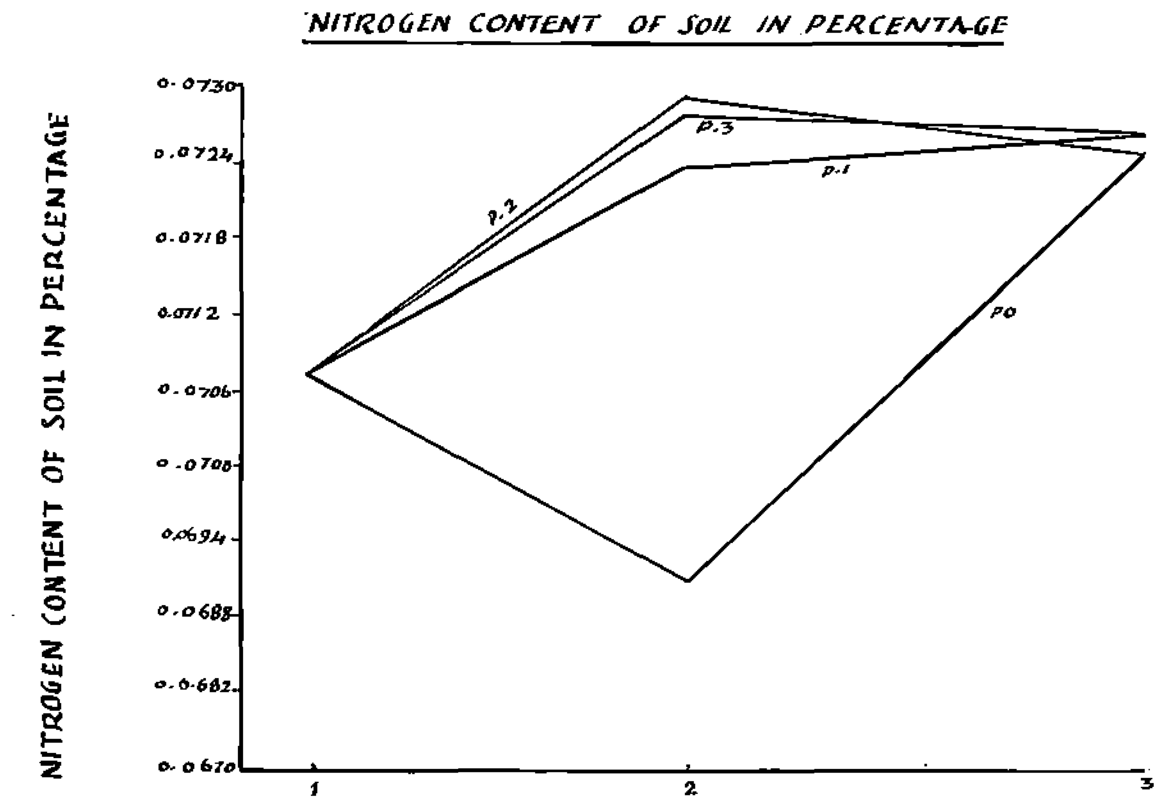
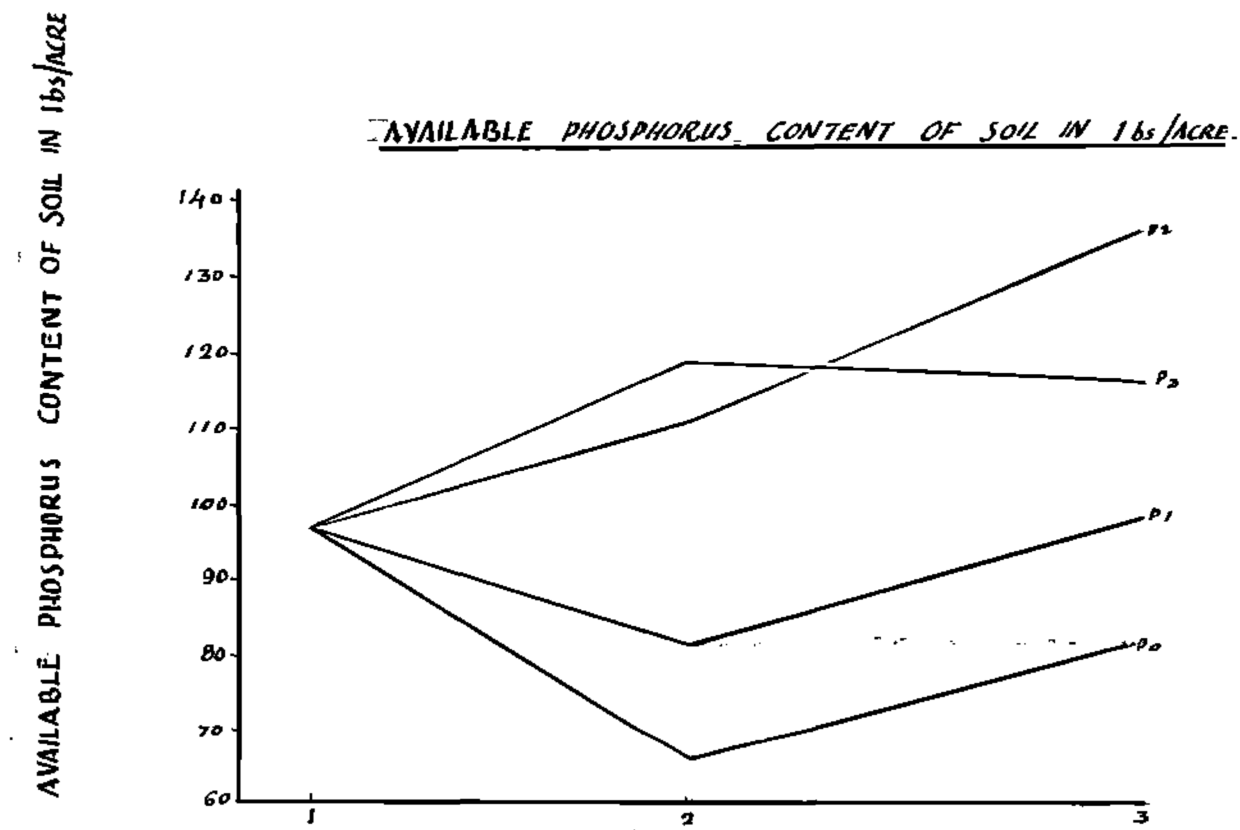


FIG 5



P0 – NO PHOSPHORUS, P1 – 25 kg – P_2O_5/HA, P2 – 50 kg P_2O_5/HA, P3 – 75 kg P_2O_5/HA
1 – AT THE BEGINNING, 2 – 50th DAY 3 – AT FINAL HARVEST.

FIG 6

The effect of spacing has been significant in this respect. However, s_1 has recorded significant reduction in the available phosphorus content of soil over S_0 and S_2.

3. Available potash content of soil

The data on the available potash content of soil taken on the 60th day were analysed and the analysis of variance table is presented in Appendix XXI. The mean values of available potash content are given in Table 11. The data on the available potash content of soil taken at the time of final harvest were not analysed as it was found to be traces in all treatments.

It is noted that p_1, p_2 and p_3 have significantly reduced the available potash content over p_0, whereas p_2 and p_3 were on par

Contrary to the above, highest level of potash, viz., k_2 has increased the available potash content of soil significantly over k_0 and k_1, while k_0 and k_1 were on par.

Regarding spacings, s_2 has effected significant increase in available potash content over s_0 and s_1.

The different combinations and interactions were also significant.

TABLE 11

Available potash content of soil (K lb/acre) on 60th day

	P_0	P_1	P_2	P_3	Mean
S_0	28.17	28.17	16 33	12.33	21.25
S_1	38.67	8.33	8.38	7 00	15.58
S_2	25.33	24.00	28.00	33.33	27.66
K_0	44.00	12.17	8.33	17.50	20.50
K_1	20.17	13.50	20.17	26.83	20.16
K_2	28 00	34.83	24.17	8.33	23.83
Mean	30.72	20.17	17.55	17.56	--

	K_0	K_1	K_2	Mean
S_0	12.37	22.12	29.25	21.25
S_1	22.12	12.37	12.25	15 68
S_2	27.00	26.00	30.00	27.66
Mean	20.50	20.16	23.83	--

C D. (0.05) for levels of P - 1.656

C.D. (0.05) for levels of K or S = 1.434

C D (0 05) for combinations of P and K or combinations of P and S - 2.870

C.D. (0 05) for combinations of K and S - 2 484

4. <u>Nitrogen content of pods</u>

The data on the nitrogen content of green pods have been analysed and the analysis of variance table is given in Appendix XXII. Table 12 summarises the percentage nitrogen content of pods under each treatment.

Results showed that the higher levels of phosphorus were significant over no phosphorus treatment in increasing the nitrogen content of pods. But the differences between these levels, viz., between p_1 and p_2, and p_2 and p_3 were not statistically significant.

It is seen that k_1 has significantly increased the nitrogen content of pods over k_0. At k_2 level, there has been a reduction in nitrogen content which is also significant.

Spacings did not effect any change in this respect.

Among interactions, pk interaction was statistically significant. p_1k_1 combination has recorded 4.590% of nitrogen, which was the highest value among the different combinations of p and k.

5. <u>Nitrogen content of haulm</u>

Analysis of variance is given in Appendix XXIII and mean values are presented in Table 13.

TABLE 12

Percentage of nitrogen in pods

	P_0	P_1	P_2	P_3	Mean
s_0	4.458	4.497	4.479	4.555	4.497
s_1	4.423	4.525	4.526	4.538	4.503
s_2	4.419	° 4.493	4.582	4.527	4.505
k_0	4.423	4.478	4.549	4.498	4.487
k_1	4.416	4.590	4.535	4.572	4.527
k_2	4.462	4.446	4.503	4.551	4.491
Mean	4.434	4.505	4.529	4.540	--

	k_0	k_1	k_2	Mean
s_0	4.418	4.511	4.562	4.497
s_1	4.493	4.605	4.411	4.503
s_2	4.550	4.466	4.499	4.505
Mean	4.487	4.527	4.491	--

C.D. (0.05) for levels of P = 0.0408

C.D. (0.05) for levels of K or S = 0.0353

C.D. (0.05) for combinations of P and K or combinations of P and S = 0.0693

C.D. (0.05) for combinations of K and S = 0.0612

TABLE 13

Percentage of nitrogen in haulm

	p_0	p_1	p_2	p_3	Mean
s_0	2.369	2.417	2.473	2.513	2.443
s_1	2.363	2.474	2.497	2.469	2.451
s_2	2.393	2.443	2.488	2.523	2.462
k_0	2.353	2.461	2.500	2.485	2.445
k_1	2.342	2.482	2.487	2.523	2.459
k_2	2.430	2.411	2.471	2.497	2.452
Mean	2.376	2.445	2.486	2.502	--

	k_0	k_1	k_2	Mean
s_0	2.413	2.438	2.479	2.443
s_1	2.464	2.494	2.394	2.451
s_2	2.457	2.444	2.484	2.462
Mean	2.445	2.459	2.452	--

C.D. (0.05) for levels of P - 0.0116

C.D. (0.05) for levels of K or S = 0.0102

C.D. (0.05) for combinations of P and K or combinations of P and S = 0.0499

C.D. (0.05) for combinations of K and S = 0.0175

It is seen that the effects due to p, k, s and interactions were significant

Phosphorus levels have contributed progressively significant increase in the nitrogen content of haulm

k_1 has been found to be significantly superior to k_0, while k_2 has recorded a slight decrease in nitrogen content over k_1

Regarding spacing, s_2 has been significantly superior to s_0 and s_1, while s_0 and s_1 were on par

The different interactions were also found to be significant

6 <u>Phosphorus content of pods</u>

The data on the phosphorus content of pods were analysed and the analysis of variance table is given in Appendix XXIV. The average values of nitrogen in percentage are given in Table 14.

It is evident from the analysis of variance table that all the treatments and interactions were highly significant.

Significant increase in the phosphorus content was noticed with incremental doses of phosphorus application

TABLE 14

Percentage of phosphorus in pods

	p_0	p_1	p_2	p_3	Mean
s_0	0.537	0.553	0.517	0.583	0.547
s_1	0.496	0.566	0.590	0.583	0.559
s_2	0.496	0.556	0.589	0.549	0.547
k_0	0.503	0.540	0.542	0.5o3	0.537
k_1	0.470	0.606	0.563	0.563	0.550
k_2	0.556	0.529	0.590	0.590	0.566
Mean	0.510	0.568	0.565	0.572	--

	k_0	k_1	k_2	Mean
s_0	0.476	0.532	0.633	0.547
s_1	0.578	0.615	0.483	0.559
s_2	0.558	0.503	0.583	0.547
Mean	0.537	0.550	0.566	--

C.D. (0.05) for levels of P = 0.00159

C.D. (0.05) for levels of K or S = 0.00139

C.D. (0.05) for combinations of P and K or combinations of P and S - 0.00277

C.D. (0.05) for combinations of K and S = 0.00241

Regarding potash, k_1 and k_2 have significantly increased the phosphorus content of pods over k_0 level The increase noted at k_2 over k_1 was also significant.

It is seen that only the middle level of spacing viz , s_1 has effected increase in phosphorus content of pods significantly, while the s_0 and s_2 were on par.

All different interactions were also found to be significant.

7. Phosphorus content of haulm

The data on the phosphorus content of haulm were analysed and the analysis of variance table is given in Appendix XXV Mean values are given in Table 15.

It is observed that significant increase in phosphorus content of haulm has been brought about by incremental doses of phosphorus. P_3 has increased the phosphorus content of haulm to 0.286% from 0.261% under no phosphorus treatment.

Progressively significant increase in phosphorus content of haulm was brought about by the graded doses of potash also. The highest level of potash has recorded 0.293% phosphorus, while it is only 0.251% under no potash treatment.

TABLE 15

Percentage of phosphorus in haulm

	p_0	p_1	p_2	p_3	Mean
s_0	0.248	0.272	0.261	0.261	0.260
s_1	0.274	0.286	0.275	0.284	0.280
s_2	0.262	0.265	0.303	0.313	0.286
k_0	0.217	0.246	0.260	0.281	0.251
k_1	0.276	0.292	0.268	0.291	0.282
k_2	0.291	0.285	0.311	0.286	0.293
Mean	0.261	0.274	0.280	0.286	--

	k_0	k_1	k_2	Mean
s_0	0.239	0.270	0.272	0.260
s_1	0.257	0.288	0.294	0.280
s_2	0.256	0.287	0.313	0.286
Mean	0.251	0.282	0.293	--

C.D. (0.05) for levels of P = 0.00116

C.D. (0.05) for levels of K or S = 0.00102

C.D. (0.05) for combinations of P and K or combinations of P and S = 0.00204

C.D. (0.05) for combinations of K and S - 0.00175

N TROGEN CONTENT OF POD AND AULM AT DEFFERENT EVE S OF PHOSPHORUS

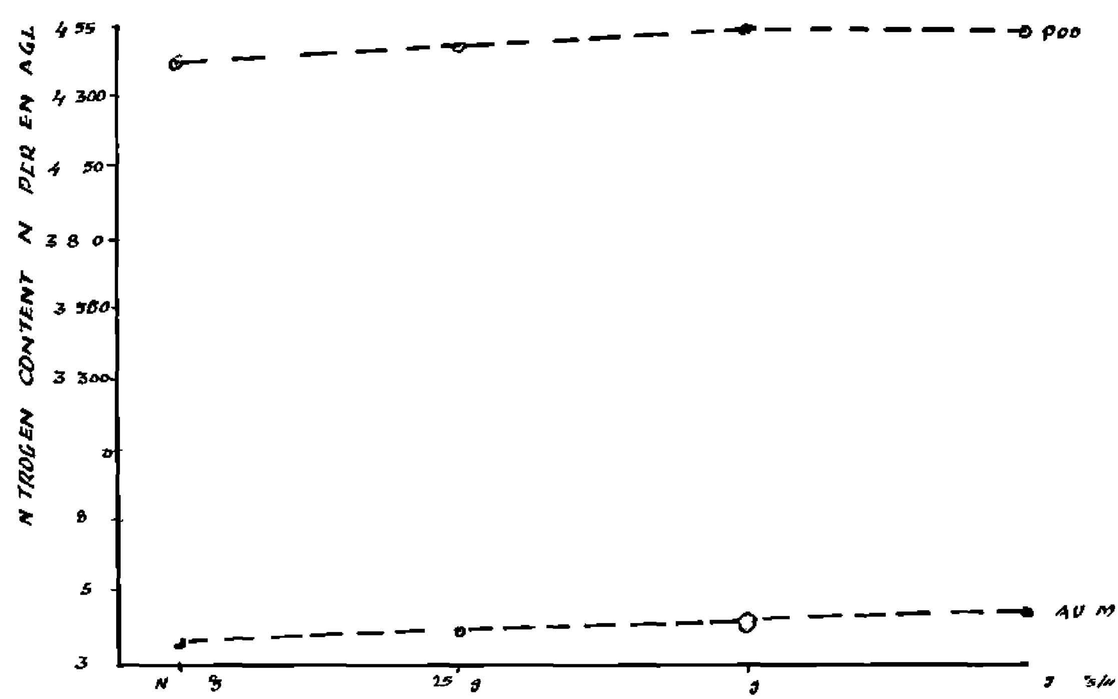


FIG 7

P OSPHORUS CONTEN OF POD AND HAULM AT D FFERENT EVELS O PHO PHORU

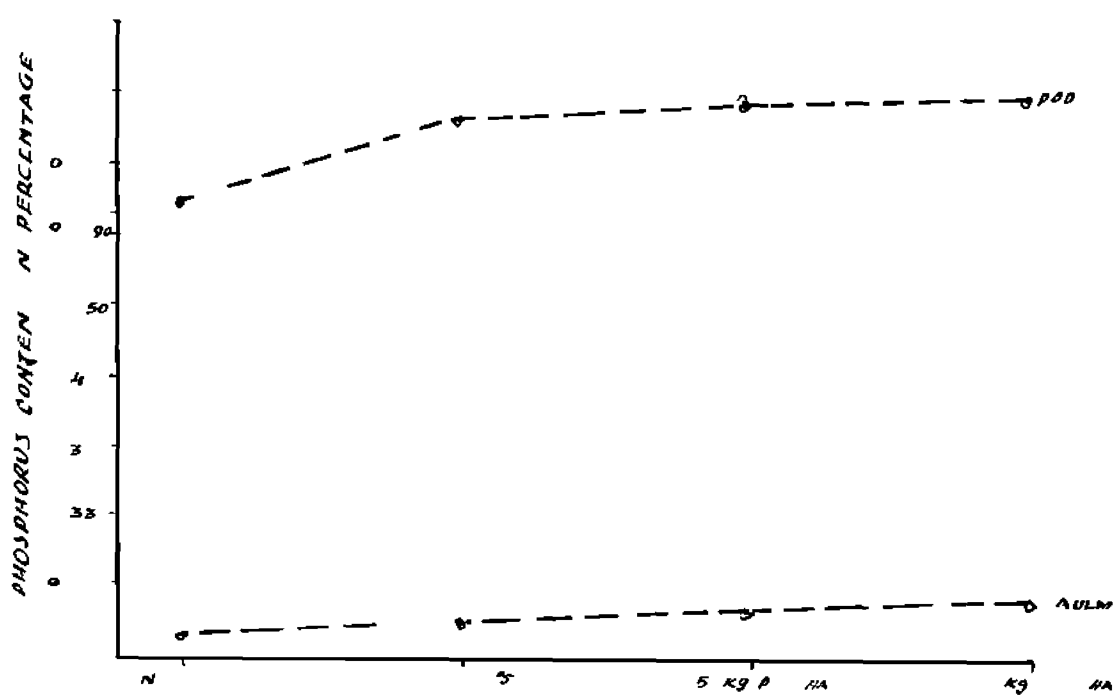


FIG 8

Significant increase in phosphorus content of haulm has been recorded by wider spacings, viz., s_1 and s_2 over s_0. The difference between s_0 and s_1 and s_1 and s_2 has also been found to be significant.

All interactions have been found to be significant in their effects.

DISCUSSION

DISCUSSION

An experiment to study the performance of Co.1 lab-lab (Ottumochai) under graded doses of phosphorus and potash at different spacings was conducted in the farm attached to the Agricultural College and Research Institute, Vellayani.

The effects on the various biometric characters as well as yield were studied to assess how best each attribute has been influenced by the treatments. The roles of applied phosphorus and potash on these characters were also assessed.

The results obtained from the present study on the above factors are discussed hereunder.

A. Biometric observations

1. Height of plants

As evidenced from Table 1, phosphorus did not significantly increase the height of plants, though higher levels of phosphorus showed a tendency to increase the height over no phosphorus. The lack of response for graded levels of phosphorus was not due to the unavailability of phosphorus as indicated by the data on soil analysis (Table 9). Black (1957) has reported that the role of phosphorus is more towards the development of productive attributes rather than the vegetative characteristics of the crop. Hence, any wide variation cannot be expected in the observation on height with increase in phosphorus application. Soil analysis data of the control plot have shown that even without phosphorus application, plants were able to derive their requirements from the native phosphorus. It has been reported by Raheja (1966) that leguminous crops like gram and pigeon pea are able to tap the subsoil phosphorus pretty effectively with their deep root system.

The observations on height in the present study are in conformity with the result obtained by Shukla (1964). Nair (1966) has also obtained similar results in cowpea.

No significant increase in the height of plants was obtained by different levels of potash also. Experiments conducted by Feng (1964) showed that potash did not increase the height of plants significantly. Potash as an element that hastens the metabolic process in plant should have responded well to increase the height of plants. However, the data (Table 11) on soil analysis have indicated that there was no substantial difference in the available potash content of soil between the different levels of potash except at the highest level of application. The 345 mm. of rainfall received during the first week of application might have resulted in the leaching of a good proportion of applied potash. Thus, the applied potash might not have been available for crop growth fully and hence the lack of response for potash. Buckman and Brady (1960) have observed that unlike nitrogen and phosphorus much potassium is lost by leaching.

It is also seen that spacings did not have any significant effect on height. The variation in spacing by its influence on changing the nutrient availability affect plant characteristic. The reasons given for the lack of response for height by the application of phosphorus and potash hold good also for the absence of response noticed to spacing.

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

Phosphorus and potash did not have any significant effect in inducing earliness in flowering. As has been discussed earlier, the lack of response for applied phosphorus on this character can be attributed to the inherent capacity of leguminous plant to utilise subsoil phosphorus to satisfy the requirements in full.

The leaching loss that might have occurred due to the heavy precipitation (Appendix II) received during the first week of application might have contributed to lack of response for potash. Further, potash is not reported to exert much influence in inducing earliness.

The absence of significant response for spacing on this character can be attributed to the availability of sufficient native phosphorus (Table 9) which is the main factor that influences earliness.

3. Number of pods per plant

It is evident from Table 3 that graded doses of phosphorus did not significantly increase the number of pods per plant. However, the higher levels have effected a slight increase in the number of pods per plant over no phosphorus treatment.

The data on the phosphorus uptake have shown significant increase in phosphorus content of the plant with graded doses of the nutrient (Tables 14 and 15). However, a corresponding increase in the yield was not noticed. Thus it can be seen that the lack of significant increase in the number of pods per plant was not due to nonavailability and uptake, but phosphorus beyond a certain level in plant does not influence initiation of flower buds. It can, therefore, be presumed that increase in the uptake of phosphorus beyond a certain level only increases the phosphorus content in plants. However, the addition of phosphorus to increase the number of pods per plant cannot be completely ruled out, since a trend to increase the yield with increased phosphorus levels has been noticed. It would, therefore, seem that the optimum requirement of phosphorus will be some where slightly above that is noticed in the control plot, but lower than that of the other treatments.

Potash also followed the same trend as shown by phosphorus. Similar lack of response for potash has been reported by Vijayakumar (1967) under the same agro-climatic conditions. The lack of response for potash might be due to the leaching loss of a good proportion of applied potash due to the heavy precipitation occurred during the first week of application.

From the mean tables it can be seen that 40x35 cm. spacing was significantly superior to other two spacings. This is in conformity with the results obtained by Sen and Jana (1960). As evidenced from the differential response (Tables 12 and 14) noticed in the uptake of nutrients it may be assumed that it is not the absorption of nutrients that has brought about significant effect of spacing in increasing the number of pods per plant, but the more efficient utilization of absorbed nutrients under wider spacing. Increase in the density of population leads to overcrowding and mutual shading and thereby functional leaf area gets reduced. In wider spacing, chances for mutual shading is much less. More functional leaf area led to the more efficient assimilation of the absorbed nutrients resulting in the higher number of pods per plant under wider spacing.

4. Length of pods

An examination of Table 4 revels that only phosphorus and spacings have shown significant increase in length of pods.

It is seen that application of phosphorus at 50 kg. P_2O_5 per hectare significantly increased the length of pods, when compared to no phosphorus treatment. But the difference between 50 and 75 kg. per hectare was not significant. Moreover the increase in length of pod attributed by 25 kg. P_2O_5 per hectare over no phosphorus treatment was also not significant.

Phosphorus is an essential part of the nucleoprotein which hastens mitotic cell division (Black 1957). The increase in length of pods noticed in the present study by higher levels of phosphorus can be attributed to its role in cell division. The results are in conformity with that of Nair (1966)

Potassium has not effected any significant change in pod length. Vijayakumar (1967) also has reported similar results under the same agroclimatic conditions.

Among the different spacings, 40 x 35 cm. has been found to be significantly superior in this respect over the closest spacing of 40 x 15 cm As has been discussed earlier, the increased functional leaf area of widely spaced plants might have enhanced the assimilation and utilisation of absorbed nutrients and hence the significant effect.

6. Yield of green pods

The data have shown that phosphate application did not have any significant effect in increasing the yield of pods No significant effect of phosphorus was obtained in any of the eight harvests or by pooled analysis of the data. The results of this experiment agree with the result obtained by Agarwal and Verma (1951) in sannhemp. Desai et al (1957) arrived at the conclusion that phosphate application to green manure crops in sandy loams with an available phosphorus content of 50 lb. or above had no beneficial effects in increasing the production of green matter. The lack of response in the yield of green pods in the present investigation can be attributed to the high status of available phosphorus in the soil which is found to be 96 lb. per acre.

The lack of response for phosphorus in the pooled analysis is to be expected, since phosphorus did not have any significant effect on the number of pods per plant (Table 3). It may also be noted that there was significant difference in total phosphorus absorption by the crop. As has been discussed earlier, the increased phosphorus content of plant above a certain level was not beneficial in increasing the yield. It might have been utilised only to increase the phosphorus content of pods.

An observation on the data of individual harvests indicated that phosphorus did not have any significant effect at any of the harvest, which again shows that the available phosphorus in the soil is sufficient to meet the requirements of plants. The fact that available phosphorus has not shown substantial reduction even after a legume crop of four months duration indicates the capacity of legume to make available the native phosphorus and thereby meet its requirements. The observations of the present study are in conformity with that of Raheja (1966), who reported the capacity of legumes for increasing the availability of soil phosphorus.

It is evident from the data that graded doses of potash have no significant effect on increasing the yield of pods. Sen and Kavitkar (1960) while studying the effect of potash on crops in Pusa, permanent manurial experiment (New series) have commended "the response of potash as judged from the yields of maize, oats, peas, wheat and gram was nonsignificant over control". The reason for lack of response to potash according to Sen *et al* (1949) was that crops might have obtained their potassium requirements from the non-exchangeable portion. The lack of response for applied potash in the present investigation may be due to the fact that crop might have obtained its requirements from the non-exchangeable portion of the soils. Another reason that could be attributed to the lack of response is the leaching loss of a good proportion of potash immediately after application as evidenced from the meteorological observation (Appendix II).

Variation in spacing did not have any significant influence on the yield of green pods as evidenced from the data on pooled analysis. Variation in spacing by its influence on changing the nutrient uptake per plant affect the plant characteristics. The observation that the native phosphorus and potash could supply the requirements of plants explains in part the reason for lack of response to spacing. The superiority of wider spacing in producing significantly higher number of pods per plant, and increased pod length might have been offset by a large number of plants per unit area in closely spaced plots. Importance of high plant population for higher yield over lower density has been stressed in crops like paddy by workers like Tanaka et al (1956) and Nair (1968) Suput et al (1967) in soybeans and Cultcliffe (1967) in snapbeans obtained results in favour of closer spacings.

6. Yield of haulm

As evidenced from the data, phosphorus was not found to effect any significant change in the yield of haulm Similar results were obtained by Agarwal and Verma (1951), Desai et al (1957), Kolwany and Ganguly (1959) and Rao et al (1962) in some green manure and fodder crops. The fact that neither haulm, nor pod has been increased with addition of phosphorus further confirms that under normal conditions of soils sufficiently rich in phosphorus, plants can do well on the native phosphorus.

The effect of potash was also not significant, which might have been as discussed earlier, due to leaching losses as well as the capacity of the plant to utilise the nonexchangeable potash of the soil as stated by Sen and Kavitkar (19 0)

It is seen that the effect of spacing has been significant in increasing the haulm yield The closer spacing, viz., 40 x 15 cm. has recorded maximum yield of haulm As seen from the result , number of plants per unit area was the criterion in deciding the yield of haulm

The number of plants in each plot was 360, 210 and 150 under 40 x 15 cm , 40 x 25 cm and 40 x 35 cm spacings respectively Thus it may be seen that the closest spacing has accommodated more than double the number of plants per unit area as compared to the widest spacing. This increased population per unit area has resulted in increased haulm yield

B <u>Chemical analysis</u>

1 <u>Nitrogen content of soil</u>

Data on soil analysis has shown that phosphorus had significant effect in increasing the total nitrogen content of soil on 50th day.

It is seen that soil nitrogen has been increased from the original status (0.071%) in all treatments except in the control, were a reduction has been noticed Phosphorus exerts stimulatory effect on symbiotic microorganisms in the soil, which in association with leguminous crops fix atmospheric nitrogen and thus enrich the soil Alles (1958), Sikka and Jain (1958), Izawa and Okemoto (1959), Lin (1959) and Mudaliar (1960) obtained results in favour of phosphorus application for increasing nitrogen content of the soil In the control plot this extra stimulatory effect by the added phosphorus was lacking resulting in severe competition between the microbes and growing plants for the available quantity of nitrogen in the soil. This may probably be the reason for recording a reduction in the nitrogen content of the soil in the control treatments.

Though the effect of spacing was not significant, increased nitrogen content was noticed in plots where closer spacing was adopted. The increased facilities for symbiosis provided by larger number of plants per unit area might have resulted in greater fixation of nitrogen in the soil.

Data regarding the nitrogen content of soil at the time of final harvest (Table 8) showed that spacing alone produced significant effect in this respect and that too only at 5% level. Nitrogen content of all the treatments has been increased from the original status, although at varying degrees. As the growth of plants advanced, some of the unavailable subsoil phosphorus has been made available by the activity of deep root system in the legume crop. Data on the available phosphorus content of soil taken at the time of final harvest revealed that some subsoil phosphorus has been made available (Table 10). Thus as the growth advanced, sufficient quantity of phosphorus was made available which in turn helped to enrich the soil with nitrogen, as has been discus ed previously.

This increased availability of phosphorus by the activity of legume crop, irrespective of the level of added phosphate may be one of the reasons for not obtaining significant increase in yield due to incremental doses of phosphorus.

When conditions relating to nutrient availability is almost identical, difference in nitrogen content of soil can be brought about only by the intensity of symbiotic microbial population which is directly controlled by the plant population per unit area. Consequently, where more number of plants have been accommodated the soil has recorded significantly higher content of nitrogen. The closest spacing, viz., 40x15 cm. in the present investigation accommodated more than double the number of plants as that of widest spacing (40x35 cm.) and hence the higher percentage of nitrogen in the closest spacing.

2. Available phosphorus content of soil

The results on the available phosphorus content of soil taken on 50th day showed that the different levels of phosphorus were not only significantly superior over no phosphorus treatment, but significant between themselves also. This is in agreement with the results obtained by Bains (1967). Valora (1962) showed increased phosphorus content by the application of superphosphate to soils normally high in available phosphorus It is seen that except in control and the lowest level of applied phosphorus, all the other levels increased the available phosphorus content of soil from the original status of 96 lb per acre The depression in the available phosphorus content in the control and lowest level of added phosphorus may be due to increased uptake by the plant in the early period of growth coupled with high bacterial utilisation.

Available phosphorus content of soil was increased in plots receiving higher levels of potash also. But at K_0 level a slight decrease from the original status has been noticed. Potash has been reported to increase the biochemical reactions of the plants (Black 1957) Though a good proportion of potash had been washed off, the remaining quantity of potash might have increased the ability of plants as well as soil bacteria to increase phosphate availability

Regarding spacing, the widest spacing has recorded highest content of available phosphorus which is highly significant over the other two spacings. The middle spacing (40x25 cm.) was also significantly superior to lowest spacing (40x15 cm) The effect of spacing on the available phosphorus content is in agreement with the general behaviour of plant When plants per unit area is less, loss of nutrients on account of uptake will be less and consequently nutrient status of the soil will be high.

Data on the phosphorus content of soil at the time of final harvest substantiates that deep rooted legumes are capable of converting the unavailable subsoil phosphorus into an available form. It is seen that the available phosphorus content of soil has been increased even after the crop has been harvested and removed. Even the control plot has maintained almost the original status in respect of available phosphorus. According to Raheja (1966) subsoil contains adequate quantities of phosphorus which the deep rooted crops are able to tap and make use of in growth of crops. The result of present investigation substantiate this unique character of deep rooted legumes. At 75 kg P_2O_5 per hectare level a significant depression in the available phosphorus content of the soil was recorded. On a perusal of data on phosphorus absorption presented in Tables 14 and 15, it will be apparent that greater amounts of phosphorus was absorbed from the treatment receiving the highest level of phosphorus. Therefore, this reduction in the phosphorus availability can be taken only as a reflection of comparatively higher uptake by the crop.

Potash at 15 kg per hectare has significantly increased the phosphorus content of soil. But at higher level of potash application, significant reduction in phosphorus content has also been noticed. This reduction may be attributed to higher rate of absorption of phosphorus at highest level of potash. This is in agreement with the observation of Raheja (1966).

Significant reduction in phosphorus content of soil recorded by s_1 spacing (40x25 cm.) might have been due to the higher rate of absorption of phosphorus as seen in the data regarding phosphorus content of pod (Table 14).

3. Available potash content of soil

The data on soil analysis on 60th day revealed that incremental doses of phosphorus decreased the availability of potash significantly. The higher levels of phosphorus viz , 50 kg. and 75 kg. per hectare have recorded equal availability of potash. It is found that absorption of any particular nutrient is largely controlled by the deficiency or toxicity of certain other nutrients in the soil. Thus the availability of large quantities of added phosphorus might have resulted in increased absorption of proportionate amounts of potassium also. The significant increase of available potash noticed in the control plot may be attributed to the above reason

Higher level of added potash has recorded significantly higher content of available potash in the soil. This is in agreement with the result obtained by Bains (1967).

Among spacings, the widest spacing (S_2) has recorded significantly higher content of available potash in the soil. This can be attributed to the reduction in the plant population per unit area under wider spacing which might have reduced the uptake of potash.

The fact that only traces of available potash has been found in the soil at the time of final harvest indicates further that a very good proportion of the applied potash has been leached out from the soil due to heavy rains and the available potash left behind has been utilised by the plant fully.

4. Nitrogen content of pods

The data have indicated that phosphorus has increased the nitrogen content of pods with increasing levels of its application. But significant increase has been noticed only between 0 and higher levels. This might have resulted in the increased uptake of nitrogen in the presence of phosphorus. This is in conformity with the findings of Acharya et al (1953), Vyas and Desai (1953) and Shende and Sen (1958). Increased protein content on account of phosphorus application has been obtained by Parr and Bose (1944, 1945), Parr and Sen (1948), Klare (1950) and Panose (1959).

Significant increase in the nitrogen content of pod has been effected by potash application at the rate of 15 kg. K_2O per hectare. But the highest level of potash, viz., 30 kg. per hectare has depressed the nitrogen content of pod significantly.

The favourable effect of potash in increasing the nitrogen and protein contents of plants has been reported by Albrecht et al (1948) and Scheffer et al (1961). The depressing effect of potash at higher levels of application has also been reported by Raheja (1966) He found that application of large amounts of muriate of potash to the soil reduced the absorption of nitrogen, sulphur and phosphorus and thereby protein synthesis is also reduced.

The different spacings did not affect nitrogen content of pods It can, therefore, be assumed that spacing effect is not so pronounced so as to exhibit its effect on nitrogen content. Goldin (1966) and Singh and Singh (1968) found that spacing does not influence protein content of grain.

6. Nitrogen content of haulm

Significant increase in the nitrogen content of haulm was noted with increasing levels of phosphorus. Acharya (1953) observed that application of phosphatic fertilisers to legumes increased their nitrogen content. In the phosphatic manured series Parr and Bose (1944, 1945) observed increased nitrogen content of wheat straw.

Highest level of potash has slightly reduced the nitrogen content of haulm. Similar depressing effect of potash at higher levels has been reported by Wallace (1951) in berseem wherein nitrogen content of hay decreased from 3.18 to 2.74% as top dressing rates of K_2O increased from 0 to 180 lb. per acre.

Nitrogen content of haulm increased as the spacing between plants increased, the highest being at 40x35 cm. spacing. The closest spacing has recorded lowest nitrogen content. Donovan et al (1963) reported that protein content tended to be lower with closer spacings.

The interaction effect of phosphorus and potash was significant in respect of nitrogen content of pods as well as haulm. The increase in nitrogen content of pod and haulm may be a reflection of increased symbiotic fixation of nitrogen in the soil induced by phosphatic fertilisation. But the level of phosphorus at which the significant effect is seen is different. While p_1k_1 showed significant increase in nitrogen content in pods, p_3k_1 gave increase in nitrogen content of haulm. This differential effect of phosphorus on the nitrogen content of pod and haulm may probably be a reflection of differential priority with which the absorbed nitrogen is utilised for the protein synthesis of pods and haulm. It is quite probable that the requirements of nitrogen for the protein synthesis of pods is satisfied with the treatment combination of p_1k_1, and all the excess nitrogen made available with higher levels of phosphorus has been utilised for the protein synthesis of haulm.

6. Phosphorus content of pods

Incremental doses of phosphorus have recorded increased phosphorus content in pods. The favourable influence of added phosphorus in increasing the phosphorus content in plant has been recognised by Parr and Son (1948) Kochler and Moore (1957), Elgindi et al (1963), Hamdi et al (1965), Daniel (1966) and Bains (1967).

Significant increase in phosphorus content of pod has been recorded by two highest level of potash viz., 30 kg per hectare. The uptake of phosphorus is very largely associated with the potash content of soil. According to Raheja (1966) absorption of phosphorus increased with increasing potash content in the soil.

It is seen that s_1 spacing has increased the phosphorus content of pods significantly. This increased uptake of phosphorus by plants spaced at 40x25 cm. distance might have contributed to significant reduction in available phosphorus in soil as seen in Table 10.

The maximum phosphorus content of 0.633% has been recorded by the combination k_2s_0. This can be attributed to the increase in the absorption of phosphorus due to increasing levels of potash. This is in agreement with the findings of Raheja (1966). Further, closer spacing might have helped to increase the availability of phosphorus, resulting in the efficient uptake by higher levels of potash.

7. <u>Phosphorus content of haulm</u>

Significant increase in the phosphorus content of haulm has been effected by graded doses of phosphorus. The addition of phosphatic fertilisers had increased the available phosphorus content of the soil, which in turn resulted in increased uptake of this nutrient. This is in agreement with the findings of Parr and Bose (1944, 1945), Hamdi *et al* (1965), Elgindi *et al* (1963) and Daniel (1966).

Unni Krishnan (1961) observed that addition of phosphorus has reflected in the phosphorus content of grain and straw

The effect of potash on the phosphorus content of haulm is similar to that of pods, which is in agreement with the observations of Rahoja (1966).

Plants spaced at 40x35 cm distance recorded highest content of phosphorus in haulm which was significant. As the number of plants per unit area is considerably less under wider spacing, the soil as well as environmental conditions will be better for individual plants. This might have resulted in increased uptake of nutrients including phosphorus.

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

An experiment was laid out in the farm attached to the Agricultural College and Research Institute, Vellayani during 1968-1969 to study the performance of Co.1 lab-lab (Ottumochai) under graded doses of phosphorus and potash at different spacings. The treatments comprised four levels of phosphorus (0, 25, 50 and 75 kg P_2O_5 per hectare), three levels of potash (0, 15 and 30 kg K_2O per hectare) and three spacings (40x15 cm, 40x25 cm and 40x35 cm).

The observations of the present study are summarised as follows:

1. The treatment effects were not significant on height of plants.
2. Earliness in flowering was also not affected by the different levels of phosphorus, potash and spacings.
3. Significant increase in the number of pods per plant was recorded at 40x35 cm spacing.
4. Effect of phosphorus on the length of pod was significant.
5. There was significant increase in the length of pods for the wider spacing of 40x35 cm, compared to 40x15 cm spacing.

6. The interaction effect between phosphorus and potash was also significant. The maximum pod length of 5.02 cm was recorded by the combination P_2K_0.

7. The yield of green pods was not influenced by any of the treatments. Treatment combination $P_1K_2S_0$ has recorded the highest yield of 3269.761 kg of green pods per hectare.

8. Spacing alone had significant effect on the yield of haulm. 40x15 cm and 40x25 cm spacings were significantly superior to 40x35 cm spacing.

9. Application of phosphorus had significantly increased the nitrogen content of soil on 50th day over no phosphorus treatment, although the differences between various levels of phosphorus were not significant.

10. Spacing of 40x15 cm had significantly increased nitrogen content of soil over other levels at the time of final harvest.

11. Significant increase in the availability of phosphorus in soil on 50th day was observed with increasing levels of phosphorus and potash application.

12. The availability of phosphorus in the soil was significantly higher under wider spacing on 50th day.

13. Potash at 30 kg K_2O and phosphorus at 75 kg P_2O_5 per hectare significantly reduced the available phosphorus content of soil at the time of final harvest.

14. There was significant increase in the available potash content of soil at 30 kg K_2O per hectare on 50th day

15. Nitrogen content of pods increased with increasing levels of phosphorus.

16. Potash application reduced the nitrogen content of pods significantly beyond 15 kg K_2O per hectare.

17. The effect of spacing on nitrogen content of pods was not significant.

18. Increase in the levels of phosphorus application significantly increased the nitrogen content of haulm.

19 Potash at 15 kg K_2O per hectare has significantly increased the nitrogen content of haulm over no potash treatment

20. 40x35 cm spacing was significantly superior to other two spacings in increasing the nitrogen content of haulm.

21. Graded doses of phosphorus and potash significantly increased phosphorus content of pods and haulm.

22. Increase in spacing significantly increased the phosphorus content of haulm.

The present study has indicated that addition of phosphorus in soils rich in available phosphorus only helps to maintain the phosphorus status of soil rather than increasing the yield. It would be worthwhile to have further investigations on this aspect to come to definite conclusions The absence of response for potash in the present study suggests the necessity for further investigations on this line also.

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APPENDICES

APPENDIX I

Chemical analysis of the soil from the experimental field

Total nitrogen	..	0.071 per cent
Total P_2O_5	..	0.041 "
Total K_2O	..	0.081
Available phosphorus (P)	..	0.0048 "
Avaialble Potash (K)	..	0.0042 "
pH	..	6.8

APPENDIX II

Meteorological data recorded at the Agricultural College Farm during the crop period

Month	Week	Temperature°C		Relative humidity%	Rainfall (in mm)
		Maximum	Minimum		
September 1968	24-30	29.0	23.7	92.0	345.0
October 1968	1-7	29.1	23.6	89.0	33.8
"	8-14	30.1	23.2	87.0	--
"	15-21	30.3	23.7	91.0	256.0
"	22-28	30.7	24.1	86.0	75.0
"	29-4 Nov.	29.5	23.4	92.0	377.0
November 1968	5-11	29.3	22.8	90.0	173.0
"	12-18	30.5	25.0	88.0	29.0
"	19-25	30.7	23.0	92.0	117.2
"	26-2 Dec.	31.2	22.8	91.0	--
December 1968	3-9	31.4	23.4	91.2	79.0
"	10-16	31.1	21.1	90.3	--
"	17-23	30.5	22.2	88.4	114.0
"	24-31	30.1	22.9	91.1	--
January 1969	1-7	31.9	22.6	80.1	--
"	8-14	31.0	22.0	91.1	--
"	15-21	30.7	22.1	88.0	--
"	22-28	30.8	21.7	88.4	--

APPENDIX III

Height of plants on 50th day
(Analysis of variance)

Source	SS	DF	Variance	F
Total	145584.82	71		
Block	10258.73	5	2051.74	< 1
P	13480.70	3	4493.56	1.9
S	1720.44	2	860.22	< 1
P.S	15838.68	6	2639.78	1.11
K	3766.86	2	1883.48	< 1
P.K	7036.26	6	3518.63	1.4
KS	4187.72	2	2093.86	< 1
KS^2	3173.72	2	1586.86	< 1
P.K.S.	12887.74	12	1073.97	< 1
Error	73232.47	31	2362.33	

APPENDIX IV

Earliness in flowering
(Analysis of variance)

Source	SS	DF	Variance	F
Total	77.320	71		
Block	6.400	5	1.28000	1.02795
P	7.040	3	2.34670	1.88461
S	1.190	2	0.59500	0.47783
P.S	5.920	6	0.98670	0.79240
K	4.190	2	2.09500	1.68247
P.K	4.920	6	0.82000	0.65853
KS	0.393	2	0.19650	0.15780
KS^2	5.166	2	2.58300	2.07438
P.K.S	3.600	12	0.29166	0.23422
Error	38.601	31	1.24519	

APPENDIX V

Number of pods per plant
(Analysis of variance)

Source	SS	DF	Variance	F
Total	102261.78	71		
Block	3939.94	5	787.98	<1
P	3683.44	3	1227.81	<1
S	21677.78	2	10838.89	8.37**
P.S	6102.22	6	1017.03	<1
K	1954.78	2	977.39	<1
P.K	3920.22	6	653.37	<1
KS	96.06	2	48.03	<1
KS^2	294.50	2	147.25	<1
P.K.S	20477.12	12	1706.42	1.3
Error	40115.72	31	1294.05	

** Significant at 1% level

APPENDIX VI

Length of pods

(Analysis of variance)

Source	SS	DF	Variance	F
Total	3.3160	71		
Block	0.2666	5	0.05332	2.24
P	0.4175	3	0.13916	5.85**
S	0.2492	2	0.12460	5.23*
P.S	0.1416	6	0.02360	0.99
K	0.0712	2	0.03560	1.49
P.K	0.8486	6	0.14143	5.94**
KS	0.1138	2	0.05690	2.39
KS^2	0.0222	2	0.01110	0.46
P.K.S	0.4465	12	0.03720	1.56
Error	0.7378	31	0.02380	

** Significant at 1% level

* Significant at 5% level

APPENDIX VII

Yield of green pods in the first harvest
(Analysis of variance)

Source	SS	DF	Variance	F
Total	2907915.00	71		
Block	609266.00	5	121853.00	3.18*
P	52554.00	3	17518.00	< 1
S	268198.00	2	134099.00	3.50*
P.S	156677.00	6	26113.00	< 1
K	36808.00	2	18404.00	< 1
P.K	206550.00	6	34425.00	< 1
KS	31934.00	2	15967.00	< 1
KS^2	12309.00	2	6155.00	< 1
P K.S	344317.00	12	28693.00	< 1
Error	1189302.00	31	38365.00	

* Significant at 5% level

APPENDIX VIII

Yield of green pods in the second harvest
(Analysis of variance)

Source	SS	DF	Variance	F
Total	5064092.88	71		
Block	350653.13	5	70130.63	<1
P	128189.49	3	42729.83	<1
S	21408.08	2	10704.04	<1
P.S	292021.14	6	48670.19	<1
K	199026.34	2	99513.17	1.15
P.K	142754.22	6	23792.37	<1
KS	134262.72	2	67131.36	<1
KS^2	45440.72	2	22720.36	<1
P.K.S	1073432.78	12	89452.73	1.03
Error	2676904.26	31	86351.75	

APPENDIX IX

Yield of green pods in the third harvest
(Analysis of variance)

Source	SS	DF	Variance	F
Total	6831897.95	71		
Block	1129374.12	5	225874.82	2.30
P	35096.50	3	11698.83	<1
S	214477.78	2	107238.89	1.09
P.S	492218.67	6	82036.44	<1
K	203157.03	2	101578.51	1.03
P.K.	340703.09	6	56783.84	<1
KS	4027.17	2	2013.58	<1
KS^2	465615.72	2	232857.86	2.37
P.K.S	913448.24	12	76120.68	<1
Error	3033779.63	31	97863.85	

APPENDIX X

Yield of green pods in the fourth harvest

(Analysis of variance)

Source	SS	DF	Variance	F
Total	9877537.33	71		
Block	1977166.16	5	395453.23	3.6152
P	146644.33	3	48881.44	<1
S	714767.41	2	357383.70	3.2671
P.S	507301.92	6	84550.32	<1
K	90399.93	2	45199.96	<1
P.K	641626.07	6	106937.64	<1
KS	135813.17	2	67906.58	<1
KS^2	835588.22	2	417794.11	3.8194
P.K.S	1437258.96	12	119771.58	1.0949
Error	3390971.16	31	109386.10	

APPENDIX XI

Yield of green pods in the fifth harvest
(Analysis of variance)

Source	SS	DF	Variance	F
Total	1300388.00	71		
Block	196204.00	5	39242.80	2.2976
P	52563.00	3	17521.00	1.0259
S	48378.00	2	24189.00	1.4162
P.S	36773.00	6	6128.80	<1
K	27123.00	2	13561.50	<1
P.K	192515.00	6	32086.00	1.8786
KS	24039.00	2	12019.50	<1
KS^2	50738.00	2	25369.00	1.4853
P.K.S	142596.00	12	11883.00	<1
Error	529459.00	31	17079.30	

APPENDIX XII

Yield of green pods in the sixth harvest
(Analysis of variance)

Source	SS	DF	Variance	F
Total	2302073.32	71		
Block	239636.90	5	47927.38	1.4413
P	246378.71	3	82126.24	2.4697
S	59472.03	2	29736.01	<1
P.S	232926.41	6	38821.07	1.1674
K	19398.36	2	9699.18	<1
P.K	129882.75	6	21647.12	<1
KS	59397.14	2	29698.57	<1
KS^2	80353.39	2	40176.69	1.2082
P.K.S	203802.76	12	16983.56	<1
Error	1030824.87	31	33252.41	

APPENDIX XIII

Yield of green pods in the seventh harvest

(Analysis of variance)

Source	SS	DF	Variance	F
Total	5203079.88	71		
Block	1193788.46	5	238757.69	14.89
P	196216.71	3	65405.57	<1
S	30101.88	2	15050.94	<1
P.S	145856.79	6	24309.46	<1
K	101628.88	2	50814.44	<1
P.K	163741.12	6	27290.18	<1
KS	206713.60	2	103356.80	1.24
KS^2	31192.20	2	15596.10	<1
P.K.S	554312.08	12	46192.67	<1
Error	2579528.16	31	83210.58	

APPENDIX XIV

Yield of green pods in the eighth harvest
(Analysis of variance)

Source	SS	DF	Variance	F
Total	605487.99	71		
Block	104464.41	5	20892.88	2 23
P	17492.38	3	5830.79	< 1
S	12392.20	2	6196.10	< 1
P.S	22226.91	6	3704.49	< 1
K	40382.11	2	20191.06	2.16
P.K	46486.67	6	7747.78	< 1
KS	5207 17	2	2603.59	< 1
KS^2	188.23	2	94.12	< 1
P K.S	66541.66	12	5546.14	< 1
Error	290106.25	31	9358.27	

APPENDIX XV

Total yield of green pods (8 harvests combined)
(Analysis of variance)

Source	SS	DF	Variance	F
Total	105830521.28	71		
Block	13977676.28	5	2795516.06	1.822
P	1493876.50	3	497958.83	<1
S	4681950.37	2	2340975.18	1.526
P.S	3012707.41	6	652117.90	<1
K	3396093.68	2	1698046 84	1.106
P.K	4729287.10	6	788214.51	<1
KS	916702.39	2	458351.19	<1
KS^2	6069504.66	2	3034752.33	1.978
P.K S	19099500.74	12	1591625.06	1.037
Error	47553323.15	31	1533978 16	

APPENDIX XVI

Yield of haulm

(Analysis of variance)

Source	SS	DF	Variance	F
Total	30538437.59	71		
Block	4479995.83	5	895999.16	2.33
P	3798218.00	3	1266072.66	3.20
S	5460381.25	2	2730190.62	7.10**
P.S	990471.55	6	165078.59	<1
K	493225.00	2	246612.00	<1
P.K	1213177.83	6	202196.30	<1
KS	76129.16	2	38064.58	<1
KS^2	695329.16	2	347064.58	<1
P.K.S	1419238.87	12	118269.90	<1
Error	11912270.85	31	384266.80	

**Significant at 1% level

APPENDIX XVII

Nitrogen content of soil on 50th day

(Analysis of variance)

Source	SS	DF	Variance	F
Total	0.00026058	71		
Block	0.00000027	5	0.00000005	<1
P	0.00018304	3	0.00006101	31.77**
S	0.00000210	2	0.00000105	<1
P.S	0.00000046	6	0.00000007	<1
K	0.00000711	2	0.00000355	1.84
P.K.	0.00000735	6	0.00000122	<1
KS	0.00000007	2	0.00000003	<1
KS^2	0.00000016	2	0.00000008	<1
P.K.S	0.00000056	12	0.000000046	<1
Error	0.00005944	31	0.00000192	<1

**Significant at 1% level

APPENDIX XVIII

Nitrogen content of soil at the time of final harvest
(Analysis of variance)

Source	SS	DF	Variance	F
Total	0.00000170	71		
Block	0.00000006	5	0.000000012	<1
P	0.00000014	3	0.000000046	<1
S	0.00000016	2	0.000000080	3.63*
P.S	0.00000002	6	0.000000003	<1
K	0.00000003	2	0.000000015	<1
P.K	0.00000015	6	0.000000025	1.13
KS	0.00000002	2	0.000000010	<1
KS^2	0.00000005	2	0.000000025	1.13
P.K.S	0.00000037	12	0.000000030	1.36
Error	0.00000070	31	0.000000022	

*Significant at 5% level

APPENDIX XIX

Available phosphorus content of soil on 50th day

(Analysis of variance)

Source	SS	DF	Variance	F
Total	186460.00	71		
Block	19230.16	5	3846.03	149.123**
P	34264.00	3	11421.33	442.858**
S	4969.33	2	2484.66	96.341**
P.S	8636.00	6	1439.33	55.809**
K	12916.00	2	6458.00	250.407**
P.K	38652.00	6	6442.00	249.786**
KS	14460.66	2	7230.33	280.354**
KS^2	5076.16	2	2538.08	98.413**
P.K.S	57456.00	12	4788.00	185.653**
Error	799.69	31	25.79	

**Significant at 1% level

APPENDIX XX

Available phosphorus content of soil at the time of final harvest

(Analysis of variance)

Source	SS	DF	Variance	F
Total	240856.00	71		
Block	28459.67	5	5691.93	47.5000**
P	30074.67	3	10024.89	91.8174**
S	8892.00	2	4446.00	37.1025**
P.S	30230.66	6	6538.44	54.5642**
K	25084.00	2	12542.00	104.6649**
P.K	51241.33	6	8540.22	71.2694**
KS	16684.40	2	8342.20	69.6169**
KS^2	10889.05	2	5444.52	64.5646**
P.K.S	26585.34	12	2215.44	18.4881**
Error	3714.88	31	119.83	

**Significant at 1% level

APPENDIX XXI

Available potash content of soil on 50th day

(Analysis of variance)

Source	SS	DF	Variance	F
Total	21234.00	71		
Block	760.16	5	152.03	25.594**
P	2123.00	3	707.66	119.134**
S	1754.33	2	877.16	147.670**
P S	3649.67	6	608 27	102.402**
K	197.33	2	98.66	16.609**
P.K	5355.00	6	892.50	150.252**
KS	408.66	2	204.33	34.398**
KS^2	380.66	2	190.33	32 042**
P.K.S	6420.83	12	535.06	90.077**
Error	184.36	31	5 94	

**Significant at 1% level

APPENDIX XXII

Percentage of nitrogen in pods

(Analysis of variance)

Source	SS	DF	Variance	F
Total	0.663	71		
Block	0.123	5	0.0246	6.8333**
P	0.124	3	0.0413	11.4722**
S	0.001	2	0.0005	0.1388
P.S	0.042	6	0.0070	1.9444
K	0.025	2	0.0125	3.4722*
P.K	0.075	6	0.0125	3.4722**
KS	0.117	2	0.0585	16.2500**
KS^2	0.002	2	0.0010	0.2777
Error	0.154	43	0.0036	

**Significant at 1% level
*Significant at 5% level

APPENDIX XXIII

Percentage of nitrogen in haulm

(Analysis of variance)

Source	SS	DF	Variance	F
Total	0.443	71		
Block	0.035	5	0.007	23.333**
P	0.173	3	0.0576	192.000**
S	0.004	2	0.002	6.666**
P.S	0.020	6	0.0033	11.000**
K	0.003	2	0.0015	5.000*
P.K	0.047	6	0.0078	26.000**
KS	0.020	2	0.010	33.333**
KS^2	0.010	2	0.005	16.666**
P.K.S	0.121	12	0.010	33.333**
Error	0.010	31	0.0003	

**Significant at 1% level

*Significant at 5% level

APPENDIX XXIV

Percentage of phosphorus in pods

(Analysis of variance)

Source	SS	DF	Variance	F
Total	0.476301	71		
Block	0.097658	5	0.0195316	3487.78**
P	0.043080	3	0.0143600	2564.28**
S	0.002055	2	0.0010225	182.58**
P.S	0.030728	6	0.0051213	914.52**
K	0.010143	2	0.0050715	905.62**
P.K	0.042989	6	0.0071648	1279.43**
KS	0.080257	2	0.0401285	7165.80**
KS^2	0.014176	2	0.0070880	120.57**
P.K.S	0.155042	12	0.0129201	2307.16**
Error	0.000173	31	0.0000056	

**Significant at 1% level

APPENDIX XXV

Percentage of phosphorus in haulm

(Analysis of variance)

Source	SS	DF	Variance	F
Total	0.0779	71		
Block	0.0008	5	0.000160	53.33**
P	0.0060	3	0.002000	666.66**
S	0.0083	2	0.004160	1350.00**
P.S	0.0086	6	0.001430	476.66**
K	0.0231	2	0.011550	3850.00**
P.	0.0124	6	0.002070	690.00**
KS	0.0006	2	0.000300	100.00**
KS	0.0004	2	0.000200	66.66**
P.K.S	0.0176	12	0.001470	490.00**
Error	0.0001	31	0.000003	

**Significant at 1% level

APPENDIX XXV

Percentage of phosphorus in haulm

(Analysis of variance)

Sour	SS	DF	Variance	F
Tota	0.0770	71		
Bloc	0.0008	5	0.000160	53 33**
P	0.0060	3	0.002000	666.66**
S	0.0083	2	0.004150	1350.00**
P.S	0.0086	6	0.001430	476.66**
K	0.0231	2	0.011550	3850.00**
P.	0.0124	6	0.002070	690.00**
KS	0.0006	2	0.000300	100.00**
KF	0.0004	2	0.000200	66.66**
P K.S	0.0176	12	0.001470	490.00**
Error	0.0001	31	0.000003	

**Significant at 1% level