EFFECT OF LIME AND POTASH ON THE YIELD AND QUALITY OF GROUNDNUT (*Arachis hypogaea Linn*) IN THE RED LOAM SOILS OF KERALA STATE

BY

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THESIS

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C E R T I F I C A T E

This is to certify that the thesis herewith submitted contains the results of bonafide research work carried out by Sri. P.G. Veeraraghavan 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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C O N T E N T S

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CHAPTER I

INTRODUCTION

The importance of calcium and potassium in the nutrition of legumes including groundnut has been reported by many investigators. It has been emphasised that the status of calcium and potassium in soils greatly influences pod production in groundnut. Colwell et al (1946) observed that response to application of potassium increased when it was combined with lime in soils which were low in both the plant nutrients.

Physiological processes related to the nutrient supply in general, determine the yield of field grown peanuts. According to Collins and Morris (1942), a peanut crop yielding 2000 pounds of pods and 4000 pounds of hay per acre removes 139.7 lb. N, 24.3 lb. P_2O_5, 103 lb. K_2O, 58.9 lb. CaO and 30.3 lb. MgO. Moreover, it has also been observed that the nitrogen fixed by legumes is in proportion to the calcium and potassium absorbed from the substrate.

Recognising the important role of calcium in the nutrition of groundnut crop, investigations on the requirement of calcium for groundnut have been specifically carried out in countries like the U.S.A. Jones (1885) describing the soil suitable for the growing of peanuts, said that unless it contains a good percentage of lime in some form in an available state, no land will produce a paying crop of "solid" pods, although it may yield large luxuriant vines. Murray (1935) has indicated that the quality of peanuts is influenced by calcium to a greater extent than the quantity of the pod, and, a deficiency of calcium in soils is usually manifested by a large number of unfilled pods. The better quality of pods in soils well supplied with calcium is evidenced by a whiter, firmer hull, well-developed kernels and an increase in weight per bushel of unshelled pods.

Morris (1941), Burkhart and Collins (1942), observed that potassium induces more vegetative growth but causes a reduction in groundnut quality. This adverse effect can be overcome by adequate liming. Colwell et al (1946) found that the yield of peanut was reduced by potassium when the soil is not adequately supplied with lime. Cowie (1951) reports that calcium has been found to improve not only the yield but also the quality of pods while potassic manuring had little or no direct effect on the quality of the crop. Results of fertilizer trials on peanut in the different parts of United States showed that generally the response of peanuts to calcium had been more consistent than to addition of any other nutrients and unless the crops grown in rotation with peanuts receive very liberal applications of potassium, it may be necessary to apply some fertilizers containing this element to obtain maximum peanut yields.

In India, where liming is not generally practiced, very few investigations have been undertaken to study the response of groundnut crop to lime either alone or in combination with other fertilizers. Seshadri and Sayeed (1956) have reported that field trials undertaken at Nileshwar, in Kerala State, by liming the laterite soil with slaked lime has not only given substantial increase in yield but also helped in proper filling of the pods. Kothandaraman (1960) studying the effect of liming acid soil (pH 4.5) in Madras State, found, that by application of lime at 7000 pounds per acre the yield of pods increased over the control by nearly 43 percent. Manurial experiments in the red loam soils of Hebbal, in Mysore State, have shown that application of lime at half a ton per acre increased the yield of groundnut pods by over 10 percent. Application of lime was found to depress the groundnut yield in the black cotton soils at Akola.

Liming experiments carried at Ranchi, in Bihar, showed that liming the soil (pH 5.3) with 3600 pounds of lime alone per acre increased groundnut yield by 123 percent as against 18 percent by NPK fertilizers alone. The combined application of lime and NPK fertilizers has recorded 154 percent increased yield over the control. Panikkar (1961) reviewing the manurial trials on groundnut in different States in India has reported that an average response of 4.8 lb. pods per pound of K_2O was obtained at Akola.

It can thus be seen that calcium and potassium play the major role in the nutrition of groundnut and an adequate supply of these nutrients is quite indispensable for getting the maximum yield and quality of the crop. Though consistent results by way of increased yields and better quality have been achieved by the application of lime, it has been observed by many workers that mere application of potash in the absence of lime has a depressing effect on the yield and quality of the crop. Investigations in the United States on the combined application of lime and potash to peanut crop have definitely indicated that positive response could be obtained by a judicious combination of these nutrients. In India, data are very limited with regard to studies on the calcium and potassium nutrition of groundnut.

Groundnut crop in Kerala extends over 40,000 acres and there are immense possibilities of further extending the area under this crop by resorting to intercropping in coconut gardens and practising double cropping by introducing as a summer crop in paddy fallows in the project areas. The soils of Kerala State generally are characterised by poor lime and potash status. Under such conditions, crops, particularly legumes like groundnut are bound to favourably respond to the application of calcium and potassium. The present investigation has therefore been taken up to study the effect of graded doses of lime and potash on groundnut, in the red loam soils and to assess how far a combined optimum dose of these two nutrients could influence the yield and quality of the crop for obtaining maximum economic returns.

CHAPTER II

REVIEW OF LITERATURE

A. Removal of nutrients by groundnut

Various authors have reported differently on the removal of calcium and potassium by groundnut crop. Such differences are attributed to the soil conditions in which the experiments were conducted. According to John and Kenny (1916) an average crop of groundnut removes 30 lb. K_2O per acre. It was reported by Collins and Morris (1942) that a groundnut crop yielding 2000 pounds of pods and 4000 pounds of hay per acre removes 103 lb. K_2O and 58.9 lb. CaO. Bouyer (1949) noted that a crop of 1338 pounds of pods per acre required 37 lb. K_2O and 24 lb. CaO. Panikkar (1961) in his review says, that an average crop of 3600 pounds per acre removed about 18 lb. K_2O and 65 lb. CaO from the soil.

Nagarajan (1959) in his physiological studies on the nutrition of groundnut plant found that the optimum level of calcium for growth and development should be 30 ppm. and any great excess over this level resulted in physiological disorders in the plant. At higher levels of calcium, the uptake of potassium was reduced resulting in poor growth, flower formation, dry matter production and yield of pods. A correct proportion of calcium, magnesium, and potassium was essential in the growing medium to ensure normal growth and yield, and, a ratio of 1:1:1 was found suitable for the purpose.

B. Studies on calcium nutrition in groundnut

The function of calcium in the growth of groundnut has been recognised as early as 1885. Results obtained from the use of lime on peanuts by various investigators indicate that the quality of the peanuts is affected much more than the quantity. Peanuts grown on soil having sufficient lime are usually better filled, the shells are whiter, and they have greater weight per bushel. Middleton (1945) found response to calcium applications in soils with low exchangeable calcium. Rogers (1945) obtained increased groundnut yields from the application of lime. He found that increasing the calcium level of soil from approximately 400 pounds $CaCO_3$ equivalent per acre to 800 or 900 pounds by the application of lime, resulted in a fivefold increase in yield of spanish peanuts. Strauss and Grizzard (1946) studying, ten fields of five soil types, showed that the percentage calcium saturation of the exchange complex was correlated with the average weight of nuts produced by a plant and that potassium and magnesium ratio of soil was correlated with the number of nuts per plant. Glendonhill (1947) has reported that in Senegal in East Africa, lime applied at the rate of 3 tons per acre gave as much as 35 percent increase in yield. Reed and Brady (1948) have reported that on soils with low calcium, broadcast applications of dolomite lime-stone increased the size of plant and the number of gynophores. Brady <u>et al</u> (1948) stated that of the various nutrients added to the fruiting zone, calcium was the only one which consistently increased fruit filling.

Burkhart (1941) showed that plants fertilized with superphosphate utilised the calcium much more readily than phosphorus. Colwell and Brady (1945) in their field experiments using calcium, potassium and magnesium, found that on soils low in calcium, use of gypsum increased the proportion of a two-cavity size fruit of virginia bunch and N.C. runner peanut types. For all varieties there was higher proportion of two-cavity fruits. Gypsum increased the average weight of kernels. Brady (1947), Bolhius (1955), and Shibuya

(1955), while studying nutritional aspect in peanuts have observed that calcium is essential for pod-filling.

Prevot (1949 and 1950) mentions that phosphorus and potassium are important at the beginning and lime at the end of the vegetative period. He studied at regular intervals the nitrogen, phosphorus, potassium and calcium content of leaves by foliar analysis and observed that calcium content of leaves increased regularly from the vegetative to the harvest stage.

Bledsoe <u>et al</u> (1949) mention that "Ca 45" applied to the fruiting zone was absorbed by the pegs and shell. Bledsoe and Haris (1950) noted that the pegs absorbed potassium and calcium in larger quantities than phosphorus or magnesium from the growing medium.

York and Colwell (1951) reviewing the results of the fertilizer trials on peanut in the different parts of the United States, report, that generally the response of peanut to amendments of calcium has been more consistent than to addition of any other nutrient. Anon (1953) reports that lime failed to improve yield in groundnut in work carried out in East Africa. Puh (1953) found that application of lime at 1500 to 3000 kilograms per hectare could increase peanut yield by more than 40 percent. Wilson *et al* (1956) noted that the peanut yield on a well fertilized but unlimed sandy loam in South Eastern Alabama could be increased from 895 pounds to 1900 pounds of pods per acre by the application of one ton of lime.

In India, not much work has been done on the fundamental aspects of calcium nutrition in groundnut. Only a few reports are available and they are reviewed below.

Seshadri and Sayeed (1956) noted that in the laterite soils at the Agricultural Research Station, Nileshwar, in Kerala, liming the soil with slaked lime as a top dressing at 4 cwt. per acre at the time of first intercultivation of the crop, has given substantial increase in yield. The liming was also found to have helped in the proper filling of pods. According to Venkata Rao and Govindarajan (1960) result of manurial experiments carried out for seven years in the red loam soils of Hebbal, in Mysore State, have shown that the treatment with lime alone at half ton per acre increased the yield of pods by over 10 percent while the combined application of lime with phosphoric acid at 60 lb. per acre increased the yield by 20 percent. These two nutrients were found to be important in increasing the yield and pod filling. Kothandaraman (1960) in his pot culture studies on the effect of liming acid soils (pH 4.5) on the yield of groundnut found that the yield of groundnut increased by the application of lime at 7000 lb. per acre alone or in combination with super phosphate. The yield of groundnut haulms increased by 11 percent over the unlimed pot, and by the application of lime at 7000 lb. per acre, the yield of pods and kernels also increased over the control by nearly 43 percent.

Panikkar (1961) has reported that the application of lime depressed yields of groundnut in the black cotton soils at Akola. But in trials in Bihar there was a response of 60 lb. nut per maund of gypsum added at 1-4 maund per acre. Chakrabarthy et al (1961) reviewing the liming experiment conducted at Ranchi, in Bihar, report that liming the soil with pH 5.3 at 3600 lb. of lime alone per acre increased groundnut yield by 123 percent as against 18 percent by NPK fertilizer alone. The combined applications of lime and NPK fertilizers has recorded 154 percent increased yield over the control.

Nagarajan (1959) studying the role of calcium in the nutrition of the groundnut plant found that a supply of calcium in the early stages was found to be of vital importance to assure normal germination. Growth and development of root as well as nodulation, were influenced most by the availability of calcium in the growing medium. A lack of calcium adversely affected the kernel development resulting in poor quality pods and low yields. Calcium had no direct influence on the oil content of the seed.

C. <u>Symptoms of calcium deficiency in groundnut</u>

Seshadri (1962) reports that calcium deficiency is characterised first by the development of localised pitted areas on the lower surface of the leaves. Later on, large necrotic spots are found on both the leaf surfaces which give the leaves a bronze colour. The youngest foliage presents a distorted appearance. Harris and Bledsoe (1951) have reported that the basal stem cracks and dieback of the shoots occur during later stages. Nagarajan (1959) found that the young primary root breaks into for sub-rootlets and sometimes the terminal root dies off giving place to adventitious root. Deficiency of calcium results in poor root development.

The most serious ill effect of calcium deficiency is its adverse influence on the filling and quality of pods. York and Reed (1953) observed that calcium deficiency markedly reduced the number of flowers which formed pegs. Bolhuis and Stubbs (1955) found that the presence of calcium is absolutely necessary for fruit formation.

D. <u>Symptoms of potassium deficiency in groundnut.</u>

Peanut removes large amounts of potassium, but actual deficiency symptoms seldom appear on this crop in the field. According to Seshadri (1962) potassium deficiency in groundnut manifest itself in stunted growth, with drying up of leaf margins. The stem gets a reddish colour, at the tips of branches. York and Reed (1953) reported potassium deficiency to cause the reduction in the number of flowers, forming pegs. Bledsoe and Harris (1950) found that potassium deficiency results in the foliage becoming darker green in colour and in the later stages there was some abscission of lower leaves.

E. Investigations on potassium nutrition in groundnut.

Investigations in the United States have shown that despite the relatively large amount of K absorbed by peanuts the yield responses to applications of potash fertilizers are often small or negligible, even on soils of low potassium content.

Anon (1942) found that an average of the yields obtained in an experiment conducted at the Georgia Coastal Plain Experimental Station over a 10 year period had shown that the use of 32 pounds of potash in combination with nitrogen and phosphorus increased the yield of spanish peanut, only by 139 pounds per acre. Colwell and Brady (1942) have reported that in experiment conducted by the North Carolina Station between 1938 and 1943, 12 to 48 pounds of K_2O per acre proved beneficial in only one of the locations. In several instances the yields were actually reduced by the application of potash. Brady et al (1946) noted interesting relations regarding the response of peanut to potash in some experiments conducted in North Carolina. It was found that on a soil low in both potassium and calcium there was significant increase in yield from the addition of potash when adequate calcium was supplied. Without the addition of calcium, potash was found to decrease the yields of peanuts. The deleterious effect of potash in the absence of applied calcium was due to the reduction in shelling percentage. The response of peanuts to potash was found to be dependent upon the initial level of K in the soil. It was observed that the vegetative growth was stimulated by the added potash and that the increased yields were due to the effect of potash on the plant size and number of fruit rather than on kernel development. Davis and Brogden (1951) found that adequate potassium and insufficient calcium resulted in larger quantity of light groundnuts in harvest.

Other workers, Burkhart and Collins (1942), Morris (1941), and Rogers (1944), have also observed that potash may stimulate vegetative growth but cause a reduction in peanut quality. However, this harmful effect of potash on peanut quality was overcome by maintaining an adequate level of calcium in the soil. Other studies in Georgia, Florida, Alabama, South Carolina and elsewhere have given no consistent results with potash fertilizers.

Roberstson *et al* (1956) found that there was a negative response to potassium when more than 15 pounds per acre were applied as KCl. The level of exchangeable potassium in the soil did not appear responsible for negative results. Ninety pounds per acre of exchangeable potassium was sufficient for maximum yields. Comber (1959) noted that 200 pounds per acre of KCl can enhance hay yield (above normal) by 30 percent with a simultaneous depression in nut yield of 14 percent.

In India, investigations on the potash nutrition of groundnut are very few. John *et al* (1948) in the first series of experiment carried out in Madras on an NPK basis with and without a basal dressing of cattle manure found that in light sandy-loam soils deficient in organic matter and nutrients, the crop responded to potash, phosphoric acid and cattlemanure. But in the next series of experiments undertaken with the different doses of these manures for the purpose of determining their optimum doses, it was found that higher dose of phosphoric acid (40 and 60 lb. P_2O_5 per acre) and potash (50 and 75 lb. K_2O per acre) over a basal dressing of cattlemanure gave the best results. Venkata Rao and Govindarajan (1960) reviewing the experiments on manuring groundnut in Mysore, report that the addition of potash at 30 pounds per acre did not enhance yield to any marked extent while lime alone at half a ton per acre or phosphoric acid alone at 60 lb. per acre increased the yield of groundnut pods by over 10 percent.

Panikkar (1961) reviewing the results of manurial experiments on groundnut in India has reported that an average response of 4.8 lb. nuts per pound of K_2O was obtained in 15 trials at Akola for the application of 25 to 35 lb. of K_2O per acre as sulphate of potash. The response at Tindivanam for the application of 25 lb. K_2O per acre was found to be 4.5 lb. nuts per pound of K_2O. In Madhya Pradesh, application of 30 lb. K_2O per acre was found to be sufficient and a combination of 20 lb. N or P with 30 lb. K gave significantly high yields. Similarly studies at Jalgaora, in Maharashtra, showed that application of 10 lb. N and 100 pounds K_2O per acre gave the best yield. Seshadri (1962) has stated that at the Akola experimental station in Madhya Pradesh, a definite response to the application of potassium sulphate was obtained, and at Mysore, muriate of potash at 80 lb. per acre in conjunction with super phosphate gave economic results.

From the foregoing review, it is evident that more or less consistent results have been obtained both in India and abroad for the application of lime to groundnut crop, while the response for potash is highly varying. But it has been established in the United States that on soils low in potassium and calcium there was significant increase in yield from the addition of potash when adequate calcium has been supplied. This aspect of nutrition on groundnut crop has not been studied in detail in India and hence this investigation was taken up.

CHAPTER III

MATERIALS AND METHODS

1. Seed material.

The groundnut strain, TMV 2, was selected for the investigation. This is a short duration bunchy strain and is one of the most popular strains grown in Kerala. The distinguisting features of this strain as described by Seshadri (1962) are given below:

TMV 2. (A.H. 32) - A mass selection from the 'Spanish' type grown extensively in North Arcot district of Madras State. A short duration type with bunch habit of growth, cannot stand long periods of drought. Leaflets: Large, light green. Pods: Small, 1-2 - seeded; beak - distinct; veins-distinct; constriction - shallow to medium; shell - very thin. Kernels: small, light rose, rounded, plump, non-dormant. This strain is about 105 days duration and is suitable for both rainfed and irrigated cropping.

2. Field: The experiment was laid out in the dry land block of the Agricultural College Farm, Vellayani.

The soil is red loam with sandy texture. Soil analysis was carried out for available nitrogen, available phosphoric acid, available potash, total potash, total calcium and available calcium. The following are the values obtained.

Available nitrogen	- 280 lb. per acre (medium)
Available phosphoric acid	- 28 lb. per acre (medium)
Total potash	- 124 lb. per acre (low)
Available potash	- 16 lb. per acre (very low)
Lime (CaO)	- 2480 lb. per acre (low)
Available calcium	- 1.25 m.e. per 100 grams of soil.
pH	- 5.7 (medium acid)

3. (i) Fertilizers.

Since the investigation was confined to a study of the effect of graded levels of lime and potash only, the dose of nitrogen and phosphoric acid was kept uniform for all the treatments. Optimum levels of nitrogen and phosphoric acid for groundnut crop in Kerala have not been worked out. The Fertilizer Work Shop Seminar of 1961 has recommended an arbitrary dose of 10 lb. N, 30 lb. P_2O_5 and 30 lb. K_2O per acre for the groundnut crop under Kerala conditions. Taking this recommendation as the approximate basis, the levels of different nutrients were fixed with minor alterations.

Nitrogen and phosphoric acid were applied in all the plots at a uniform rate of 10 lb. and 20 lb. per acre as ammonium sulphate and super phosphate respectively. They were analysed and found to contain 20 percent nitrogen and 16 percent water coluble phosphoric acid.

Potash was applied in the form of muriate of potash analysing 60 percent K_2O, at three levels of 25 lb., 50 lb. and 75 lb. per acre. As the soil is highly deficient in potash, the minimum level was taken as 25 lb., which is more or less on a par with the dose recommended by Panikkar (1961). The higher levels of 50 lb. and 75 lb. were included to study how far this will economically contribute to the increase in yield and oil content of the crop under Kerala conditions. Houg (1953) has reported that oil content of groundnut seeds generally increases in response to potash.

Lime was applied as hydroxide of lime at three levels of 0 lb., 750 lb. and 1500 lb. per acre. The levels of lime was fixed by estimating the actual lime requirement of the soil and taking the highest dose at double the actual requirement.

(ii) Treatments:

The following were the nine treatment combinations included in the trial.

Treatment No.	Lime lb. per acre	Potash (K_2O) lb. per acre
1	0	25
2	750	25
3	1500	25
4	0	50
5	750	50
6	1500	50
7	0	75
8	750	75
9	1500	75

The different levels of nutrients are denoted by the following symbols.

0 lb.	Lime	L_0
750 lb.	Lime	L_1
1500 lb.	Lime	L_2

25 lb.	Potash	K_1
50 lb.	Potash	K_2
75 lb.	Potash	K_3

(iii) Application of fertilizers.

The full quantity of the three fertilizers was applied in a single dose prior to sowing and worked into the soil using spade. The lime was applied in a single dose 30 days before sowing and thoroughly incorporated into the soil.

4. Layout.

The layout adopted was factorial experiment in randomised block design as recommended by Panse and Sukatme (1957).

Design:	3x3 Factorial experiment in randomised block design.		
Replication:	Four		
Size of plot:	Gross	-	28' x 16'
	Net	-	26' x 14'
	Spacing	-	6" x 6"

The number of replications and plot size were fixed as suggested for standard Agricultural experimental techniques.

5. Sowing

The seeds were shelled prior to sowing. Groundnut kernels were dibbled in singles at one inch depth giving a spacing of 6" x 6", which is the optimum spacing recommended in Madras for the bunch type raised under rainfed conditions. Sowing was done on the 20th June, 1963, which is the optimum season for sowing short duration groundnut types in this tract. Proper protection was given to the seeds from birds and rodents. Gap filling was done one week after sowing.

6. After cultivation

One hand hoeing and earthing was given three weeks after sowing just at the commencement of flowering. Hand pulling of tall growing weeds was done twice during the later stages.

Adequate plant protection measures were taken as a preventive measure against pests and diseases. One preventive spraying with Fytolon (1 lb. in 40 gallons) was given against any possible attack of 'Tikka' leaf-spot disease, when the crop was one month old. There was no incidence of any pests though there was slight incidence of 'Tikka' leaf-spot disease at the stage of maturity of the crop. Another spraying with Fytolon was given at this stage.

7. Harvest

The crop was harvested on 26-9-1963. Before harvesting the net plot, two rows all round each plot left as guard rows were first removed. Harvesting was done by lifting the plants and separating the nuts by hand.

8. Characters studied

The following characters were studied. All measurements were recorded in the metric units.

(i) Height of the plant at maturity

Twenty plants were selected at random from each plot before harvest, the height measured individually and the average worked out. The height was taken from the cotyledonary node to the terminal node, and expressed in centimetres.

(ii) Weight of pods per plant

Pods from each of the twenty plants selected above were separately collected and the wet and dry weights recorded. The average dry weight per plant was calculated.

(iii) Number of pods per plant

The pods collected from the twenty plants separately were counted under the following two categories and the average per plant worked out.

(a) Fully matured, immature and tender pods
(b) One seeded and two-seeded pods.

(iv) Root nodule counts

The number of root nodules from ten plants selected at random from each plot, were counted for individual plants and the average calculated.

(v) Yield of pods

The wet and dry weight of pods obtained from the net plot of size 26'x 14' were recorded for all the thirty six plots in the experiment.

(vi) Yield of shoots

The wet and dry weight of shoots obtained from each net plot was recorded.

(vii) Natural-test-weight

This is the weight per unit volume of pods (nuts in shell) and is utilised in assessing the maturity and development of kernels when the pods are disposed by volume. For this purpose the weight of one local measure (pakka-heaped) of pods was recorded for the thirty six plots separately.

(viii) Weight of 100 pods

The weight of 100 pods from each plot was recorded, by taking random samples.

(ix) Weight of 100 kernels

The weight of 100 kernels was determined as above.

(x) Shelling percentage

The shelling percentage is expressed as the weight of kernels when the weight of the whole pods is taken as 100; this is the percentage of kernels to pods by weight.

For calculating shelling percentage, 100 grams of pods from each plot was taken by random selection, shelled and the weight of kernels recorded and expressed in percentage. The determinations were done on dry basis.

(xi) Oil content

Oil estimation was carried out as per procedure given by Kartha and Sethi (1957) by extracting the oil chemically, adopting the cold percolation method and estimating gravimetrically. The extraction was done in duplicate for each of the thirty six samples of kernels drawn at random. The kernel samples were oven dried, before the extraction. Three hundred milligrams of the kernel sample was accurately weighed, ground well with powdered pyrex glass and anhydrous sodium sulphate in a clean dry mortar, and packed in a glass percolator. The percolation was done using petroleum ether of B.P. 70-90^{o}C and the extracted oil weighed and expressed as percentage.

CHAPTER IV

EXPERIMENTAL RESULTS

The observations, namely, height of plant at maturity, weight of pods per plant, number of pods per plant, percentage of two-seeded pods per plant, number of root nodules per plant, yield of pods, yield of shoots, natural-test-weight, weight of 100 pods, weight of 100 kernels, shelling percentage and oil yield, taken at the pre-harvest and post-harvest stages of the TMV 2 groundnut crop were analysed statistically. The analysis of variance tables are furnished in Appendix I to XII. The mean yields are given below.

The levels of lime were 0, 750 and 1500 pounds per acre and the levels of potash were 25, 50 and 75 pounds of K_2O per acre. The following notations are adopted to represent the treatments.

L_0 = No lime

L_1 = 750 lb. lime per acre

L_2 = 1500 lb. lime per acre

K_1 = 25 lb. K_2O per acre

K_2 = 50 lb. K_2O per acre

K_3 = 75 lb. K_2O per acre

A. Pre-harvest observations.

1. Height of plant at maturity:

The mean height of plants (in cms.) at maturity show slight increase with the increase in the level of potash. Corresponding to the different levels of lime also there is slight variation in mean height, the level L_2 giving the maximum mean height of 75.66 cms. But none of these is found to be statistically significant. The interaction also is not significant as evidenced by the analysis of variance table in Appendix I. The mean height in centimetres corresponding to the treatments are given in Table I.

2. Weight of pods per plant:

The effect of lime on increasing the weight of pods is pronounced, the mean weight of pods being 19.86, 21.86 and 22.58 grams per plant, showing an increase of 10 percent for L_1 and about 14 percent for L_2 over L_0.

TABLE I

Height of plant at maturity

Doses of lime	Doses of potash			Average
	K_1	K_2	K_3	
L_0	72.69	73.62	73.99	73.43
L_1	68.10	74.69	74.32	72.37
L_2	80.81	71.97	74.20	75.66
Average	73.86	73.42	74.17	73.82 General mean

C.D. (5 percent) for fertilizer means - 9.16

The level L_1 is giving significantly higher yield than L_0, but the increase due to L_2 over L_1 is not found to be significant, but L_2 and L_1 are definitely superior to L_0.

The mean weight of pods per plant shows an increasing trend with the levels of potash but the differences are not statistically significant.

Eventhough the interaction between lime and potash is not significant, there is a definite indication that combined applications of lime and potash give higher values for weight of pods per plant.

The analysis of variance table for weight of pods per plant is given in Appendix II, indicating that the effect of lime is significant and the effects of potash and interactions are not significant.

The Table II gives the mean weight of pods corresponding to the treatments.

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

The mean percentage of mature pods per plant shows progressive increase with increase in levels of lime, the percentage being 80.69, 81.52 and 86.56 per plant, thus

TABLE II

<u>Weight of pods per plant</u>

Doses of lime	Doses of potash K_1	K_2	K_3	Average
L_0	19.13	20.80	19.67	19.86
L_1	21.55	22.34	21.68	21.86
L_2	22.27	21.34	24.13	22.58
Average	20.98	21.49	21.83	21.43 General mean

C.D. (5 percent) for fertilizer means - 1.76

C.D. (5 percent) for combined treatment means - 3.05

<u>Conclusion</u>: $\overline{L_2 \ L_1} \ L_0$

showing an increase of 1 percent for L_1 and 7.2 percent for L_2 over L_0. The level L_2 is statistically significant to L_1 and L_0 but the increase due to L_1 over L_0 is not significant. Corresponding to the levels of potash, the increase in the number of pods per plant is negligible. The interaction effect is also not significant.

The analysis of variance table for percentage of mature pods per plant is given in Appendix III, indicating the significant effect of lime.

The mean percentage of mature pods per plant as influenced by the different treatments is given in Table III.

4. <u>Percentage of two-seeded pods per plant</u>:

The effect of lime in increasing the percentage of two-seeded pods per plant is seen pronounced, the mean percentage being 81.15, 83.94 and 85.83, showing an increase of 3.4 percent for L_1 and 5.7 percent for L_2 over L_0. The increase due to L_2 over L_0 is statistically significant while the levels L_2 and L_1, L_1 and L_0 are on a par with each other. There is no progressive increase in the percentage of two-seeded pods per plant showing an increase of 1 percent for L_1 and 7.2 percent for L_2 over L_0. The level L_2 is statistically significant to L_1 and L_0 but the increase due to L_1 over L_0 is not significant. Corresponding to the levels of potash, the increase in the number of pods per plant is negligible. The interaction effect is also not significant.

The analysis of variance table for percentage of mature pods per plant is given in Appendix III, indicating the significant effect of lime.

The mean percentage of mature pods per plant as influenced by the different treatments is given in Table III.

4. Percentage of two-seeded pods per plant:

The effect of lime in increasing the percentage of two-seeded pods per plant is seen pronounced, the mean percentage being 81.15, 83.94 and 85.83, showing an increase of 3.4 percent for L_1 and 5.7 percent for L_2 over L_0. The increase due to L_2 over L_0 is statistically significant while the levels L_2 and L_1, L_1 and L_0 are on a par with each other. There is no progressive increase in the percentage of two-seeded pods per plant

TABLE III

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

Doses of lime	Doses of potash			Average
	K_1	K_2	K_3	
L_0	82.37	82.03	77.67	80.69
L_1	80.42	81.90	82.25	81.52
L_2	86.31	87.26	86.12	86.56
Average	83.03	83.73	82.01	82.92 General mean

C.D. (5 percent) for fertilizer means - 4.38

C.D. (5 percent) for combined treatment means - 7.61

<u>Conclusion</u>: L_2 $\overline{L_1 \quad L_0}$

corresponding to levels of potash. Eventhough there is no evidence of interaction, there is every indication that combined application of lime and potash results in the increased number of two-seeded pods per plant.

The analysis of variance table for percentage of two-seeded pods per plant, indicating the significant effect of lime, is given in Appendix IV.

The mean percentage of two-seeded pods per plant as affected by the various treatments is given in Table IV.

5. Number of root nodules per plant:

Application of lime has contributed to a significant increase in the number of root nodules per plant, the mean number being 88.6, 95.6 and 98.8, thus recording an increase of 8 percent for L_1 and 11.5 percent for L_2 over L_0. The increase due to L_1 and L_2 over L_0 is statistically significant.

Corresponding to levels of potash their is increasing trend in the mean number of nodules per plant though the difference is not significant. Combinations of lime and potash have shown greater number of root nodules per plant.

TABLE IV

Percentage of two-seeded pods per plant

Doses of lime	Doses of potash			Average
	K_1	K_2	K_3	
L_0	81.21	81.03	81.20	81.15
L_1	83.87	82.53	85.42	83.94
L_2	86.31	85.74	85.43	85.83
Average	83.78	83.10	83.95	83.64 General mean

C.D. (5 percent) for fertilizer means - 2.88

C.D. (5 percent) for combined treatment means - 5.03

Conclusion: $\underline{L_2\ \overline{L_1}}\ \overline{L_0}$

Appendix V gives the analysis of variance table for the number of root nodules per plant.

Table V shows the mean number of root nodules per plant as influenced by the different treatments.

B. Post-harvest observations.

6. Yield of pods:

Lime has favourably enhanced the yield of dry pods (in kilograms) per plot, the mean weight of pods per plot being 10.506, 11.138 and 11.761, showing an increase of 6 percent for L_1 and 12 percent for L_2 over L_0. The increase due to L_2 over L_0 is statistically significant. The levels L_2 and L_1, L_1 and L_0 are on a par with each other.

There is also increase in the mean yield of pods per plot corresponding to the levels of potash, K_2 recording the maximum increase of about 8 percent over K_1. However the different levels are not significant. There is also definite indication that combined application of lime and potash contribute to general increase in the yield of pods. The treatment combination of 1500 lb. plus

TABLE V

Number of root nodules per plant

Doses of lime	Doses of potash K_1	K_2	K_3	Average
L_0	87.4	90.6	87.9	88.6
L_1	94.1	96.8	96.0	95.6
L_2	93.4	98.8	104.1	98.8
Average	91.6	95.4	96.0	94.3 General mean

C.D. (1 percent) for fertilizer means - 6.23

C.D. (1 percent) for combined treatment means - 10.83

Conclusion: $\underline{L_2 \; L_1} \; L_0$

50 lb. K_2O per acre has recorded the maximum increase in yield of 20 percent over the control (25 lb. K_2O alone).

The analysis of variance table for the yield of pods per plot is given in Appendix VI, indicating that the effect of lime is significant.

The mean yield of pods per plot as affected by the various treatments is given in Table VI.

7. Yield of shoot:

The effect of lime in increasing the yield of dry shoot (hay) per plot is seen highly significant, the mean yield being 32.62, 34.33 and 42.70 kilograms, showing an increase of 5.2 percent for L_1 and 31 percent for L_2 over L_0. The increase due to L_2 over L_1 and L_0 is statistically significant. The levels L_1 and L_0 are on a par with each other.

Increasing levels of potash have also contributed to slight variation in the yield of shoot, K_2 giving the maximum mean yield of 38.52 kilogram. There is no significant interaction effect though the combined application of lime and potash have given greater shoot yield. The treatment combination of 1500 lb. lime plus 25 lb. K_2O

TABLE VI

Yield of pods

Doses of lime	Doses of potash K_1	K_2	K_3	Average
L_0	10.285	11.197	10.037	10.506
L_1	10.747	11.770	10.897	11.138
L_2	11.322	12.247	11.815	11.761
Average	10.784	11.738	10.916	11.135 General mean

C.D. (5 percent) for fertilizer means - 1.07

C.D. (5 percent) for combined treatment means - 1.85

Conclusion: $\underline{L_2 \quad \overline{L_1}}\,\overline{\quad L_0}$

per acre has recorded the maximum increase of about 55 percent shoot yield over the control (25 lb. K_2O alone).

Appendix VII gives the analysis of variance table for the yield of shoot, indicating the significant effect of lime.

The mean yield of shoot corresponding to the treatments is given in Table VII.

8. <u>Shelling percentage</u>:

There is significant increase in the shelling percentage corresponding to the levels of potash, the mean percentage being 78.43, 81.39 and 82.60, thus recording an increase of 4.4 percent for K_2 and 5.3 percent for K_3 over K_1. K_3 is found statistically significant over K_1 and is on a par with K_2. Though there is progressive increase in shelling percentage corresponding to the levels of lime, the difference is not significant. There is no evidence of interaction either as indicated by Appendix VIII.

Table VIII, given shows the mean shelling percentage as affected by the various treatments.

TABLE VII

Yield of shoot

Doses of lime	Doses of potash			Average
	K_1	K_2	K_3	
L_0	29.06	35.81	33.00	32.62
L_1	35.50	37.50	30.00	34.33
L_2	45.00	42.25	40.87	42.70
Average	36.52	38.52	34.62	36.55 General mean

C.D. (1 percent) for fertilizer means - 7.10

C.D. (1 percent) for combined treatment means - 12.30

Conclusion: $L_2 \quad \overline{L_1 \quad L_0}$

TABLE VIII

Shelling percentage

Doses of lime	Doses of potash			Average
	K_1	K_2	K_3	
L_0	75.81	82.10	82.09	80.00
L_1	78.06	81.38	80.67	80.04
L_2	81.43	80.69	85.05	82.39
Average	78.43	81.39	82.60	80.81 General mean

C.D. (5 percent) for fertilizer means - 3.06

C.D. (5 percent) for combined treatment means - 5.30

Conclusion: $\underline{K_3 \quad \overline{K_2} \quad \overline{K_1}}$

9. Oil yield:

The effect of potash in increasing oil yield is found statistically significant at the level K_2, while at the level K_3 there is considerable decrease in the oil yield. Corresponding to levels of lime there is depression in oil yield. The decrease in the mean oil yield due to L_1 was about 5 percent and due to L_2 about 7 percent over L_0. There is no evidence of interaction.

Appendix IX gives the analysis of variance table, indicating the significant effect of potash in increasing the oil yield and the significant effect of lime in depressing the oil yield.

The mean percentage of oil yield as influenced by the various treatments is given in Table IX.

10. Natural-test-weight (Weight of one local measure of pods)

The application of lime is found to have a pronounced effect in increasing the weight (in grams) of one local measure of dry pods, the mean weight being 475.66, 482.33 and 484, thus showing an increase of 1.4 percent due to L_1 and 1.8 percent due to L_2 over L_0.

TABLE IX

Oil yield

Doses of lime	Doses of potash K_1	K_2	K_3	Average
L_0	46.08	47.75	44.41	46.08
L_1	45.00	44.33	42.25	43.86
L_2	43.66	43.11	42.08	42.95
Average	44.91	45.06	42.91	44.29 General mean

C.D. (5 percent) for fertilizer means - 1.63

C.D. (5 percent) for combined treatment means - 2.82

Conclusion: L_0 $\underline{L_1 \quad L_2}$

$\underline{K_2 \quad K_1}$ K_3

Corresponding to levels of potash also there is progressive increase in the mean weight, the increase being 1.8 percent due to K_2 and 2 percent due to K_3 over K_1. Neither the levels of lime nor potash are statistically significant. Eventhough there is no interaction effect, there is indication that lime and potash combinations favourably increase the weight of one measure of pods.

The analysis of variance table for the weight of one local measure of pods is given in Appendix X and the mean weight of pods as affected by the different treatments are given in Table X.

11. Weight of 100 pods:

Lime is found to favourably affect the weight of 100 pods showing an increase of 1.5 percent for L_1 and 2 percent for L_2 over L_0. There is significant increase in the weight of 100 pods due to the levels of potash the level K_3 being statistically significant over K_1. But none of the levels of lime are found statistically significant.

Appendix XI shows the analysis of variance table for the weight of 100 pods and Table XI given indicates the mean weight of 100 pods (in grams).

TABLE X

Natural-test-weight

Doses of lime	Doses of potash			Average
	K_1	K_2	K_3	
L_0	476.00	472.00	479.00	475.66
L_1	471.00	493.00	483.00	482.33
L_2	476.00	484.00	492.00	484.00
Average	474.33	483.00	484.66	480.66 General mean

C.D. (5 percent) for fertilizer means - 11.60

TABLE XI

Weight of 100 pods

Doses of lime	Doses of potash			Average
	K_1	K_2	K_3	
L_0	87.00	98.00	96.00	93.00
L_1	95.00	94.00	96.00	95.00
L_2	95.00	92.00	100.00	95.60
Average	92.30	94.60	97.30	94.70 General mean

C.D. (5 percent) for fertilizer means - 4.68

C.D. (5 percent) for combined treatment means - 8.13

<u>Conclusion:</u> $\underline{K_3 \quad K_2} \quad K_1$

12. <u>Weight of 100 kernels:</u>

The effect of potash is found favourable in increasing the weight of 100 kernels, the mean weight being 41.3, 43.6 and 45 grams for the levels K_1, K_2 and K_3 respectively. Lime is found to have a depressing effect on the weight of 100 kernels. None of the levels of lime or potash are found statistically significant.

The analysis of variance table for the weight of 100 kernels is furnished in Appendix XII and the mean weight of 100 kernels corresponding to the different treatments is given in Table XII.

<u>Economics:</u>

The economics of application of the different treatments is furnished in Table XIII.

TABLE XII

Weight of 100 kernels

Doses of lime	Doses of potash K_1	K_2	K_3	Average
L_0	40.0	47.0	46.0	44.3
L_1	41.0	43.0	43.0	42.3
L_2	43.0	41.0	46.0	43.3
Average	41.3	43.6	45.0	43.3 General mean

C.D. (5 percent) for fertilizer means - 4.49

CHAPTER V

DISCUSSION

The present investigation was an attempt to study the effect of graded doses of lime and potash over a basal dose of 10 lb. N and 20 lb. P_2O_5, on the yield and quality of the popular short duration strain of TMV 2 groundnut. The soil in which the experiment was laid out was a red loam, deficient in lime and potash.

The plant characters which contribute directly or indirectly to yield and quality of produce were studied to ascertain the magnitude of response of each character under observation. The data were analysed statistically and the analysis of variance tables are furnished in Appendices I to XII. From the results obtained, it can be seen that most of the characters studied responded significantly to the various treatments and even those that were found not significant showed a trend in favour of certain treatments in yield and quality attributes like natural-test-weight, weight of kernels, etc. These are discussed hereunder.

1. <u>Height of plant at maturity:</u>

From the results presented in Table I, it can be seen that there was slight increase in the mean height of plant corresponding to the highest levels of lime and potash.

Earlier work by many workers in the United States has shown that the vegetative growth of peanut plant was stimulated by the added potash. Vegetative growth is a character largely influenced by nitrogen, by increased meristomatic activity and other nutrients had a comparatively minor role to play, but, for the full manifestation of the functions of nitrogen, the presence of adequate dose of potash is necessary.

In the present investigation it was noticed that plants in limed plots had greater number of root nodules. Hence the increase in growth in limed plots may be also due to the added nitrogen by the root nodule bacteria.

2. <u>Weight of pods per plant:</u>

The data presented in Table II show that the weight of pods had progressively increased due to applications of lime and potash at higher doses. The increase due to application of lime was found to be 10 percent for L_1 and about 14 percent for L_2 over the control (L_0). The effect of potash was found not statistically significant.

Strauss and Grizzard (1946) have reported that the percentage calcium saturation of the exchange complex was correlated with the average weight of nuts produced by a plant. One of the major roles of calcium in groundnut nutrition is to reduce the abortion of ovaries and thus contribute to increased fruit filling. Well filled fruits naturally have a greater weight. Thus the increase in weight of pods due to addition of lime may be explained due to the presence of larger number of well filled pods per plant.

3. Number of pods per plant:

The yield of groundnut is directly correlated with the number of pods produced in a plant. Brady (1948) noted increase in the number of gynophores due to application of dolomite lime-stone. Experiments in North Carolina have shown that on a soil low in both potassium and calcium the yield was significantly increased from the addition of potash when adequate supply of calcium was supplied.

In the present investigation, the results showed (Table III) that addition of higher doses of lime had significantly increased the number of matured pods per plant. The highest level of lime at 1500 lb. per acre had recorded about 7 percent increase over no lime. The effect of potash was found negligible, when applied alone, but in combination with lime the effects were found remarkable. The level of potash at 50 lb. K_2O in combination with 1500 lb. lime per acre had recorded the highest percentage of 87.26 of matured pods per plant.

The trend of results in the present study is in agreement with the findings of Brady (1948) and other workers in North Carolina. The increase in the number of pods per plant due to lime application may be explained due to the formation of greater number of gynophores.

4. Percentage of two-seeded pods per plant.

The peculiar fruiting habit of groundnut, in developing its pods underground, has the peculiar effect of both pod-filling and shelling percentage being adversely affected by a lack of calcium in the fruiting medium. Calcium is required in the early stages for the elongation of the young gynophore and at later stages for conditions of protoplasm, wall formation, etc.

required in fruit growth and development. Under such deficiency condition of calcium in fruiting medium Nagarajan (1959) observed that the basal segment alone is developed in the pod, while the distal portion remains as an elongated stump, with the ovule aborted inside. Smith (1954) has also reported the abortion of ovules due to calcium deficiency. As a corollary, the number of two-seeded pods developed is closely correlated with the availability of calcium in the fruiting medium and this is borne out by workers like Colwell, Brady and Piland (1945), who found that liming the soil increased the proportion of two-seeded pods in the groundnut crop.

The data in Table IV clearly indicate that the percentage of two-seeded pods had considerably increased by the application of lime. There was progressive increase in the percentage with the increase in the dose of lime, the increase being 3.4 percent for L_1 and 5.7 percent for L_2 over control (L_0). The level L_2 was found statistically significant. The result in the present study is thus in agreement with the finding of Colwell and others.

5. Number of root nodules per plant

The essentiality of calcium for groundnut is nowhere more in evidence than in nodulation, which was severely affected by lack of calcium in the growing medium, even when the seeds had been inoculated with the appropriate nodule bacteria prior to sowing. This is also true in other legumes. Mann (1935) has reported that addition of lime to virgin soils (pH 4.5 - 5.3) resulted in large increase in nodulation of peanuts. The beneficial effects of calcium for legume nodulation has been noted by workers like Davis et al (1929), Albretch (1936), Mc.Calla (1937), Spencer (1950) and Nagarajan (1959).

The results presented in Table V show that addition of lime had significantly increased the root nodule population per plant. The levels of lime were statistically significant over no lime. The result in the present investigation thus confirms the findings of previous workers.

6. Yield of pods

The importance of lime in ensuring good yields in groundnut has been reported by several workers.

Middleton (1945) found response to calcium applications in soils with low exchangeable calcium. Rogers (1945) obtained five fold increase in the yield of spanish peanuts by increasing the calcium level in the soil from 400 pounds $CaCO_3$ equivalent per acre to 800 pounds by the application of lime. Glendonhill (1947) has reported 35 percent increase in yield in East Africa by the application of 3 tons lime per acre. Puh (1953) recorded an increased yield in peanut by 43 percent by the application of lime at 1500 to 3000 kilograms per hectare.

Under Indian conditions, Seshadri and Sayeed (1956) noted that in the laterite soils at Nileshwar, in Kerala, liming the soil with slaked lime at 4 cwt. per acre has given substantial increase in yield. Venkata rao and Govindarajan (1960) have reported 10 percent increase in the yield of pods by liming the soil with half a ton of lime per acre in the red loam soils of Hebbal, in Mysore State. Kothandaraman (1960) has reported a 43 percent increase in the yield of pods by the application of lime at 7000 lb. per acre to acid soil with pH 4.5. Chakrabarthy et al (1961) found in Bihar that liming the soil with pH 5.3 at 3600 lb. lime alone per acre increased groundnut yield by 123 percent as against 18 percent by NPK fertilizers alone. The combined applications of lime and NPK fertilizers has recorded 154 percent increased yield over control.

Investigations in the United States on potassium nutrition in groundnut have shown that despite the relatively large amount of K absorbed by peanuts, the yield responses to applications of potash fertilizers were often small or negligible even in soils of low potassium content. Colwell and Brady (1942) noted in North Carolina that the yields were actually reduced by the application of potash. Brady et al (1946) found in North Carolina, that, on a soil low in both potassium and calcium there was significant increase in yield from the addition of potash when adequate calcium was supplied. Without the addition of calcium, potash was found to decrease the yield of peanuts. John et al (1948) from experiments conducted in Madras have found that higher doses of potash at 50 and 75 lb. K_2O per acre over a basal dressing of cattlemanure gave the best results. Panikkar (1961) has reported that an average response of 4.8 lb. nuts per pound of K_2O was obtained at Akola for the application of 25 to 35 lb. K_2O per acre. The response at Tindivanum for the application of 25 lb. K_2O per acre was found to be 4.5 lb. nuts per pound of K_2O.

The results of the present investigation presented in Table VI indicated that the application of lime had a pronounced effect in increasing the yield of pods. There was progressive increase in the yield of pods corresponding to the raise in the level of lime, the increase being 6 percent for L_1 and 12 percent for L_2 over L_0. Among the different levels of potash, the level at 50 lb. K_2O per acre had recorded the maximum yield, the increase being about 9 percent over K_1 (25 lb. K_2O). However this increase was found not statistically significant. The highest level of 75 lb. K_2O had recorded an increase of 1.2 percent only over K_1. The combination of lime and potash had shown definite superiority over potash alone and the increase in yield of pods due to these combinations ranged from 4 to 20 percent over control (L_0K_1). The treatment combination of 1500 lb. lime plus 50 lb. K_2O per acre had recorded the maximum yield of 1465 kilograms of pods per acre as against 1230 kilograms by control (25 lb. K_2O alone). This increase in yield was about 20 percent over the control and was found statistically significant.

The foregoing findings of several investigators indicate that there is favourable response in the yield of groundnut to lime application, while the response to potash was inconsistent. The interesting finding of Brady et al (1946) on the application of potash in combination with lime to get good yield response in soils low in both potassium and lime is noteworthy. The response or lack of response to lime or potash in the different localities has been explained in most cases due to the inadequate or satisfactory level of these nutrients in the soil.

Taking the overall picture, the result of the present study indicate that there exists a quantitative relationship between lime and potash for their optimum utilisation and a judicious combination of the two is absolutely essential to get the maximum yield response in groundnut. The fact that lime-potash combinations have recorded higher yields as compared to potash alone fully supports the finding of Brady et al (1946), that there was significant increase in yield from the addition of potash if only adequate calcium was supplied to the medium. There was lack of response for potash at higher level (75 lb. K_2O). The response to 75 lb. K_2O over the 25 lb. K_2O level (control) was found negligible as compared to the 50 lb. K_2O level over the control. Similar lack of response to higher levels of potash has been observed in crops like paddy, ragi and cotton. According to Dastur (1959) the lack of response to potash at higher levels is due to the nutritional unbalance caused by absence of nitrogen. In the present investigation it was found that there was a definite trend in increase in the yield upto 50 lb. K_2O and there after a decrease. The 50 lb. K_2O was balanced by 10 lb. nitrogen. When potash alone was increased with no corresponding increase in nitrogen, the yield was depressed. Hence the lack of response to higher level of potash may also be due to nutritional unbalance due to the absence of adequate nitrogen.

7. Yield of shoots.

Several workers are of the opinion that the vegetative growth of peanut plant is stimulated by added potash. Burkhart and Collins (1942), Morris (1941), Rogers (1944), Anon (1945), and Brady and Colwell (1945) have observed that potash stimulates vegetative growth in peanut. Cowie (1951) reported that potash manuring increases the growth of groundnut plant. Comber (1959) has reported that 200 lb. per acre of KCl can enhance hay yield by 30 percent. Although the vegetative growth of the plant was not very much affected by calcium in general, Fielding Reed and Cummings (1948) have reported that addition of lime in acid soils improved the growth of groundnut plants. Kothandaraman (1960) noted that the yield of groundnut haulms increased by 11 percent by the application of lime at 7000 lb. per acre in acid soils (pH 4.5).

The results presented in Table VII indicate that lime had significantly increased hay yield, while potash levels showed no significant difference. The increase in yield of hay due to application of lime was 5.2 percent for L_1 and 31 percent for L_2 over L_0.

The beneficial effect of lime on the increased hay yield may be attributed to the indirect effect of lime in stimulating the activities of root nodule and other nitrogen fixing bacteria thus enhancing the amount of fixed nitrogen. The nitrogen is responsible for the increased shoot yields.

8. Shelling percentage.

This is an important character deciding the quality of groundnut. The data presented in Table VIII show that there was progressive increase in shelling percentage with increasing levels of lime though the increase was not statistically significant. On the other hand there was significant increase in shelling percentage corresponding to the levels of potash, the increase being 4.4 percent for K_2 and 5.3 percent for K_3 over K_1. Among lime-potash combinations, treatment No. 9 with 1500 lb. lime and 75 lb. K_2O per acre had recorded the maximum shelling percentage of 85.05 showing an increase of about 12 percent over control (L_0K_1).

It has been established that one of the beneficial effects of adding calcium to groundnut growing soils is due to the influence of this element in enhancing the shelling percentage of the produce. It is also said that the application of potassium in the absence of calcium causes reduction in shelling percentage. The present investigation has indicated that application of higher levels of lime as well as higher levels of potash have contributed to increase in shelling percentage.

9. Oil Yield.

The comparative effects of the various treatments on the oil content of kernels presented in Table IX indicate that potash at the dose of 50 lb. K_2O per acre (K_2) had slightly increased the oil yield while at the higher dose of 75 lb. K_2O (K_3) there was actually a reduction in the oil yield. Corresponding to levels of lime there was a progressive depression in oil yield, the decrease in the mean oil yield being 5 percent for L_1 and 7 percent for L_2 over L_0. The level of K_2 was found statistically significant over K_3 but was on a par with K_1.

A number of investigators have shown that fertilizer potassium increased the oil content of certain crops. Nelson et al (1945) reported that liberal applications of potash fertilizer to a soil low in potassium increased the oil content of two varieties of Soyabeans by an average of 1.5 percent. Drosdoff et al (1947) and Brown and Potter (1949) have reported significant increases in yield and oil content of fruits from tung trees fertilized with potassium. Houg (1953) has stated that oil content of seeds in groundnut generally increases in response to potassium. Roberston et al (1956) found that there was a negative response to potassium when more than 15 pounds per acre were applied as KCl. Sivappah (1960) has reported a slight increase in oil content in Sesamum by potash fertilization. Nagarajan (1959) found that calcium was of no effect on the oil content of groundnut seed.

In the present investigation a slight increase in the oil yield was noted due to potash fertilization upto a dose of 50 lb. K_2O.. It was also noted that the weight of kernels and shelling percentage were increased due to potash application. These characters naturally contribute to the increased oil yield. The present finding is thus in agreement with those of the previous workers, who have stated that potash fertilization generally contributes to an increase in oil yield.

10. Natural-test-weight, weight of 100 pods and kernels.

These characters determine the quality and market value of the groundnut pods and kernels. Though they are purely varietal characters, they are reported to be influenced by environmental conditions and manuring, particularly with lime and potash. A lack of calcium adversely affect the kernel development, resulting in poor quality pods.

The data in Table X show that there was progressive linear increase in the natural-test-weight of pods corresponding to levels of lime and potash though the increase was not statistically significant. The lime-potash combinations in general have contributed to a higher natural-test-weight as compared to potash alone.

As regards weight of pods, the results presented in Table XI indicate that potash had significantly increased the mean weight of 100 pods, the increase being 2.4 percent for K_2 and 5.4 for K_3 over K_1. The application of lime though favourably increased the weight of pods, it was found that the levels of lime were not statistically significant.

The data on the weight of 100 kernels presented in Table XII show that potash applications have progressively increased the weight while the levels of lime have not contributed to any increase in the weight. Some of the treatment combinations were found significant.

Taking the overall picture it was found that the addition of lime and also potash at higher levels have enhanced the quality of the produce by increasing the natural-test-weight and also the weight of pods and kernels.

Many investigators agree on the beneficial effect of calcium in improving the quality of groundnut pods. Murray (1935) has indicated that the quality of peanuts is influenced by calcium to a greater extent than is the quantity of the pod. He observed that in soils well supplied with calcium, the kernels were well developed and the pods showed an increase in weight per unit volume. Adequate potassium and insufficient calcium resulted in larger quantity of light groundnuts.

Workers in U.S.A. have observed that potash may stimulate vegetative growth but cause a reduction in peanut quality. Other studies in Georgia, Florida, Alabama, South Carolina and elsewhere have given inconsistent results with potash fertilizers.

The results of the present investigation have indicated that the application of lime and also potash at higher levels have favourably increased the quality of the produce.

Economics of fertilization.

Table XIII provides the economics of pod and shoot yield compared between treatments, the profit or loss having been calculated on the basis of yield per acre. The value of nitrogen and phosphoric acid has not been taken into consideration, as these are common for all treatments. Treatment No. 1 with 25 lb. K_2O alone per acre has been taken as the base for comparison.

On evaluation of the economics of treatments, it was found that treatment No.4 with 50 lb. K_2O alone was significantly outstanding with a profit of Rs.51.58 followed by treatment No. 5 with 750 lb. lime and 50 lb. K_2O per acre, with a profit of Rs.43.50

Third in order is treatment No. 6 with 1500 lb. lime and 50 lb. K_2O per acre, with a profit of Rs.30.70. The rest of the five treatments have resulted in varying degrees of losses compared to the base, the highest loss of Rs.29.22 having been recorded by treatment No. 7 with 75 lb. K_2O alone per acre, closely followed by treatment No. 8 with 750 lb. lime and 75 lb. K_2O per acre, the loss sustained being Rs.27.55.

The economics of the various treatments are indicated below.

	Treatment		Profit/Lose
	Lime	K_2O	Rs. nP.
1.	0	25	(Control)
2.	750	25	(-) 17.92
3.	1500	25	(-) 9.37
4.	0	50	(+) 51.58
5.	750	50	(+) 43.50
6.	1500	50	(+) 30.70
7.	0	75	(-) 29.22
8.	750	75	(-) 27.55
9.	1500	75	(-) 0.33

Summarising the above discussion, TMV 2 strain of groundnut was found to respond best in the red loam soils of Vellayani in Kerala, to a dose of potash at 50 lb. K_2O per acre applied in the form of muriate of potash. Among lime-potash combinations, the dose of 750 lb. lime and 50 lb. K O per acre appears best from a consideration of the net profit per acre and also favourable effects on some of the quality attributes like natural-test-weight, shelling percentage etc. of the produce.

CHAPTER VI

SUMMARY AND CONCLUSIONS

A trial was laid out in the Agricultural College Farm, Vellayani, to study the effect of graded doses of lime and potash over a basal dose of 10 lb. N and 20 lb. P_2O_5, on the yield and quality attributes of TMV 2 (bunchy type) groundnut. The soil in which the experiment was carried out, was a red loam characterised by very poor potash and lime status. Three levels of potash at 25 lb., 50 lb. and 75 lb. K_2O alone per acre and in combination with three levels of lime at 0 lb., 750 lb. and 1500 lb. per acre, were the treatments adopted for the investigation.

The soil was analysed for available nitrogen, available phosphorus, total and available potassium and calcium. The results of analysis showed that the soil was highly deficient in lime and potassium. The soil exhibited medium acidity (pH 5.7).

Plant characters such as height at maturity, number and weight of pods per plant, number of root nodules per plant, pod yield, shoot yield, natural-test-weight, shelling percentage and oil yield were studied.

The results were statistically analysed and the following conclusions were drawn.

1. Lime and potash at higher levels of 1500 lb. per acre and 75 lb. K_2O per acre respectively were found to slightly increase the mean height of plant as compared to lower levels.

2. There was progressive increase in the weight of pods per plant corresponding to the levels of lime, the increasing being 10 percent for L_1 (750 lb. lime per acre) and 14 percent for L_2 (1500 lb. lime) over L_0 (no lime). The increase in weight due to the levels of potash was found not significant.

3. The percentage of fully matured pods per plant was found to be generally greater at the highest level of lime (1500 lb. lime per acre) in combination with all the three levels of potash.

4. There was progressive increase in the number of two-seeded pods per plant corresponding to the levels of lime.

5. The application of lime resulted in larger increase in nodulation of the groundnut plants.

6. Liming was found to have a pronounced effect on the yield of pods. The pod yield increased corresponding to the levels of lime, the increase being 6 percent for 750 lb. lime and 12 percent for 1500 lb. lime per acre over no lime. Corresponding to levels of potash, there was increase in pod yield upto 50 lb. K_2O while at higher level of 75 lb. K_2O per acre there was no substantial increase. The level at 50 lb. K_2O had recorded an increase in yield of 9 percent over the 25 lb. K_2O level, while the 75 lb. K_2O level had shown an increase of about 1 percent only over 25 lb. K_2O. The combinations of lime and potash have shown definite superiority over potash alone. The treatment combination of 1500 lb. lime plus 50 lb. K_2O per acre had recorded the maximum pod yield of 1465 Kilograms (3223 lb.) per acre as against 1230 Kilograms (2706 lb.) per acre by control (25 lb. K_2O alone). This increase in yield was about 20 percent over the control and was found to be statistically significant.

7. The yield of hay (dried shoot) was considerably increased by the application of lime, the increase being 5.2 percent for 750 lb. lime and 31 percent for 1500 lb. lime per acre over no lime. There was no significant difference among potash levels.

8. Shelling percentage was found to increase progressively corresponding to the levels of lime and potash. The effect of potash in increasing shelling percentage was more pronounced than that of lime. The treatment combination of 1500 lb. lime and 75 lb. K_2O per acre had recorded the maximum shelling percentage of 85 percent thus showing an increase of 12 percent over the control (25 lb. K_2O alone).

9. There was slight increase in oil yield due to potash application upto the level of 50 lb. K_2O. At higher level of 75 lb. K_2O, there was a decrease in the oil yield. The mean percentage of oil yield recorded was 44.91 for 25 lb. K_2O, 45.06 for 50 lb. K_2O and 42.91 for 75 lb. K_2O. Liming was found to have a highly depressing effect on the oil yield.

10. Lime and potash at higher levels were found to favourably increase the quality attributes like natural-test-weight, weight of kernels etc.

11. On evaluation of the economics of the various treatments it was found that the treatment, 50 lb. K_2O alone per acre showed the maximum profit of Rs.51.58 followed by the treatment with 750 lb. lime plus 50 lb.

K_2O, showing a profit of Rs.43.50. The third in order was the treatment with 1500 lb. lime plus 50 lb. K_2O with a profit of Rs.30.70, while the rest of the treatments showed varying degrees of losses.

12. The results of the experiment have indicated that, TMV 2 groundnut was found to respond best in the red loam soils of Vellayani, to a dose of potash at 50 lb. K_2O, supplied as muriate of potash. As regards the combination of lime and potash, the treatment with 750 lb. lime plus 50 lb. K_2O per acre appears to be the best from a consideration of the net profit and also favourable effects on some of the quality attributes like natural-test-weight, shelling percentage etc. of the produce.

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A P P E N D I C E S

APPENDIX I

Height of plant at maturity

Analysis of Variance

Source	D.F.	S.S.	M.S.	F
Replications	3	3828.87	1276.29	
L	2	67.70	33.85	0.28
K	2	3.33	1.66	0.014
L x K	4	278.95	69.73	0.58
Error	24	2840.41	118.35	
Total	35	7019.26		

Not significant

APPENDIX II

Weight of pods per plant

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Replications	3	865.82	288.60	
L	2	47.39	23.69	5.39*
K	2	4.34	2.17	0.49
L x K	4	19.01	4.75	1.08
Error	24	105.39	4.39	
Total	35	1041.95		

* Significant at 5 percent level

APPENDIX III

Percentage of mature pods per plant

Analysis of Variance

Source	D.F.	S.S.	M.S.	F
Replications	3	1396.20	465.40	
L	2	242.10	121.05	4.44*
K	2	17.84	8.92	0.32
L x K	4	47.59	11.89	0.43
Error	24	654.01	27.25	
Total	35	2357.74		

* Significant at 5 percent level

APPENDIX IV

Percentage of two-seeded pods per plant

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Replications	3	278.16	92.72	
L	2	128.22	64.11	5.39*
K	2	6.29	3.14	0.26
L x K	4	12.42	3.10	0.26
Error	24	285.51	11.89	
Total	35	710.60		

* Significant at 5 percent level

APPENDIX V

<u>Number of root nodules per plant</u>

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Replications	3	85499.34	28499.78	
L	2	559.90	279.95	9.31**
K	2	107.12	53.56	1.78
L x K	4	67.12	16.78	0.56
Error	24	721.08	30.04	
Total	35	86954.56		

** Significant at 1 percent level

APPENDIX VI

Yield of pods per plot

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Replications	3	15.42	5.14	
L	2	9.96	4.98	3.43*
K	2	6.40	3.20	2.20
L x K	4	0.73	0.18	0.13
Error	24	34.91	1.45	
Total	35	67.42		

* Significant at 5 percent level

APPENDIX VII

Yield of shoots per plot

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Replications	3	691.90	230.63	
L	2	698.93	349.46	8.99**
K	2	91.08	45.54	1.17
L x K	4	156.84	39.21	1.00
Error	24	933.25	38.88	
Total	35	2572.00		

** Significant at 1 percent level

APPENDIX VIII

Natural test weight - Weight of one local measures of pods

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Replications	3	2098.31	699.43	
L	2	450.39	225.19	1.18
K	2	758.72	379.36	1.99
L x K	4	822.45	205.61	1.08
Error	24	4562.44	190.10	
Total	35	8692.31		

Not significant

APPENDIX IX

Weight of 100 pods

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Replications	3	112.55	37.51	
L	2	24.39	12.19	0.39
K	2	165.72	82.86	2.66
L x K	4	273.78	68.44	2.20
Error	24	745.45	31.06	
Total	35	1321.89		

Not significant

APPENDIX X

Weight of 100 kernels

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Replications	3	17.63	5.87	
L	2	26.05	13.02	0.45
K	2	92.72	46.36	1.63
L x K	4	99.61	24.90	0.83
Error	24	683.61	28.48	
Total	35	919.62		

Not significant

APPENDIX XI

Shelling percentage

Analysis of variance

Source	D.F.	S.S.	M.S.	F
Replications	3	12.90	4.30	
L	2	44.99	22.49	1.70
K	2	110.55	55.28	4.18*
L x K	4	62.76	15.69	1.19
Error	24	317.29	13.22	
Total	35	548.40		

* Significant at 5 percent level

APPENDIX XII

Percentage oil content

Analysis of variance

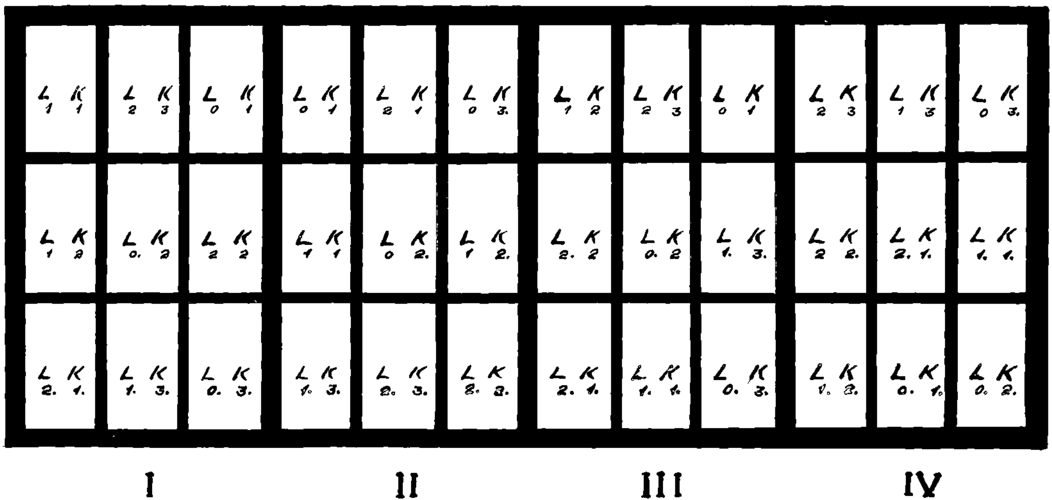
Source	D.F.	S.S.	M.S.	F
Replications	3	112.16	37.38	
L	2	62.14	31.07	8.22*
K	2	34.60	17.30	4.58*
L x K	4	9.30	2.32	0.61
Error	24	90.59	3.78	
Total	35	308.79		

* Significant at 5 percent level

FIGURES AND PLATES

LAYOUT–FACTORIAL EXPERIMENT IN RANDOMISED

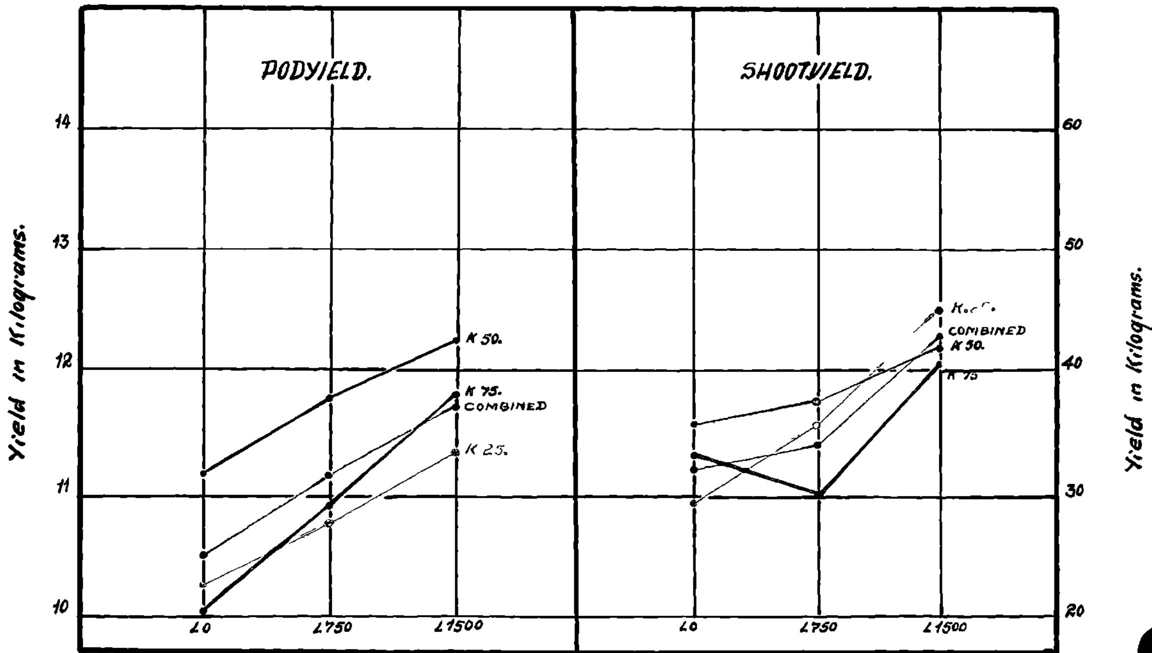
BLOCK DESIGN



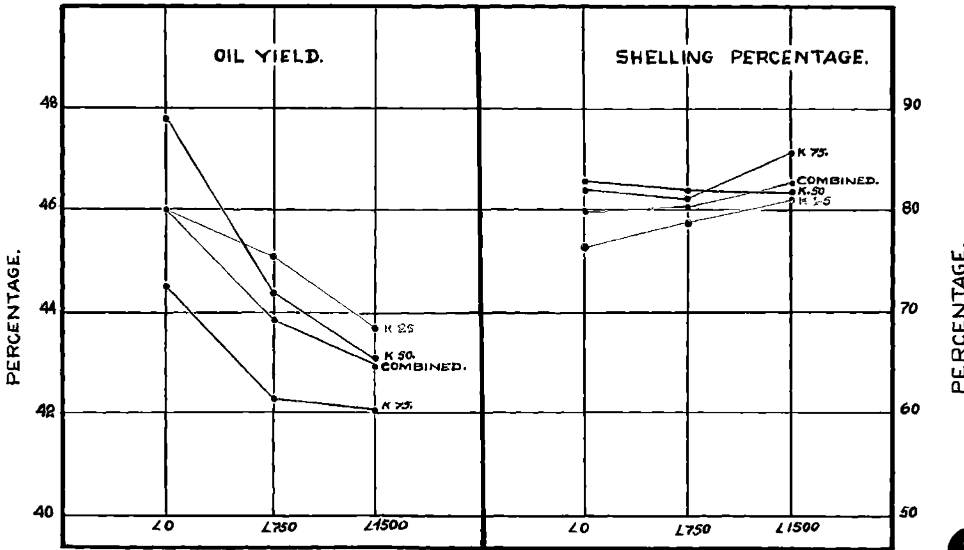
MEAN YIELD OF PODS AND SHOOT PER PLOT

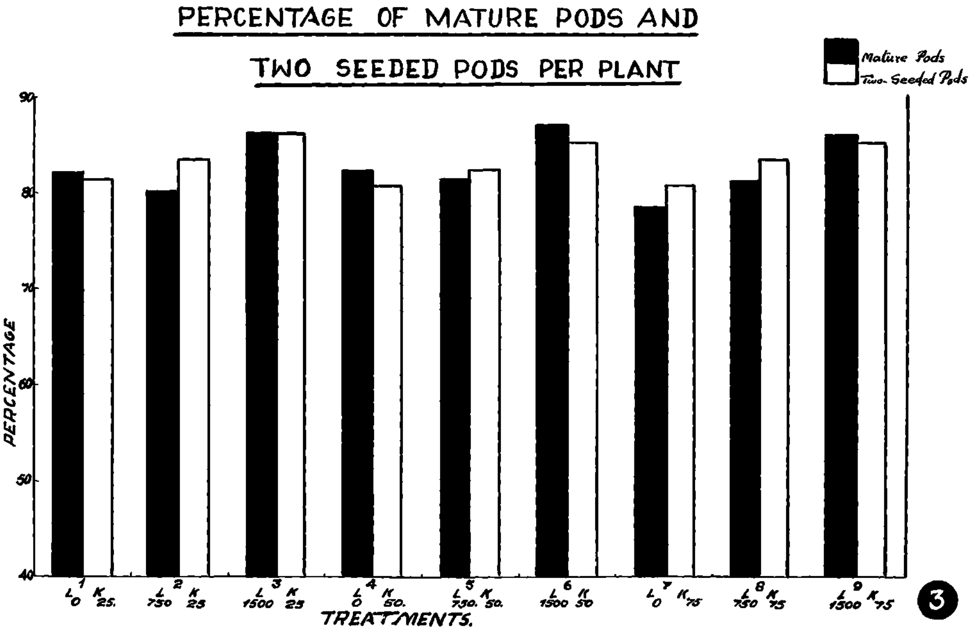
-RESPONSE TO LEVELS OF POTASH

WITH DIFFERENT LEVELS OF LIME.

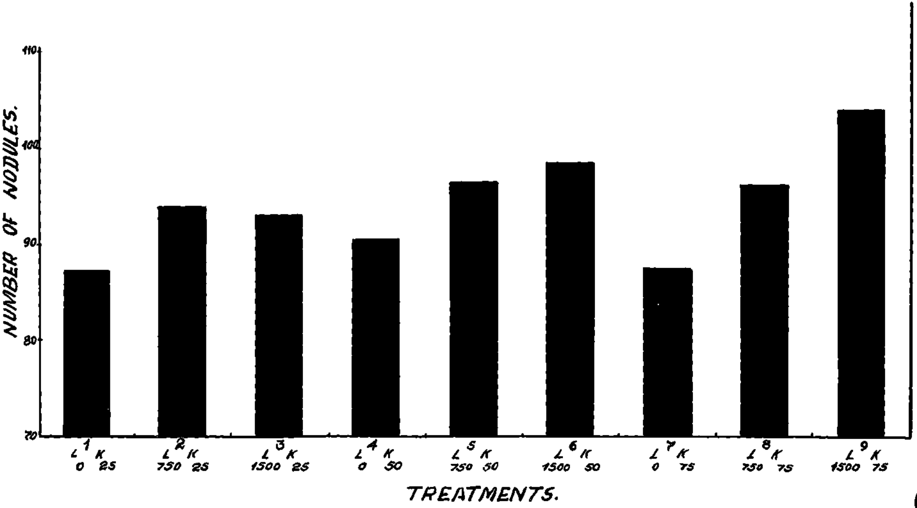


OIL YIELD AND SHELLING PERCENTAGE
-RESPONSE TO LEVELS OF POTASH WITH DIFFERENT LEVELS OF LIME.




PERCENTAGE OF MATURE PODS AND
TWO SEEDED PODS PER PLANT
Mature Pods
Two- Seeded Pods
PERCENTAGE
90
80
70
60
50
40
1 L 0 K 25.
2 L 750 K 25
3 L 1500 K 25
4 L 0 K 50.
5 L 750. K 50.
6 L 1500 K 50
7 L 0 K 75
8 L 750 K 75
9 L 1500 K 75
TREATMENTS.

NUMBER OF ROOT NODULES PER PLANT



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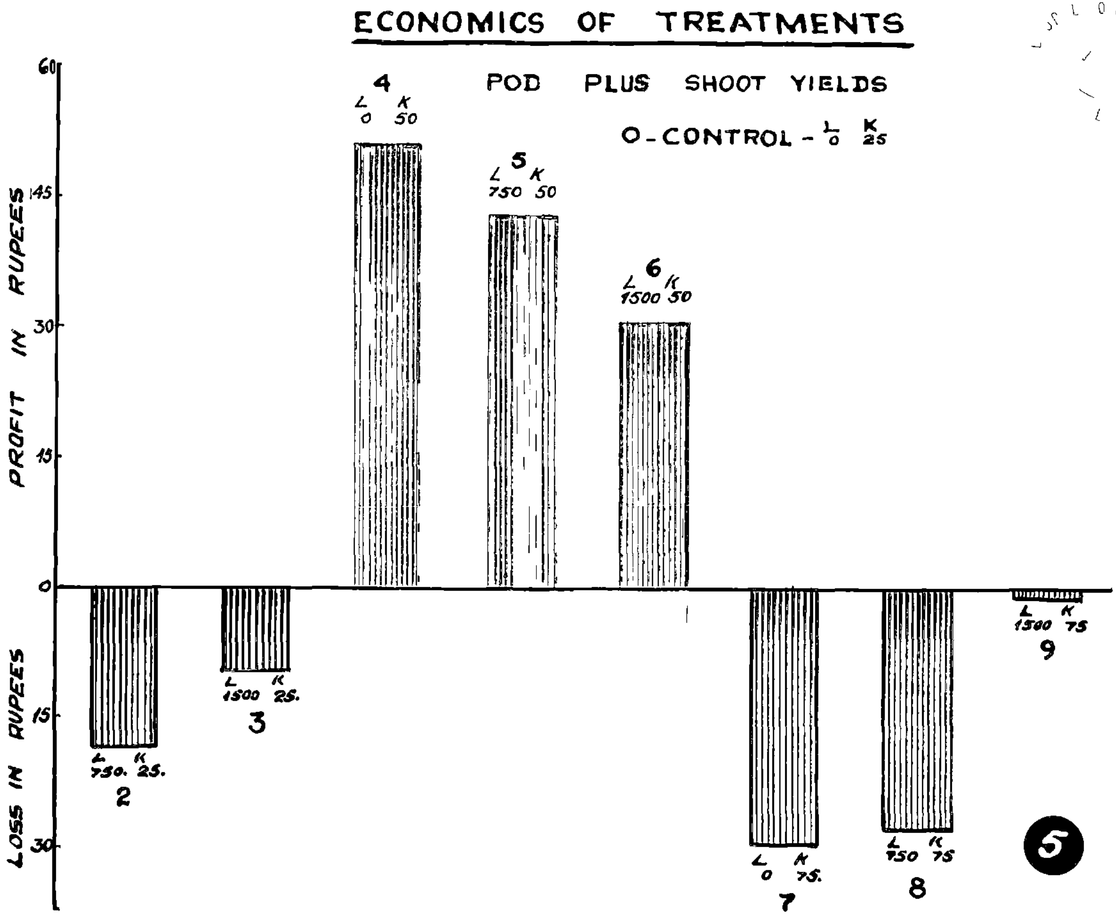

ECONOMICS OF TREATMENTS
POD PLUS SHOOT YIELDS
O-CONTROL - L 0 K 25
PROFIT IN RUPEES
LOSS IN RUPEES
60
45
30
15
0
15
30
4 L 0 K 50
5 L 750 K 50
6 L 1500 K 50
L 750. K 25. 2
L 1500 K 25. 3
L 0 K 75. 7
L 750 K 75 8
L 1500 K 75 9
5

PLATE 1

A GENERAL VIEW OF THE EXPERIMENTAL CROP

Plate 1

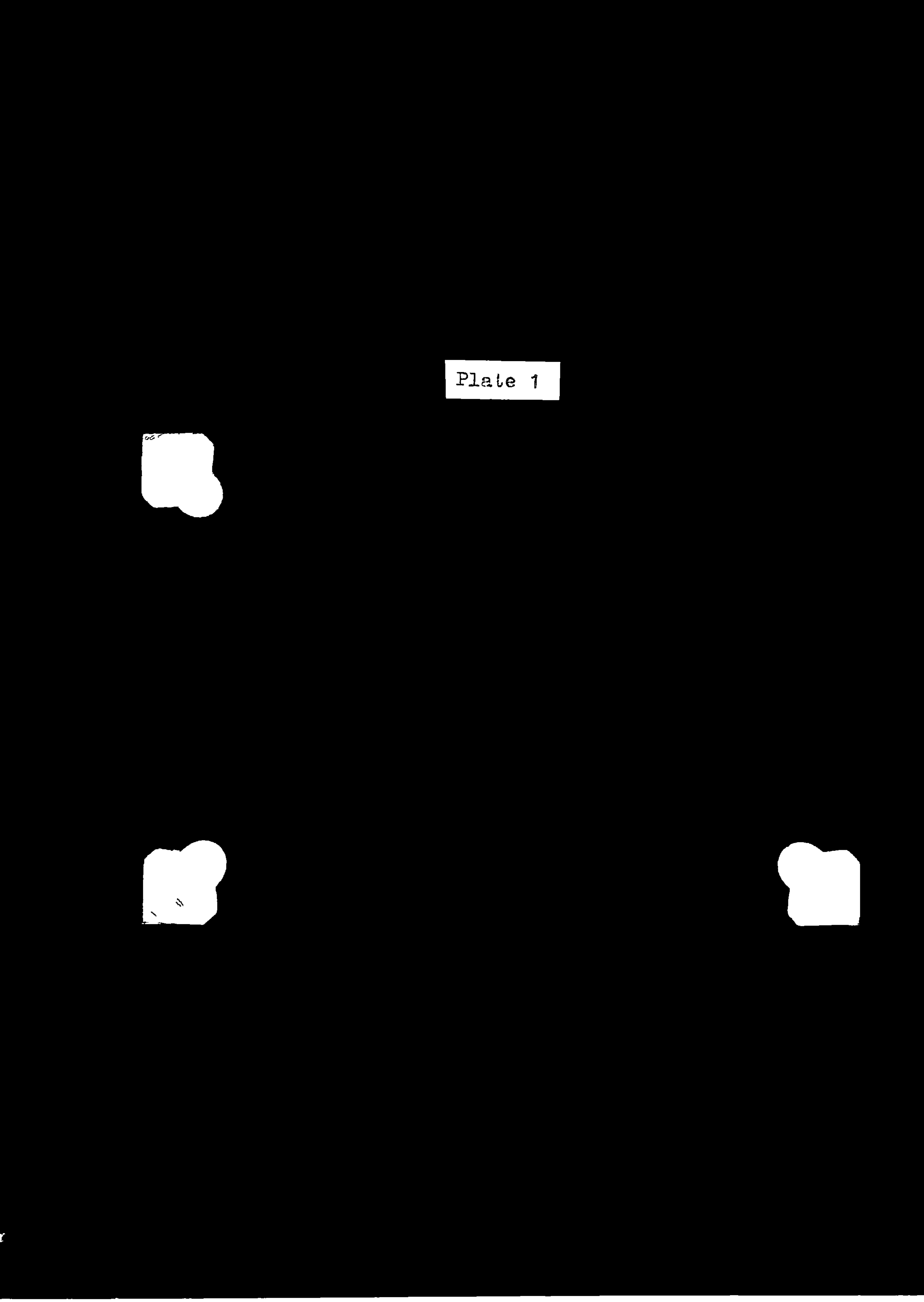

PLATE 2

COMPARISON OF PLANTS AT

1. 0 lb. Lime + 25 lb. K_2O

2. 750 lb. Lime + 25 lb. K_2O

3. 1500 lb. Lime + 25 lb. K_2O

Plate 2

PLATE 3

COMPARISON OF PLANTS AT

4. 0 lb. Lime + 50 lb. K_2O

5. 750 lb. Lime + 50 lb. K_2O

6. 1500 lb. Lime + 50 lb. K_2O

Plate 3

PLATE 4

COMPARISON OF PLANTS AT

7. 0 lb. Lime + 75 lb. K_2O

8. 750 lb. Lime + 75 lb. K_2O

9. 1500 lb. Lime + 75 lb. K_2O

Plate 4

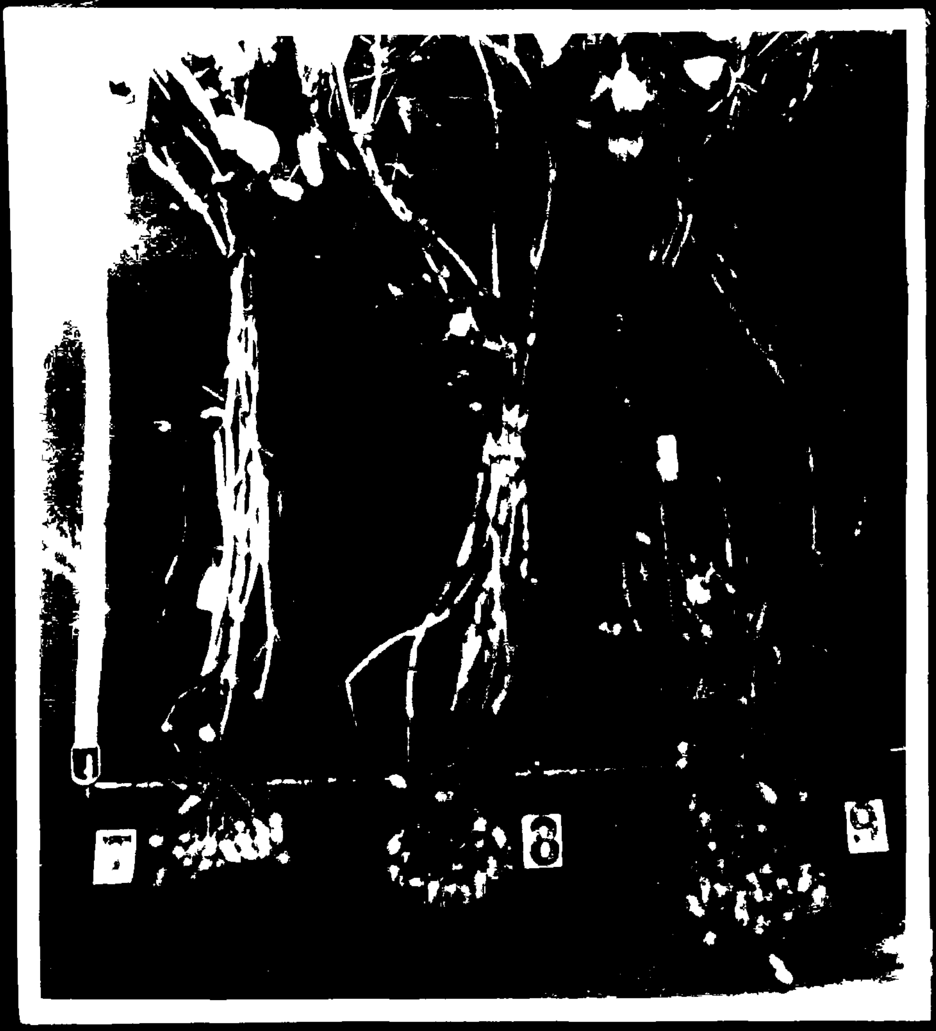

PLATE 5

COMPARISON OF PLANTS AT

1. 25 lb. potash

4. 50 lb. potash

7. 75 lb. potash

Plate 5