THE NATURE OF ACIDITY IN UPLAND AND RICE FALLOWS IN RELATION TO RESPONSE OF PULSE CROP TO LIMING

BY

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THESIS
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DECLARATION

I hereby declare that this thesis entitled "The nature of acidity in upland and rice fallows in relation to response of pulse crop to liming" is a bonafide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me of any degree, diploma, associateship, fellowship or other similar title, of any other University or Society.

(C.R.SUDHARMAI DEVI)

Vellayani,
6th September, 1983.

CERTIFICATE

Certified that this thesis entitled "The nature of acidity in upland and rice fallows in relation to response of pulse crop to liming" is a record of research work done independently by Smt. SUDHARMAI DEVI, C.R. under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to her.

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INTRODUCTION

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Pulses are an indispensable source of protein for the predominantly vegetarian population of our country. No doubt, they form a major component in our daily diet. Further, pulses play an important role in the agricultural economy of India because of their ability to fix atmospheric nitrogen and yield moderately even under varying stresses of soil moisture, soil acidity and toxicity and low nutrient levels.

The area under pulses has been fluctuating between 20-22 million hectares. However, pulse production is stagnant around 11-12 million tonnes, the average productivity being a low 500 kg/ ha---unfortunately due to the neglected production technology on the one hand, the vagaries of the weather at the usual time of its cropping on the other.

A mixed diet of cereals and pulses has a biological value equivalent to skim milk which is recommended as a protein-rich source. The average per capita intake of protein/day in India is around 55 g, while in the developed countries, it is about 100 g. With the increase in population, the per capita availability of pulses has gone down. The time has thus come to give a serious thought to increasing ways and means of the production of pulses. For the next decade, considerable importance has to be given to pulse and oilseed production in this country to meet the increasing demand on protein and edible oil requirements of our people. This has been accorded high priority in agricultural research and development programmes.

Among the cultivated pulses, cowpea occupies a prominent position in Kerala because of its ready adaptability to varied soil and climatic conditions, short duration and high content of protein. Blackgram occupies the second place. Out of 2.2 million hectares of net area sown, about 35 thousand hectares have been cultivated with pulses. The yield of cowpea per unit area is rather low in Kerala when compared to other States. The per hectare yield is only 250 kg. This low yield may partly be attributed to the poor management practices and partly to the low productivity of the varieties used.

Recently a number of new high yielding varieties of different pulses have been released, but many of them require higher amounts of inputs such as lime, fertilisers and pesticides. In many areas of the country it may be economical to cultivate them with high inputs of fertilizers. The situation in Kerala, however, is totally different. The pulse crop is generally grown in uplands, in kitchen gardens along with kharif vegetables. They are also grown in rice fallows during the summer season. In both these situations the cultivators' preference is to grow it as a catch crop without the use of much fertilizers or soil amendments. So it has become necessary to screen and locate varieties that can be cultivated economically with the least amount of fertilizers. Since many of the small farmers in Kerala would like to reduce the quantity of lime used as amendment, it further becomes necessary to choose an acid tolerant variety that would be least demanding in its lime requirement. In other parts of the world this approach has been made in cultivating pulse crop in acid soil situations.

Spain(1976) could obtain cowpea varieties which are tolerant to soil acidity. Several other scientists could locate differential tolerance among the varieties of many cultivated crop plants. Very wide differences have been exhibited between one species and another and among cultivars of the same species in their tolerance to soil acidity. These differences are mainly due to the differences in the nature and extent of toxicity exhibited by the soils.

Foy(1976) found that both Al and Mn are important growth limiting factors in many acid soils. He also pointed out that the correction of Al and Mn toxicity by liming is not always economically feasible, especially Al toxicity in strongly acid subsoils. Plants can be effectively screened for specific tolerance to either factor.

If it is possible to select an acid tolerant pulse variety for the uplands and rice fallows, it will be able to minimise the input per unit of output. Hence this study was undertaken with the following objectives:-

1. To detect the toxic factors causing acidity in the uplands and rice fallows of the Southern region of the State.
2. To select pulse varieties that are most tolerant to toxic factors.
3. To study the response pattern of such tolerant and non-tolerant varieties to different rates of liming and in soils with different degree of acidity.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Acid soils, according to definition are soils with pH less than 7.0 and are generally low in bases like Ca, Mg, K, Na, but have a fairly high concentration of H, Al, Fe, Mn etc. Considerable research on various types of acid soils have been reported in literature. Only reports relevant to the present investigation have been briefly reviewed in the following pages.

Nature of acidity of tropical soils:

It is reported by Wright(1937) that internal precipitation of P by Al evidently plays an important role in the poor development of certain plants grown on acid soil. Russell(1950) reported that exchangeable Al contributed markedly to exchange acidity in mineral soils. Wright and Donahue(1953) suggested that low yields of certain crops grown on acid soils were due to the relatively high concentration of aluminium in those soils. Al interferes with the normal phosphorus metabolism of plants. In 1957, Black reported that acidity of soils is associated with the presence of H and Al in exchangeable form. Mn behaves similar to Al in that its concentration in the soil solution increases as the pH decreases. McLean *et al.*(1958) reported that in the absence of phosphate considerable amount of aluminium may be maintained in soil solution between pH 4.0 and 4.5

Beer(1969) reported that the extractable Al increases as the pH decreases. Marinez(1970) and Karthikakutty Amma et al. (1979) also obtained similar results.

Sumner(1970) conducted pot experiments with sudangrass in some acid sandy soils from Natal and found toxic amounts of exchangeable Al in the subsoil as the cause of low crop yields. Erico et al.(1979) and Farina et al.(1980) obtained similar results.

In acid soils with values of pH below 5.0, Al and Mn toxicities are quite common and sufficient to injure some plants (Chapman, 1971; Foy et al.1973; Baker, 1976; Helyar, 1978)

Low yield of leguminous crops on a ferrallitic soil over basalt were traced to Mn toxicity by Ngochanbang et al. (1971).

Tripathi & Pande(1971) reported that there was convincing evidence that at low soil pH, uptake of nutrients particularly P, Ca, Mg and K was reduced because of excess soluble Al. Results obtained by Goswami et al.(1976) support this view.

Studies by Jones(1976) revealed that acidification was accompanied by losses of exchangeable Ca and Mg, but those of Mg were the more serious.

Exchangeable Al in soil forms an important source of soil acidity (Das et al.1976; Satyanarayana et al.1976; Keyser and Munns, 1979b; Saigusa et al. 1980)

According to Mukherjee(1976) in acid soils the H ions associated with clay particles contribute primarily to soil acidity.

But Deshpande(1976) observed acid producing cations like Al, Fe & Mn.

Van(1976) reported that oxisols are most prone to Mn toxicity, Ca deficiency and P immobilization; ultisols to Al toxicity; Alfisols to nutrient deficiency and poor physical properties.

Bloom et al.(1979) found that concentration of Al in soil solution is a function of pH. Godo and Reisenauer(1980) found that the amounts of Mn brought into solution increased with acidity and with reaction time.

Franco and Munns(1982) explained the failure of bean to nodulate in some acid soils as due to Mn toxicity.

Aluminium concentration in soils:

Beer(1969) reported that in soils of GDR, exchangeable Al varied from 1.1 to 169 ppm.

Evans and Kamprath(1970) observed that soil saturation of Al in mineral soils was related to % Al saturation of the effective CEC, while in organic soils it was more related to the amount of exchangeable Al. Increased amount of organic matter resulted in lower soil solution Al at a given pH.

Helias and Coppenet(1970) assessed exchangeable Al in soils of Brittany and reported that in horizons of uncultivated soils with pH values 5.5 contained 1-5 meq. exchangeable Al/100 g soil, exceeding the amount of total exchangeable bases. Only traces of exchangeable Al were found where the pH had been increased by liming to 5.8 -6.0

Soluble and extractable Fe and Al were determined by Marinez(1970) in 15 Argentinian soils. Values for extractable and soluble Al ranged from 0.8-100 ppm and 0-36 ppm respectively.

Karthikakutty Amma _et al_.(1979) found that KCl exchangeable Al in rice soils of Kerala ranged from 85-3700 ppm. Concentration of Al extracted by normal Ammonium acetate ranged from 275-7000 ppm; water soluble from 1 to 16 ppm.

Manganese concentration in soils:

Pisharody(1965) reported a highly significant positive correlation between exchangeable Mn and clay + silt fraction in Kerala soils. The water soluble Mn content of 14 typical profiles of Kerala State ranged from 1.8 to 14.8 ppm and the value for exchangeable, easily reducible and active Mn were 10.2 to 8, 8.9 to 124.2 and 35.5 to 159.6 ppm respectively.

Merodio(1969) studied forms of Mn and their correlation with soil properties. Available Mn was significantly correlated with pH, decreased with increased pH values.

The total, water soluble, exchangeable, easily reducible and active Mn contents of 5 soil samples of Vindhyan region in UP were determined by Singh and Singh(1969). Total Mn contents varied from 150-612 ppm. Available amounts of total and easily reducible Mn were higher at lower pH, where as the average amount of exchangeable Mn bore a negative relationship with $CaCO_3$, organic carbon, silt and clay contents.

The average amount of total water soluble and easily reducible Mn had no apparent relationship with $CaCO_3$, organic carbon, silt and clay content.

Mithyantha and Perur(1970) studied the Fe:Mn relationship in some soil profiles of Bangalore district. With few exceptions, the ratio of Fe to Mn in surface soil samples is 1.5 indicating a probable Fe deficiency and Mn toxicity.

Singh(1970) reported that total Mn ranged from 200-499 ppm, exchangeable from 0.6-4.9 ppm, reducible from 15-81 ppm, active from 18-82.5 ppm and less reducible oxides from 12.5 to 79.5 ppm in soils of Punjab. Total Mn was positively correlated with $CaCO_3$ and the fine fractions and negatively correlated with the sand fraction. Exchangeable and active Mn were positively correlated with organic carbon and clay content and negatively correlated with pH and $CaCo_3$ level.

Badhe et al.(1971) investigated the content of available Cu and available Mn in 70 soils of Maharashtra. Available Mn ranged from 2-43 ppm.

Dalal and Chatterjee(1971) reported that exchangeable + water soluble Mn and extractable Mn were significantly correlated with Mn uptake, whereas total Mn was a poor index of the availability of this nutrient.

Mohapatra and Kibe(1972) studied soil samples from 6 agro-climatic zones. The amounts of available, easily reducible, active and HCl-soluble Mn were 1.5-67, 88-516, 102.5-520 and 250-1652.5 ppm respectively. Rainfall was the most important factor affecting available Mn which also decreased with increased pH and CEC.

Patel et al.(1972) studied Mn distribution and availability in S.Gurjrat soils. Water soluble + exchangeable Mn tended to accumulate in surface layers and increased with increased organic matter content and acidity, while active Mn accumulated in middle layers and with easily reducible Mn, increased with increased clay content.

Kanwar(1976) reported that total Mn in Indian soils vary from 92-11500 ppm, but the majority of Indian soils contain 300-1600 ppm of Mn. For an acid soil, the amount of exchangeable + water soluble Mn was 2.8-15.6% of the total.

Studies conducted by Aiyer et al.(1975) and Rajagopal et al. (1977) showed that the available Mn content of Kerala State ranged from 0.2 to 220 ppm. Exchangeable Mn was not found to be deficient in the districts of Alleppey, Kottayam, Quilon and Cannanore.

Godo and Reisenauer(1980) measured the solubility of soil Mn and of MnO_2 in root exudates and in rhizosphere and bulk soils over the pH range of 4.5-6.5. The amounts of Mn brought into solution increased with acidity and with reaction time.

Screening for tolerance to Aluminium toxicity:

In 1957 Black reported that although plant species and varieties have much in common in terms of their response, important differences may exist in individual instances.

Foy and Brown(1963) reported that the most characteristic symptom of Al toxicity in cotton is P deficiency. An accumulation of Al compounds in or on the root is believed to be detrimental to both chemical and physical absorptive processes by the cotton plant. Again in 1964 they located differential tolerance of plant species to Al in nutrient solution and in acid Bladen soil. Al tolerance of plant species was closely related to their abilities to absorb and utilize P in the presence of excess Al. Similar type of observation is reported by Foy et al.(1974).

Differential tolerance of plant species to Al toxicity has been reported by Armiger et al.1968; Foy et al.1969; Long and Foy(1970); Long et al.1973; Campbell and Lafever, 1976; Rhue and Grogan 1976; Howeler and Cadavid, 1976, Sartain and Kamprath(1978).

Ruschel et al.(1968) found that nutrient solution containing 33 ppm Al decreased plant growth. Solution containing 7 ppm Al significantly increased Al content of both roots and aerial parts. Results suggested that the harmful effects were due to Al toxicity and not to Al induced P deficiency.

Reid et al.(1969) opined that Al tolerance is genetically controlled.

Hutchinson and Hunter(1970) observed that drymatter production of lucerne, alsike clover and barley was significantly reduced by Al contents exceeding 100 kg/ha whereas drymatter yields of Oats, orchardgrass and timothy were unaffected.

Foy et al.(1973) obtained by screening, a wheat variety 'April Red' which was tolerant to both excess Al and Mn.

Relative yields of both tops and roots reflected a wide range in tolerance to Al toxicity and P deficiency in nutrient solution. Visual symptoms of Al injury were noted in the roots which became thickened, turned brown and lateral roots which did not elongate (Anonymous, 1975; Chapman, 1975; Pinkerton and Simpson, 1981).

Konzak et al. (1976) developed simplified methods to grow seedlings for Al tolerance screening. Al tolerance for barley and rice was measured in terms of root growth in control versus Al solution and for wheat in terms of root growth in Al solutions only. Similar findings have been reported by Moore et al. (1976).

Reid (1976b) reported the procedures for acid value of field and greenhouse and techniques for soil and solution screening.

Silva (1976) stressed the importance of cropping without the need for lime in large areas of Brazil and made use of tolerance to Al, P nutrition, root development, moisture use and liming.

Wallace and Romney (1977) studied the Al toxicity symptoms in plants grown in solution culture. Yields of rice and soybean were significantly reduced by presence of Al.

Helyar (1978) found that plant tolerance of Al is associated with OH^- excretion at the root surface to reduce the substrate Al concentration and low root CEC to reduce Al binding effects and Al uptake.

The effect of 0,10,20,30,40 and 50 ppm Al on the yield and growth characters of the rice plant grown in solution culture was studied by Alice Abraham et al.(1979). They could not observe any significant yield reduction due to Al toxicity.

Fleming(1979) studied the adaptive response of plant root systems to nutrient stress. In Al sensitive plants, Ca and NO_3 uptake was reduced, acid phosphatase activity increased and external P accumulation increased in response to Al treatments.

Garcia et al.(1979)developed a sand culture technique to screen Al tolerant maize genotypes. Relative radicle length and root visual score constituted an efficient screening method for tolerance to Al toxicity. Similar observation is reported by Furlani and Clark(1981).

The effects of acidity and Al on nodulation, N fixation and shoot and root growth in bean plants were studied by Franco and Munns(1982) in both solution and sand culture to explain the frequent failure of nitrogen dependent bean plants in acid soils. The failure has been attributed to Al and Mn toxicity in tropical soils.

Effects of Al toxicity on Coffee seedlings have been reported by Pavan and Bingham(1982).

Screening for tolerance to Mn toxicity:

Carter et al.(1975) studied variation in susceptibility to Mn in 30 soybean genotypes, when grown in nutrient solution containing from 0.1 to 20 ppm Mn. They could obtain differential tolerance. Field observations showed similar symptoms and varietal difference when soybeans were grown on an acid soil high in available Mn. Differential tolerance was also obtained by Reid(1976a) and Kag and Fox(1980).

Andrew(1976) conducted soil and solution culture techniques for screening tropical legumes for Mn tolerance and reported that it is preferable to choose a solution culture technique that facilitates early initiation of nodulation and efficient legume-rhizobia symbiosis.

Foy(1976) described the general principles involved in screening plants for Al and Mn tolerance. The correction of Al and Mn toxicity by liming is not always economically feasible. Plant species and varieties within species differ in their tolerance to both factors and some of these differences are genetically controlled. He suggested selecting or breeding of genotypes with greater tolerance to excess Al and Mn.

Helyar(1978) observed that tolerance to Mn toxicity is associated sometimes with reduced uptake rates, but more generally with decreased transport of absorbed Mn. Some species tolerate high levels in the plant tops.

Keyser and Munns(1979a) studied effects of Ca, Mn and Al on growth of rhizobia in acid media. High levels of Mn has been found toxic to legume hosts of the strains tested.

In 29 cowpea genotypes studied by Horst(1980), there was considerable variation in tolerance to excess Mn in sand and water culture. Mn tolerance was not related to greater vigour or exclusion of Mn from uptake and translocation, but depended mainly on internal tolerance of excess Mn, especially in leaf tissues.

LIMING OF SOILS

a) in relation to Al toxicity:

In incubation experiments with 11 acid soils, Brauner and Catani(1967) found that additions of $CaCO_3$ at 100 and 300 mg/100 g soil decreased both exchangeable Al and titratable acidity and increased the pH of aqueous suspensions. Similar results are reported by Kamprath(1970), Helyar and Anderson (1971); Sartain and Kamprath(1975); Spain(1976), Erico et al. (1979), Hati et al.(1979a), Alley(1981), Bache and Crooke(1981).

Soileau et al.(1969) studied effects of soluble Ca,Mg and Al on roots and tops of cotton. They found that native levels of Ca and Mg were insufficient to maintain optimum growth especially in presence of high level of soluble Al.

Reeve and Sumner(1970a) found that response to lime, $CaSO_4$ and Ca silicate was due to the elimination of Al toxicity and consequent improvement in P uptake by plants rather than to any improvement in the rate of P supply to the soils.

Exchangeable Al status was reported as a suitable criterion for the measurement of lime requirement by Reeve and Sumner(1970b), Ábruna et al.(1974), ~~Abruna et al. (1974)~~, Cochrane et al.(1980).

Tripathi and Pande(1971) obtained convincing evidence that at low soil pH, uptake of nutrients particularly P, Ca, Mg and K was reduced because of excess soluble Al. Liming reduced the solubility of Al and improved the uptake of these nutrients.

Ekpete(1972) reported that liming the soils to pH 6.5-7.0 significantly increased soybean yields, N and K uptake but not P uptake. Lime requirement was significantly correlated with clay content, organic matter, pH and exchangeable Al.

Baumgartner et al.(1974) found that liming increased dry matter yield and total N content of the plants irrespective of the rates of liming.

Pieri(1974) suggested that lime requirements of soils should be determined on the basis of plant response.

Janghorbani et al.(1975) opined that lime application decreased tissue concentration of Al and Mn but increased plant Ca and P.

Amedee and Peech(1976) are of the view that the amount of Al(111) extracted by IN KCI does not represent an intrinsic property of the acid soils of the humid tropics. In 1976 itself they again examined the validity of the practice of using KCl-extractable Al for evaluating the lime requirement of acid tropical soils and found that it would be considered minimal.

Elkins _et al._ (1976) found that lime pelleting of the seed was favourable for establishment and increased dry matter yield of soybeans.

Martini _et al._ (1977) suggested that liming to bring soil pH to 4.8-5.7 and reduce exchangeable Al to 1.5 meq/100 g was a more valid means of increasing yields than was raising soil pH to neutrality.

Zakaria _et al._ (1977) reported that neutralization of exchangeable Al by lime application significantly increased dry matter yield of tops and roots, nodulation of legumes and availability of Ca and P.

Maximum response to lime was obtained when the Al saturation fell below about 20% (Anonymous, 1979).

Quiros and Gonzalez (1979) reported that liming increased soil pH and Ca and P uptake by Sorghum. Concentrations in soil of Al, K, Mg Fe and Mn were decreased by lime applications. Similar results were obtained by Serpa and Gonzalez (1979), Vieitez _et al._ (1979).

Farina _et al._ (1980) found that as near-neutral pH values were approached, the uptake of a number of nutrients was reduced, suggesting that the long-held view that such pH values have beneficial effects on nutrient availability warrants reinvestigation. Again in 1980 they obtained similar results with corn.

Edwards et al.(1981) obtained differential response of cowpea varieties to liming in a green house trial.

Haynes and Ludecke (1981) reported that liming resulted in an increase in exchangeable Ca, percentage base saturation with concomitant decreases in levels of exchangeable Al, Fe and Mn.

b) in relation to Mn toxicity:-

White(1970) studied the effect of lime upon soil and plant Mn levels in an acid soil and found that soil Mn extracted with H_2O and Neutral Normal NH_4OAC as well as plant Mn levels were markedly reduced by liming.

Mn toxicity can be corrected in pot experiments by application of $CaCO_3$ or $CaSiO_3$ (Ngochanbang et al. 1971; Siman et al. 1971; Dahiya and Singh, 1977).

In solution culture experiments with white clover, high Ca supply alleviated Mn toxicity but high P supply intensified the toxicity, by increasing Mn uptake. Small applications of $CaCO_3$ were effective in preventing Mn toxicity. (Truong et al. 1971; Heenan and Carter, 1975; Jones and Nelson, 1978).

Liming significantly reduced the water soluble, $CaCl_2$ - extractable and exchangeable Mn content of a Missouri soil.

Soil Mn concentration was at a very low level above pH 6.0. Liming significantly reduced the plant Mn content of maize, cotton, wheat and soybean (Hati *et al*. 1979b)

Kuruvilla and Kibe (1980) reported that combined application of lime and phosphate brought about an increase in exchangeable Mn and uptake of Mn.

MATERIALS AND METHODS

MATERIALS AND METHODS

An investigation was carried out with the main intention of locating pulse varieties suited to the acid soils of both upland situations and lowland rice fallows of Kerala. The objective was to locate varieties suitable and evolve a low cash input system especially with respect to liming materials. With this overall objective in view, samples were collected from selected areas, analysed for toxic nutrient factors and pulse varieties were screened for tolerance to these factors. A pot culture study was also conducted to compare the performance of the tolerant varieties with those of the recommended varieties.

Experimental detail:

1. Collection of soil samples

Eighty soil samples from upland and rice fallows of Trivandrum and Quilon districts, where pulse is cultivated, were collected. The details regarding locations, soil type, cultural practices etc. are shown in Table 1.

2. Analysis of the samples

(a) pH

pH of the soils in 2:5 soil water suspensions and in 0.01 M $CaCl_2$ was determined using the glass electrode of the Perkin-Elmer pH meter.

(b) Conductivity

Conductivity of 1:2 soil water extracts was determined using a solu-bridge.

(c) Lime requirement

This was determined by the Shoemaker's method (Chopra and Kanwar, 1976).

(d) Water soluble Aluminium

Determined colorimetrically using Aluminon reagent (Hesse, 1971). The colour was read in a Klett-Summerson photoelectric colorimeter.

(e) Exchangeable Aluminium

KCl exchangeable Al was determined colorimetrically.

(f) Water soluble Fe

Water soluble Fe was determined by developing colour with orthophenanthroline, reading the colour in a Klett-Summerson Photoelectric colorimeter.

(g) Exchangeable Fe

KCl exchangeable Fe was determined colorimetrically using orthophenanthroline.

(h) Water soluble Mn

Water soluble Mn was estimated using an Atomic absorption spectrophotometer.

(i) Exchangeable Mn

KCl exchangeable Mn was estimated using an Atomic absorption spectrophotometer.

(j) Cation exchange capacity

It was determined using neutral normal ammonium acetate, as described by Jackson (1973).

(k) Percentage of Al saturation

The percentage Al saturation was calculated using data on exchangeable Al and CEC.

(l) Percentage of Mn saturation

Contribution of Mn to the total CEC was estimated.

3. Preliminary screening trial

A preliminary trial was conducted, based on the observations of which, the treatment concentrations for the actual screening work were fixed.

4. Screening for tolerance to Al toxicity:solution culture

One hundred and twenty numbers of long glass tubes (19 x 3 cm Borosil) were taken and covered with black paper. Hoagland's nutrient solution was prepared as described by Bonner and Galston(1952). Al was supplied as $AlCl_3$ to give a concentrations of 0, 2 and 10 ppm Al. The pH of the culture solution was adjusted to 4.5. Equal quantity of this solution was poured into the tubes and the mouth of the tubes were fitted with small pieces of plastic net so that it just touched the solution. Seeds of the selected varieties were sown in these. At two days' interval, the solution was changed.

The varieties used were:

Treatment	Cowpea	Treatment	Blackgram
T1	Kanakamony	T11	T-9
T2	S-488	T12	Paralamputhur
T3	C-152	T13	Co-4
T4	New Era	T14	LBG-17
T5	KBC-1	T15	S-1
T6	Kolungi payar	T16	Velloor
T7	RC-24	T17	TV-1
T8	RC-8	T18	Co-2
T9	V-37	T19	B-12-4-4
T10	Pusa Phalguni	T20	Pant-U-30

This culture was kept for 15 days in sun light and the following observations were taken.

Observations

(a) Root length

(b) Shoot length

(c) Root yield

(d) Shoot yield

(e) No. of roots

The results are presented in Table 7

5. Screening for tolerance to Mn toxicity: Sand culture

A similar screening was carried out for graded concentrations of Mn in Hoagland solution.

Eighty numbers of black polythene pots with a hole each at the bottom were taken. Holes were plugged with cotton.

They were filled with uniform quantities of thoroughly washed river sand of size between 2 and 0.2 mm. Seeds of pulse varieties (varieties same as used for Al) were sown. Nutrient solution was prepared as in the case of Al. $MnCl_2$ was used to give concentrations of 30 ppm Mn. Equal quantity was added to the pots and double distilled water was used for daily irrigation. Nutrient solution was renewed every 5th day. The culture was kept for one month and the following observations were taken.

a) Shoot length

b) Root length

c) Shoot yield

d) Root yield

e) No.of roots

The results are presented in Table 8.

Based on the observations, the varieties were ranked and tolerant and susceptible varieties were selected.

6. Pot culture experiment

To compare the performance of the tolerant varieties with the recommended varieties, a pot culture study was done.

(a) Collection of soils

The soils used for the experiment were collected from rice fallows of Oorupoyka and Venganoor. The mechanical and chemical composition of the soil were determined and the data are given in Table 9.

(b) Layout of the experiment

Layout : Completely Randomised Block

Treatments:

(a) 4 levels of liming viz., 0, 1/10th, 1/15th and 1/20th of the lime requirement.

(b) Varieties-

C_1 - New Era	}	Cowpea
C_2 - S-488	}	
B_1 - T-9	}	Blackgram
B_2 - Velloor	}	

(c) Soils-

S1 - Oorupoyka

S2 - Venganoor

Number of replications : 2

The treatment combinations are :

S1 C_1 L1	S1 C_2 L1	S1 B_1 L1	S1 B_2 L1
S1 C_1 L2	S1 C_2 L2	S1 B_1 L2	S1 B_2 L2
S1 C_1 L3	S1 C_2 L3	S1 B_1 L3	S1 B_2 L3
S1 C_1 L4	S1 C_2 L4	S1 B_1 L4	S1 B_2 L4
S2 C_1 L1	S2 C_2 L1	S2 B_1 L1	S2 B_2 L1
S2 C_1 L2	S2 C_2 L2	S2 B_1 L2	S2 B_2 L2
S2 C_1 L3	S2 C_2 L3	S2 B_1 L3	S2 B_2 L3
S2 C_1 L4	S2 C_2 L4	S2 B_1 L4	S2 B_2 L4

(c) Raising of the crop

Earthern pots of medium size were filled with 5 kg each of air dry soil. Fertilizers were applied as per the recommendations in package of practices. Lime was applied as fully burnt lime moistened by water for getting it powdered (Ca $(OH)_2$). Seeds were sown in the pots and irrigated daily. The pots were kept free of weeds. Picking of pods started after 45 days and continued at intervals, till fully maturity.

(d) Plant performance studies

The following observations were made regarding the yield characteristics of the varieties for the various levels of applied lime.

1) Number of pods/ plant
2) Haulm yield / plant
3) Grain yield/ plant
4) No.of nodules/ plant at the time of harvest.

(e) Analysis of plant samples

Plant samples were analysed for the total content of N, P, K, Mn and Al after digestion of samples as described by Wahhab and Bhatti(1958).

(f) Statistical analysis of the data

The data obtained from pot culture experiment and laboratory studies were analysed separately for cowpea and blackgram statistically, and the results were recorded.

TABLE 1

Details of Soil Samples collected

Sl. No.	Locality	Type and variety of pulse grown	Fertiliser/ ameliorant used
1	2	3	4
A.	UPLAND		
1.	Manappally	Kolingi payar, cowpea	Ash
2.	Manappally N	" "	"
3.	"	" "	"
4.	Manappally	" "	"
5.	Pavumpa-S	" "	"
6.	Pavumpa	Cherupayar	"
7.	"	Blackgram (Local)	"
8.	Pavumpa-S	Kolingi payar	"
9.	Thazhava	"	"
10.	"	Kolukuthi payar	"
11.	Anakkottoor	Chuvannalari payar	Ash, dung
12.	"	Aripayar	Ash, dung, superphosphate
13.	Venganoor	Kompukuthi payar	Ash, dung, Superphosphate
14.	"	Chuvannalari payar	Superphosphate, ash
15.	"	"	Bonemeal, Superphosphate
16.	Ezhukone	Attuvella	Superphosphate, ash
17.	"	Chuvannalari payar	Superphosphate, ash
18.	Anakkottoor	"	Superphosphate, ash
19.	Venmanoor	"	Superphosphate, ash.
20.	Anakkottoor	Vellapayar	Superphosphate, ash.

(Table contd.)

Table 1 contd.

1	2	3	4
21.	Kandukuzhi	Kozhinji payar	8:8:16 mixture
22.	Vengodu	"	Ash + 8:8:16
23.	Kudavoor	"	Ash + cowdung
24.	Mangamala	C.152	8:8:16 mixture
25.	Vengodu	"	$CaCO_3$, 10:5:20
26.	"	"	Ash, 8:8:16
27.	"	"	Dung, 8:8:16
28.	Mangamala	Kozhingi	Ash, Dung
29.	"	C.152	Superphosphate, ash, MOP.
30.	Kudavoor	"	8:8:16
31.	Kuttyani	Cowpea (local)	Cowdung
32.	Panthalakodu	"	Ash
33.	"	C.152	Ash, dung.
34.	Mannurkonam	Cowpea (local)	Factomphos, dung
35.	Panthalakodu	"	Ash.
36.	Mangalathukonam	"	Ash, dung.
37.	Panthalakodu	"	dung.
38.	Kuttyani	"	"
39.	"	C.152	Factomphos, MOP, dung.
40.	Panthalakodu	Cowpea (local)	dung.
B. RICE FALLOW			
1.	Chathannur	Kochu payar	Lime, Rock phosphate.
2.	Thazham Chathannur	Aripayar	Lime "
3.	"	"	Rock phosphate
4.	"	Kochu payar	Lime.
5.	Chathannur	"	"

(Table contd.)

Table 1 contd.

1	2	3	4
6.	Mampillikunnam	Kochu payar	Rockphosphate
7.	Thazham Chatha-nnur	Ari payar	Lime
8.	"	"	"
9.	Chathannur	Kochu payar	Lime, Rock phosphate
10.	Mampallikunnam	"	Lime.
11.	Venganoor	Blackgram (local)	Ash
12.	"	" (T-9)	"
13.	"	Kolingi	"
14.	"	"	"
15.	Vizhinjam	"	"
16.	"	"	"
17.	Venganoor	"	"
18.	"	Blackgram(local)	"
19.	"	" & Kolingi	"
20.	"	Kolingi	"
21.	Neduvathoor	C-152	Superphosphate
22.	"	Ari payar	Ash
23.	"	"	"
24.	Kottarakkara	Kolingi	Ash, dung
25.	"	Chuvannalari payar	Ash.
26.	"	Vella payar	Ash
27.	"	Kolingi	Ash, dung.
28.	Neduvathoor	"	Ash, superphosphate
29.	"	Blackgram(local)	Superphosphate
30.	"	Kolingi	Lime
31.	Paruthi	"	Ash, 8:8:16
32.	Oorupoyka	"	Ash, Superphosphate
33.	"	"	Ash.

(Table contd.)

Table 1 contd.

1	2	3	4
34.	Paruthi	Kolingi	Ash
35.	"	"	"
36.	Kizhuvalam	"	"
37.	Elampa	C-152	Superphosphate + lime
38.	Oorupoyka	Kolingi	Ash
39.	Kizhuvalam	"	"
40.	Oorupoyka	"	"

RESULTS

RESULTS

In the present study experiments were conducted to find out the toxic factors associated with acidity and select varieties of pulses viz. cowpea and blackgram which can withstand them, to be cultivated economically in such situations. The salient results of this investigation are presented in this chapter.

3.1. Analysis of the samples:-

The details of soil samples collected are given in Table 2. The soil samples collected from uplands recorded slightly higher pH values than those collected from rice fallows. There was not much variation in electrical conductivity. Lime requirement data indicated wide variation from location to location and all the soils required significantly large quantities of lime to acquire neutrality. The quantities of lime required varied between 0 tons to 5.2 tons/ha in uplands and 1.6 tons to 5.8 tons/ha in rice fallows.

Table 3 presents data on cation exchange capacity of the soils. It varied from 1.9 to 7.0 me/100 g soil. The percentage Al saturation is very high in some of the soils. It ranged from 3.25 to 24.14. Out of 80 soils

Table 2- pH, EC and Lime requirement of the soils

Sl. No.	pH in soil-water system	pH in 0.01M $CaCl_2$	Shift in pH	EC, milli-mhos/cm	Lime requirement. Tons $CaCO_3$/ acre
1	2	3	4	5	6
1	5.9	4.9	1.0	0.2	2.2
2	6.2	5.1	1.1	0.3	3.4
3	5.6	4.8	0.8	0.05	4.5
4	6.0	5.3	0.7	0.15	4.0
5	6.4	4.9	1.5	0.05	4.0
6	6.2	4.9	1.3	0.1	4.0
7	5.7	5.0	0.7	0.3	3.4
8	6.0	5.0	1.0	0.2	2.2
9	5.6	4.7	0.9	0.2	5.2
10	7.8	7.4	0.4	1.4	-
11	6.6	5.9	0.7	0.2	2.8
12	6.0	5.1	0.9	0.2	5.2
13	6.0	5.2	0.8	0.1	3.4
14	6.1	5.6	0.5	0.2	4.0
15	6.1	5.3	0.8	0.2	2.8
16	5.8	5.4	0.4	0.3	5.2
17	5.6	5.0	0.6	0.3	4.5
18	6.1	5.7	0.4	0.2	4.0
19	6.1	5.8	0.3	0.2	4.0
20	5.9	5.3	0.6	0.15	5.2

(Table contd.)

Table 2 contd.

1	2	3	4	5	6
21	6.2	5.5	0.7	0.15	3.4
22	6.2	5.6	0.6	0.2	4.0
23	6.6	6.5	0.1	0.3	2.2
24	6.0	5.5	0.5	0.2	2.8
25	6.1	5.4	0.7	0.1	3.4
26	6.0	5.5	0.5	0.3	2.8
27	5.7	5.2	0.5	0.2	4.0
28	6.3	6.0	0.3	0.2	2.8
29	5.3	5.2	0.1	0.3	5.2
30	5.7	5.3	0.4	0.2	5.2
31	6.7	6.2	0.5	0.075	2.8
32	7.2	6.7	0.5	0.1	-
33	6.7	6.4	0.3	0.075	2.8
34	6.8	6.3	0.5	0.05	2.2
35	6.7	6.1	0.6	0.05	2.2
36	6.5	6.0	0.5	0.1	2.2
37	6.6	6.3	0.3	0.15	2.2
38	6.3	5.6	0.7	0.05	4.5
39	6.7	6.1	0.6	0.05	2.2
40	7.0	6.7	0.3	0.1	1.6
41	5.0	4.6	0.4	0.2	4.0
42	5.0	4.1	0.9	0.1	3.4
43	4.9	4.3	0.6	0.2	3.4
44	5.2	4.3	0.9	0.2	4.5
45	5.0	4.4	0.6	0.4	2.8
46	5.6	4.6	1.0	0.2	3.4
47	5.3	4.6	0.7	0.2	2.2

(Table contd.)

Table 2 contd.

1	2	3	4	5	6
48	5.2	4.6	0.6	0.4	2.8
49	5.3	4.8	0.5	0.5	2.8
50	5.1	4.5	0.6	0.3	4.5
51	5.0	4.4	0.6	0.2	3.4
52	5.0	4.4	0.6	0.2	3.4
53	5.0	4.3	0.7	0.1	5.2
54	5.1	4.4	0.7	0.2	5.2
55	5.0	4.3	0.7	0.1	5.2
56	5.0	4.4	0.6	0.2	4.0
57	4.9	4.3	0.6	0.2	4.5
58	4.8	4.3	0.5	0.3	5.2
59	4.9	4.4	0.5	0.2	4.5
60	5.2	4.5	0.7	0.1	4.5
61	5.3	4.6	0.7	0.1	4.0
62	5.1	4.4	0.7	0.1	4.0
63	5.0	4.6	0.4	0.2	4.5
64	5.1	4.5	0.6	0.1	4.5
65	5.4	4.6	0.6	0.1	4.5
66	5.0	4.4	0.6	0.2	5.2
67	5.8	4.8	1.0	0.1	4.0
68	5.5	4.5	1.0	0.1	4.5
69	5.4	4.6	0.8	0.1	5.2
70	5.4	4.7	0.7	0.15	4.5
71	4.6	4.5	0.1	0.4	1.6
72	4.4	4.3	0.1	0.3	5.8
73	4.9	4.6	0.3	0.15	1.6
74	4.9	4.8	0.1	0.2	1.6
75	4.9	4.6	0.3	0.3	2.2
76	4.9	4.7	0.2	0.4	2.8
77	5.1	4.8	0.3	0.2	2.8
78	5.1	4.7	0.4	0.2	2.8
79	5.0	4.6	0.4	0.1	4.0
80	5.3	4.7	0.6	0.1	2.8

Table 3- CEC, % Al saturation and % Mn saturation of the soils

Sl. No.	CEC m.e/100 gm soil	% Al saturation	% Mn saturation
1	2	3	4
1	3.7	6.01	0.012
2	4.6	7.97	0.02
3	3.5	11.26	0.017
4	2	15.16	0.034
5	1.9	17.54	0.021
6	3.4	8.33	0.014
7	5.8	5.78	0.008
8	4.1	6.91	0.013
9	2.2	16.65	0.021
10	5.5	6.67	0.036
11	4.0	6.25	0.014
12	4.3	11.11	0.008
13	6.7	8.29	0.011
14	4.5	8.77	0.012
15	3.9	10.83	0.022
16	5.4	9.36	0.011
17	4.8	14.58	0.012
18	5.5	6.06	0.011
19	4.8	3.59	0.014
20	4.8	8.22	0.008
21	5.9	4.24	0.020
22	5.8	4.88	0.008
23	5.3	3.25	0.011
24	4.2	7.94	0.014
25	3.3	9.43	0.034
26	3.2	7.81	0.031
27	4.4	3.91 14.64	0.005

(Table contd.)

Table 3- contd.

1	2	3	4
28	4.4	3.91	0.005
29	3.6	14.8	0.023
30	4.7	11.82	0.022
31	5.7	4.97	0.007
32	4.0	5.56	0.005
33	4.5	4.94	0.006
34	3.6	7.87	0.002
35	4.5	4.94	0.008
36	3.3	11.11	0.012
37	4.6	3.74	0.011
38	3.7	16.67	0.008
39	1.9	19.29	0.015
40	4.8	8.79	0.034
41	4.8	5.90	0.007
42	5.1	6.54	0.005
43	4.6	5.43	0.006
44	4.0	8.33	0.022
45	3.8	6.58	0.02
46	3.5	13.65	0.027
47	4.1	7.59	0.008
48	3.7	8.41	0.007
49	3.2	8.85	0.004
50	2.9	10.72	0.026
51	3.4	10.78	0.02
52	4.2	7.94	0.011
53	5.3	7.97	0.009
54	8.5	4.64	0.006
55	4.6	9.66	0.032
56	3.8	10.38	0.013

(Table contd.)

Table 3- contd.

1	2	3	4
57	6.1	7.29	0.010
58	3.1	22.58	0.035
59	7.0	6.03	0.007
60	8.3	5.35	0.010
61	4.5	8.76	0.018
62	3.5	12.7	0.024
63	3.9	11.39	0.018
64	4.0	12.64	0.023
65	4.3	10.33	0.021
66	5	11.78	0.014
67	4.8	6.94	0.02
68	5.6	8.53	0.01
69	5.2	9.72	0.017
70	4.1	18.56	0.024
71	6.2	10.48	0.0021
72	5.7	24.14	0.036
73	5.8	13.12	0.014
74	6.2	11.29	0.0044
75	5.1	10.46	0.0026
76	4.4	21.08	0.015
77	5.3	14.88	0.031
78	6.8	12.00	0.034
79	6.2	10.48	0.030
80	7.0	7.94	0.028

Table 4- Content of KCl exchangeable Al, Mn and Fe in the soil samples

Sl. No.	Al ppm	Mn ppm	Fe ppm
1	200	11.8	4.25
2	330	24.8	3.75
3	355	16.8	3.75
4	355	20.3	5.0
5	300	11.1	9.25
6	255	13.3	5.0
7	300	13.3	3.75
8	630	15.0	3.0
9	630	12.6	5.0
10	330	5.5	5.0
11	225	14.8	4.25
12	430	10.3	6.0
13	500	20.8	5.75
14	355	14.3	15.5
15	380	24.2	5.0
16	455	16.5	3.75
17	630	15.9	6.5
18	300	16.3	5.75
19	155	17.8	5.75
20	355	10.5	5.0
21	225	33.0	6.75
22	255	13.3	6.0
23	155	15.9	6.75
24	300	16.0	20.75
25	280	30.5	6.0
26	225	27.2	7.5
27	455	9.6	6.0

(Table contd.)

Table 4- contd.

1	2	3	4
28	155	5.8	7.5
29	480	22.9	6.5
30	500	29.1	8.25
31	255	11.1	10.5
32	200	5.8	7.5
33	200	7.8	6.0
34	255	22.3	5.75
35	200	11.1	5.0
36	330	11.1	6.75
37	155	12.6	7.5
38	555	8.4	6.0
39	330	8	6.0
40	380	4.5	5.0
41	255	8.9	20.0
42	300	7.5	19.0
43	225	7.8	21.0
44	300	24.2	18.25
45	225	21.9	18.75
46	430	25.7	18.5
47	280	8.6	16.25
48	280	7.6	15.0
49	255	3.4	14.0
50	280	20.6	17.0
51	330	18.6	18.5
52	300	12.6	19.0
53	380	11.7	20.0
54	355	14.8	21.25
55	400	40.0	22.5
56	555	13.9	18.5
57	400	16.7	21.5

(Table contd.)

Table 4- contd.

1	2	3	4
58	630	29.7	24.0
59	380	12.6	21.0
60	400	22.9	21.5
61	355	21.8	11.75
62	400	23.4	14.75
63	400	18.8	13.0
64	455	25.4	10.0
65	400	25.4	17.0
66	530	19.4	16.75
67	300	25.8	15.5
68	430	15.7	15.0
69	455	23.6	14.5
70	685	27.4	15.75
71	585	3.6	12.25
72	1240	56.0	22.5
73	685	22.5	21.25
74	630	7.6	11.75
75	480	3.6	22.75
76	835	17.8	17.0
77	710	4.5	19.0
78	735	6.3	16.75
79	585	5.2	19.25
80	500	5.4	15.75

Table 5 - Content of water soluble Al, Mn and Fe in the soil samples

Sl. No.	Al ppm	Mn ppm	Fe ppm
1	2	3	4
1	100	0.3	0.5
2	50	1.3	2.5
3	155	0.8	3.0
4	100	1.2	2.5
5	50	1.3	4.0
6	155	0.6	3.0
7	100	0.6	1.0
8	50	0.7	1.0
9	100	0.8	2.5
10	200	1.5	2.25
11	155	1.3	6.5
12	100	0.6	3.0
13	155	6.4	5.25
14	100	1.1	5.0
15	155	1.3	6.75
16	155	1.2	2.75
17	100	1.3	2.5
18	100	0.6	2.5
19	155	0.8	1.0
20	100	0.75	3.0
21	155	1.3	7.75
22	80	0.8	3.0
23	55	0.9	6.75
24	200	1.6	6.75
25	155	1.9	2.75
26	155	2.7	2.75
27	225	0.8	2.5

(Tale contd.)

Table 5- contd.

1	2	3	4
28	55	2.9	2.75
29	225	3.9	2.5
30	155	1.6	1.0
31	200	1.3	2.5
32	100	0.8	2.75
33	100	1.0	2.75
34	155	1.1	1.0
35	105	1.0	2.5
36	130	1.1	6.75
37	80	1.3	2.75
38	200	1.0	2.5
39	255	1.1	1.0
40	155	1.0	2.5
41	125	2.5	8.75
42	155	0.8	5.25
43	155	8.4	8.75
44	225	19.4	13.25
45	50	19.0	11.50
46	300	19.7	14.25
47	155	3.4	5.75
48	100	6.7	6.5
49	155	2.3	11.5
50	130	11.6	12.75
51	155	5.7	5.0
52	80	11.1	9.25
53	200	8.6	12.25
54	300	9.9	10.5
55	355	7.8	5.0
56	100	10.5	12.5

(Table contd.)

Table 5- contd.

1	2	3	4
57	300	5.9	12.5
58	455	17.0	10.75
59	225	11.3	6.25
60	355	16.0	10.75
61	280	12.1	4.0
62	500	13.7	12.75
63	255	14.6	4.0
64	255	21.0	3.0
65	200	24.7	2.75
66	230	8.0	9.25
67	180	11.1	5.0
68	280	11.2	11.75
69	250	13.0	10.75
70	300	22.1	2.75
71	480	3.3	9.0
72	555	14.7	5.25
73	330	1.9	3.0
74	300	5.7	4.0
75	280	1.6	3.0
76	300	13.6	11.25
77	300	7.4	13.0
78	280	2.6	4.0
79	255	1.6	3.0
80	300	4.0	5.25

tested, twelve have a percentage Al saturation greater than 15.0.

The soil samples were analysed for their content of exchangeable and water soluble aluminium, manganese and iron and the results are presented in Tables 4 and 5. KCl exchangeable Al varied from 155 ppm to 1240 ppm, manganese from 3.4 ppm to 56 ppm and iron from 3 ppm to 24 ppm. Soil samples collected from rice fallows always recorded a higher content of water soluble aluminium, manganese and iron than those for upland soils. Maximum values of 555 ppm for aluminium, 24.7 ppm for manganese and 13.25 ppm for iron have been recorded in these soils.

3.2. Preliminary screening trial:-

Observations of the preliminary screening experiment with different varieties of cowpea are given in Table 6. As the concentration of manganese increased from 1 ppm to 30 ppm, plant height progressively decreased. With few exceptions, root length and number of roots also followed the same pattern.

3.3. Screening for tolerance to Al toxicity: solution culture:-

Table 7 summarises the data obtained from the screening experiment. For cowpea, varieties S-488 and Pusaphalguni

Table 6 - Observations of the preliminary screening with cowpea

Concentration of Mn (ppm)	Plant height		Root length		No. of roots	
	S-488	Pusaphalguni	S-488	Pusaphalguni	S-488	Pusaphalguni
0	17.5	10.5	7.5	3.5	58	34
1	17.5	11.0	4	2.9	46	26
2	16	7.5	2.5	1.0	12	6
4	15.5	10.0	4	3.5	28	21
6	13.5	8.5	4.1	2.5	40	10
8	14.1	9.5	1.9	1.9	18	23
10	12.0	9.6	1.7	3.4	9	17
15	11.5	9.0	3.2	0.4	17	14
20	10.7	9.2	2.9	2.4	24	16
30	1.2	6.3	1.4	1.3	14	7

gave the maximum and minimum Relative Root Yield (RRY), Relative Shoot Yield (RSY) and Relative Root Length (RRL) respectively. Other varieties tried had Relative Root Yield, Relative Shoot Yield and Relative Root Length, intermediate between these varieties. But in the case of shoot length, a similar pattern could not be obtained. For blackgram, (Table 7), the maximum and minimum values for Relative Root Yield(RRY), Relative Shoot Yield(RSY) and Relative Number of roots(RNR) were obtained for T_{16} (variety Velloor) and T_{18} (Co-2), respectively. It was observed that at 2 ppm concentration RSY, RRY and RNR were more than at 0 ppm and at 10 ppm.

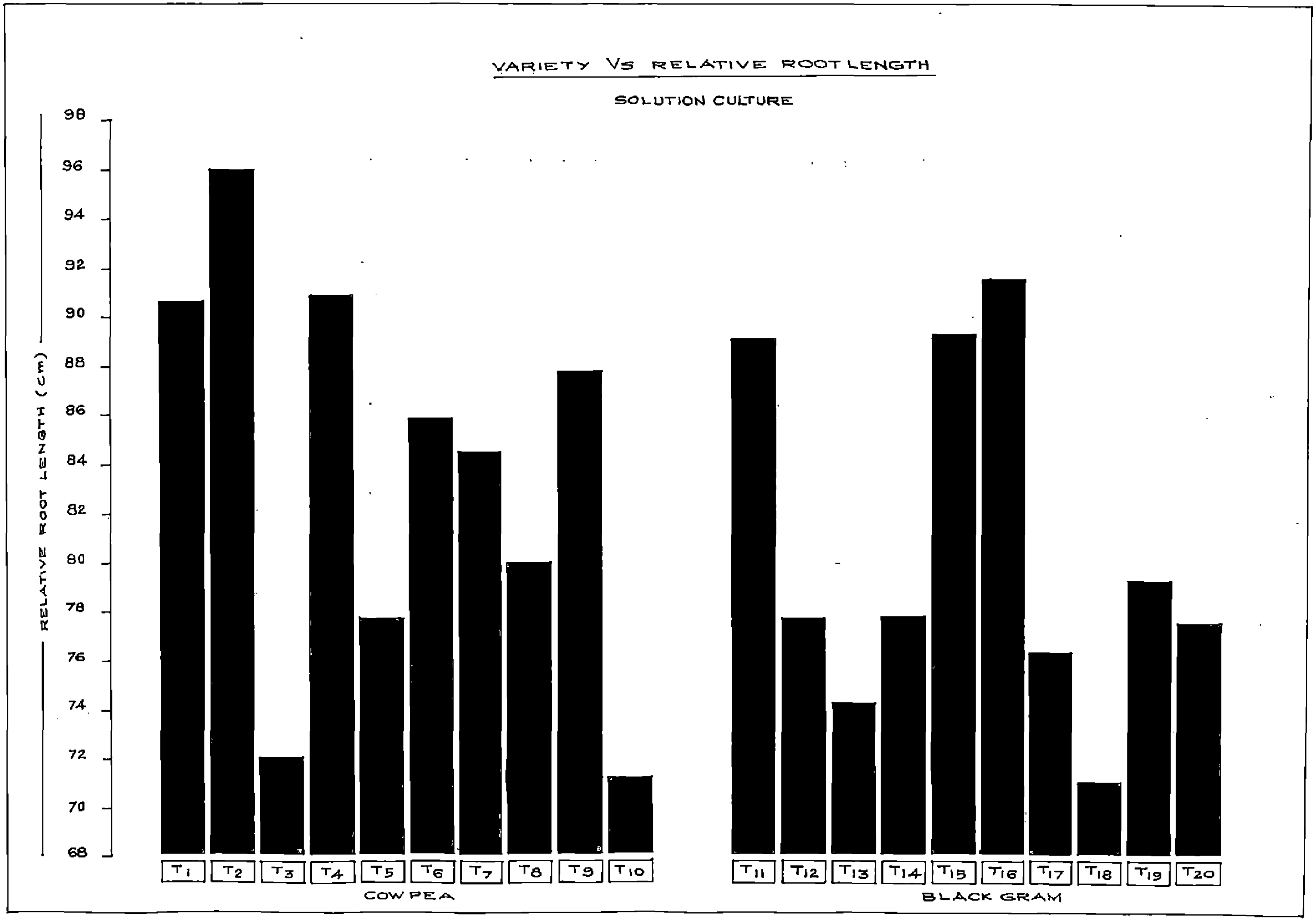
3.4. Screening for tolerance to Mn toxicity: Sand culture

Table 8 shows that there is differential tolerance to Mn toxicity. T_2(S-488) and T_{10} (Pusa phalguni) recorded the maximum and minimum values respectively, for Relative Shoot Yield, Relative Root Yield, Relative Shoot Length, Relative Root Length and Relative Number of Roots. Among blackgram varieties, T_{16}(Velloor) and T_{18}(Co-2) gave the maximum and minimum values respectively.

3.5. Pot culture experiment:-

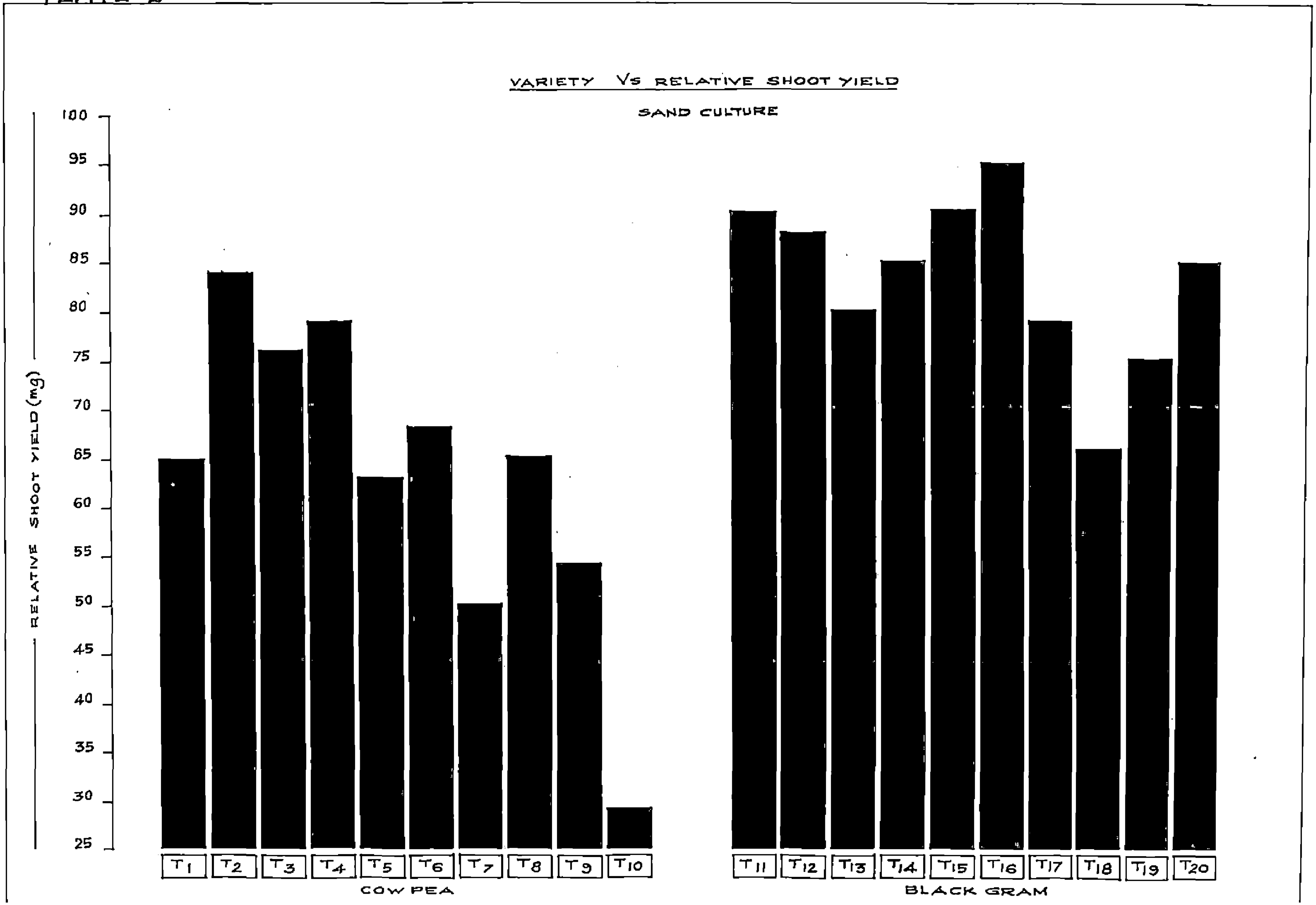
Basic data of the soils used for pot culture study is given in Table 9.

PLATE 1



VARIETY Vs RELATIVE ROOT LENGTH
SOLUTION CULTURE
RELATIVE ROOT LENGTH (cm)
98
96
94
92
90
88
86
84
82
80
78
76
74
72
70
68
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
COW PEA
T11
T12
T13
T14
T15
T16
T17
T18
T19
T20
BLACK GRAM

PLATE-2



VARIETY Vs RELATIVE SHOOT YIELD
SAND CULTURE
RELATIVE SHOOT YIELD (mg)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
COW PEA
T11
T12
T13
T14
T15
T16
T17
T18
T19
T20
BLACK GRAM

A. Plant performance studies:

3.5.1. Number of pods/plant

Table 10 and Appendix I present the number of pods obtained per plant. Appendix III gives the abstract of anova. There is significant difference between the varieties. Among the cowpea varieties C_2(S-488) is superior. There is significant difference between the various doses of lime applied. There is no significant difference between the lower doses of lime L_1 and L_2. However, the higher doses of lime L_3 and L_4 differ significantly from the rest and L_4 is superior. The treatment combinations S_2L_1, S_1L_1 and S_2L_2 are on par. S_1L_2 differs significantly from these combinations. S_1L_2, S_2L_3, S_1L_3 and S_1L_4 do not differ significantly. The maximum number of pods were obtained for the treatment combination S_2L_4. Among soil x variety combinations, S_1C_1 and S_2C_1 did not differ significantly. S_2C_2 differed significantly from S_1C_1 and S_2C_1. S_1C_2 combination was superior. Among variety x lime combinations C_1L_1, C_1L_2, C_1L_3 were on par. C_1L_2, C_1L_3, C_2L_1 were on par. C_2L_4 combination was the best. C_2L_3 differed significantly from C_2L_4 and C_2L_1. C_1L_4 and C_2L_2 were on par.

For the blackgram varieties also, there was difference between the soil types and varieties. The data is presented in Table 11 and Appendices II and IV. Significant increase

Table 9 - Basic data of the soils used for pot culture study

	Soil No.58	Soil No.72
Coarse sand (%)	8.50	50.25
Fine sand (%)	16.5	27.75
Silt (%)	23.0	6.5
Clay (%)	52.0	15.5
pH	4.8	4.4
EC millimhos/cm	0.3	0.3
CEC m.e/100 g soil	3.1	5.7
Lime requirement Tons/$CaCO_3$/acre	5.2	3.4
Total N%	0.056	0.034
Available P_2O_5 (kg/ha)	54.96	40
Available K_2O (kg/ha)	228	216
KCl Exchangeable Al ppm	630	1240
KCl Exchangeable Mn ppm	29.7	56
KCl Exchangeable Fe ppm	24	22.5

Table 10 - Observations of the pot culture experiment Cowpea

			Mean No. of pods/plant	Mean Haulm yield g/plant	Mean grain yield g/plant	No.of nodules at harvest stage/plant
Soil No.72	NEW ERA	0 kg/ha lime	2.0	3.6	0.5	46
		250 "	2.5	3.95	0.55	61
		333 "	2.5	3.9	0.55	62
		500 "	1.5	6.1	0.40	135
	S-488	0 kg/ha lime	3.5	6.05	0.95	51.5
		250 "	5.0	7.1	1.05	225.5
		333 "	7.0	6.4	1.1	181.5
		500 "	8.0	7.25	1.35	312
Soil No.58	NEW ERA	0 kg/ha lime	1.5	5.7	1.2	71
		250 "	1.5	7.8	0.8	114.5
		333 "	2.5	3.9	0.95	139
		500 "	6.0	4.15	1.9	167.5
	S-488	0 kg/ha lime	2.0	6.3	2.65	124
		250 "	3.0	5.05	1.55	163
		333 "	5.0	7.5	2.0	158.5
		500 "	8.5	10.5	3.35	209.5

Table 11 - Observations of the Pot culture experiment - Blackgram

			No.of pods/ plant mean	Haulm yield g/plant mean	Grain yield g/plant mean	No.of nodules at harvest stage/plant mean
Soil No.72	T9	0 kg/ha lime	4	1.3	0.85	66
		250 "	7	1.75	0.80	53.5
		333 "	14.5	2.15	1.9	104.5
		500 "	18.5	3.25	0.75	78
	VELLOOR	0 kg/ha lime	11.5	2.75	0.95	65.5
		250 "	13	2.75	2.1	74.5
		333 "	14	3.2	2.5	69.5
		500 "	21	4.75	3.1	143.5
Soil No.58	T9	0 kg/ha lime	11	3.1	1.9	101
		250 "	12	3.2	1.8	44.5
		333 "	20	2.8	2.4	70.5
		500 "	18.5	5.3	2.55	100
	VELLOOR	0 kg/ha lime	23.5	3.15	3.0	87
		250 "	32	2.25	3.05	92
		333 "	32	4.8	5.6	116
		500 "	34	6.35	5.7	94.5

in number of pods could be noticed when the lime dose was increased from 0 to 500 kg/ha. Among the soil Vs variety treatment combinations, S_1B_2 and S_2B_1 performed with no significant difference in number of pods. S_2B_2 recorded the maximum number of pods and S_1B_1, the least. The treatment combinations B_1L_1, B_1L_2 and B_1L_3, B_2L_1, B_1L_4 and B_2L_2, B_2L_3 were on par. B_2L_4 is the combination of 500 kg lime/ha and variety velloor which recorded the maximum number of pods.

3.5.2. Haulm yield/plant

Tables 10, 11 and Appendices III and IV present data on the haulm yield obtained per plant. Appendices I and II brief the anova for haulm yield. It is clear that the cowpea variety C_2(S-488) gave maximum haulm yield and differed significantly from the other variety New Era.

In the case of blackgram varieties no significant difference between the two varieties could be observed. However, significant difference between their performance in different soil types and with different levels of lime could be observed. Soil S_2 was more suitable than soil S_1, and L_4 (500 kg lime/ha) gave maximum yield when the other doses were compared. L_1L_2 and L_3 were on par.

3.5.3. Grain yield/ plant

Grain yield obtained is recorded in Tables 10 and 11 and the abstract of anova in Appendices I and II. The means of these values are given in Appendices III and IV. From the mean tables, it is clear that the cowpea variety S-488 gave higher grain yield than New Era. The blackgram varieties also differed significantly; B_2(Velloor) being superior. The soil S_2 gave more satisfactory conditions for higher yield.

3.5.4. Number of nodules/ plant

From Tables 10 and 11 and Appendices I and III, it is clear that there is significant difference in the development of root nodules between the two varieties of cowpea. Thus C_2(S-488) developed a maximum number of root nodules. L_4(500 kg/ha lime) gave the maximum number of nodules and L_1(0 kg/ha lime) recorded the minimum number. In the case of blackgram varieties, lime levels or soil types or any of the combinations were not able to bring a significant difference in the number of root nodules. The data is presented in Table 11, Appendices II and IV.

3.5.5. Uptake studies:

The plant samples were analysed for the content of N, P and K and uptake/plant was calculated.

a) N uptake/plant

The data is given in Table 11, Appendices I, II, III and IV. The mean values from Appendix III indicate that the cowpea variety S-488 (C_2) fixed and absorbed more quantities of N than the other variety. Soil S_2 favoured maximum absorption. When the lime applied was increased from 0-500 kg/ha there was increased uptake of Nitrogen. But between L_1 L_2 and L_3 there is no significant difference in uptake. The treatment combination S_1C_2 appeared the best combination for maximum uptake. S_2C_1, S_2C_2 and S_1C_1 were on par.

For blackgram, the data presented in Table 12 and Appendix IV clearly indicate that there is no significant difference in uptake between varieties or treatment combinations. The two soil types behaved similarly.

b) P uptake/ plant

Cowpea variety S-488 and blackgram variety Velloor utilised more phosphorus than other varieties. Soil type S_2 favoured the uptake of more P in both cowpea and blackgram. 500 kg lime/ha favoured greater absorption of P from the soil. Data is presented in Tables 11 and 12 and appendices I, II, III & IV.

Table 12 - Uptake of N, P, K by pulse plants (g/plant) observationsof the pot culture study

				Nitrogen g/plant	Phosphorus g/plant	Potassium g/plant
COWPEA	Soil No.72	NEW ERA	0 kg/ha	6.92	3.77	3.63
			250 "	6.80	3.95	6.23
			333 "	5.45	3.34	4.65
			500 "	10.72	6.21	9.36
		S-488	0 kg/ha	10.57	4.55	9.21
			250 "	12.70	5.7	7.33
			333 "	13.72	5.15	9.75
			500 "	13.73	7.8	9.03
	Soil No.58	NEW ERA	0 kg/ha	4.83	6.23	1.85
			250 "	4.11	7.05	2.43
			333 "	5.37	5.26	3.28
			500 "	8.93	7.43	4.03
		S-488	0 kg/ha	5.43	5.34	3.34
			250 "	5.70	6.8	2.73
			333 "	7.15	9.27	4.9
			500 "	10.57	13.26	4.5
BLACK GRAM	Soil No.72	T9	0 kg/ha	10.92	1.65	5.47
			250 "	11.40	2.11	8.94
			333 "	13.44	2.92	5.20
			500 "	9.94	2.97	5.37
		VELLOOR	0 kg/ha	13.78	3.03	8.42
			250 "	6.78	3.85	5.12
			333 "	10.54	6.20	5.94
			500 "	17.54	8.12	11.79
	Soil No.58	T9	0 kg/ha	7.10	5.33	3.83
			250 "	7.62	5.40	4.41
			333 "	6.65	5.74	2.90
			500 "	11.91	8.41	4.83
		VELLOOR	0 kg/ha	6.94	7.10	3.85
			250 "	9.46	7.24	4.85
			333 "	13.49	9.72	7.04
			500 "	15.39	11.05	7.82

c) K Uptake/plant

The cowpea variety S-488 and blackgram variety Velloor took up more K from the soil and maximum absorption was obtained in soil type S_2. Cowpea varieties had a maximum uptake of K into the soil amended with the highest dose of lime. The combination S_1C_2 was found superior. S_1C_1 was significantly different from S_1C_2 and S_2C_1, S_2C_2 which were on par. For blackgram, the combination B_2L_4 was preferrable for maximum K uptake. Uptake by B_1L_3 was minimal. The other combinations behaved similarly.

For cowpea, the variety C_2(S-488) combined with 333 kg lime/ha took up more K than the other combinations. C_2L_4 differed significantly from C_2L_3 and C_1L_3, C_1L_2, C_2L_2, C_2L_1, C_1L_4 which were on par. C_1L_1 took up only the minimum quantity of K.

Table 12 and appendices I, II, III & IV summarise the observations.

3.5.6. Analysis of plant samples

The plant samples were analysed for their Mn and Al content.

a) Mn content:

No significant difference was noticed among the treat-

Table 13- Mn and Al content in the plants. Observations of the pot culture study

				Mn ppm	Al ppm
COWPEA	Soil No.72	NEW ERA	0 kg/ha	230	60
			250 "	200	720
			333 "	224	420
			500 "	152	785
		S-488	0 kg/ha	212	230
			250 "	186	710
			333 "	156	450
			500 "	204	75
	Soil No.58	NEW ERA	0 kg/ha	262	680
			250 "	268	55
			333 "	258	50
			500 "	196	115
		S-488	0 kg/ha	221	575
			250 "	178	580
			333 "	204	950
			500 "	172	600
BLACK-GRAM	Soil No.72	T9	0 kg/ha	204	400
			250 "	180	150
			333 "	174	350
			500 "	260	250
		VELLOOR	0 kg/ha	218	275
			250 "	168	30
			333 "	192	25
			500 "	202	30
	Soil No.58	T9	0 kg/ha	248	750
			250 "	252	150
			333 "	208	30
			500 "	206	700
		VELLOOR	0 kg/ha	240	40
			250 "	172	300
			333 "	162	35
			500 "	138	700

ment combinations or between varieties for their Mn content in the case of cowpea. But the blackgram variety B_2(Velloor) contained more Mn in plant parts. The combinations S_2B_2, S1B_2 and S_1B_1 were on par and plants under treatment S_2B_1 was found to contain higher quantities of Mn. The results are given in Table 13 and Appendices I, II, III and IV.

b) Al content:

Data in Table 13 and appendices I, II, III & IV also show that the cowpea variety S-488 and blackgram variety Velloor have higher content of Al than the other varieties. For cowpea, when the treatment combination S_1L_1 was applied, Al content in plant parts was the least and the maximum content was obtained by combinations S_2L_3 and S_2L_1. S_2L_2, S_2L_4, S_1L_2, S_1L_4, S_1L_4, S_1L_3, S_2L_3 and S_2L_1 were on par.

For blackgram, the highest content of Al was noticed with the highest dose of lime. L_1 and L_4 were on par and L_3 and L_2 were on par. The combination S_2L_4 gave the highest content of Al in plant parts. S_2L_3, S_1L_2, S_1L_4, S_1L_3 and S_2L_2 were on par and S_1L_1 and S_2L_1 were on par.

3.5.7. Correlation studies

Correlation study was conducted between the yield and number of pods and between the yield and N and P uptake. Grain yield was significantly and positively correlated with number of pod and P uptake in the case of cowpea. Number of pods was significantly correlated with N uptake. However, significant correlation could not be obtained between N uptake and grain yield.

In the case of blackgram, grain yield was significantly and positively correlated with No. of pods and P uptake. However, no significant correlation could be observed between grain yield and N uptake. Values of simple correlation coefficients are given Table 14.

Table 14 - Values of simple correlation coefficients

Sl.No.	Characters correlated	Correlation coefficient
Cowpea		
1	Grain yield x No.of pods/plant	0.5438*
2	No. of pods x N uptake	0.7643*
3	Grain yield x N uptake	0.1022NS
4	Grain yield x P uptake	0.7176*
Blackgram		
1	Grain yield x No.of pods/ plant	0.8849*
2	Grain yield x N uptake	0.2951NS
3	Grain yield x P uptake	0.9178*

* - Significant at 0.05 level

NS - Not significant at 0.05 level

DISCUSSION

DISCUSSION

An investigation was conducted to find out the various toxic factors occuring along with acidity in the upland soils and in rice fallows of Trivandrum and Quilon districts and to screen pulse varieties which can tolerate both acidity and such toxic factors. The need of this approach was to evolve a technology economising inputs and optimising the output of pulse crop grown in low lands in summer fallows. The results obtained from this study, have been discussed in the following pages:-

1. Analysis of the soil samples:

From the results in Table 2 it is evident that the soils collected were moderately acidic to highly acidic in nature. Values of pH as low as 4.4 could be recorded. The two samples collected from rice fallows of Venganoor and Oorupoyka registered the lowest pH of 4.8 and 4.4 respectively. The soil samples collected from uplands registered slightly higher pH values than those collected from rice fallows. This may be because the rice fields are waterlogged at least for a part of the year (during the Virippu and Mundakan season) and so are less aerobic. The reactions taking place during these periods produce reduction products which are less acidic than the oxidation products. In summer months, after the harvest of the second crop of rice, when a pulse crop is grown taking advantage of residual moisture, a progressive decrease in moisture status with concomitant increase in aerobicity of the soils results. Oxidation of the reduction products takes place. These lead to greater acidity than is present originally, when the crop is grown, since the oxidised products are more acidic. Thus there is a progressive decrease in pH of the soils with increase in aerobicity. These have been shown amply under Kerala conditions in the studies conducted by Kurup and Aiyer(1973) and Hassan (1977).

Lime requirement showed wide variation, ranging from 0 tons to 5.2 tons/ha in the uplands and 1.6 tons to 5.8 tons/ha in the rice fallows. Though high lime requirements are indicated, it is neither practicable economically nor feasible to practice such high rates of liming. This aspect has been approached in two ways, firstly by studying the tolerance of varieties to acidity and consequent toxicity parameters with a view to select varieties which are tolerant to high acidity conditions, Secondly attempt has been made to find out the performance of these tolerant and recommended varieties under graded levels of lime to arrive at an optimum combination of variety and liming.

There was not much variation in electrical conductivity. Cation exchange capacity (Table 3) of the collected soil samples was very low ranging from 1.9 to 7.0 me/100 g soil. Contribution of Al to the CEC was more than that of Mn. The KCl exchangeable Al content (Table 4) varied from 155 ppm to 1240 ppm. The maximum concentration of Al had been recorded in the sample collected from Oorupoyka. The recorded values were in conformity with the values reported by Karthikakutty amma et al.(1979) for acid soils. The values of water soluble aluminium ranged from 50 ppm to 555 ppm. These values also were in agreement with the reported values of Karthikakutty amma et al.(1979) for the rice soils of the State.

In the case of Mn, both KCl exchangeable and water soluble Mn (Tables 4 and 5) ranged from 3.4 ppm to 56 ppm and 0.3 ppm to 24.7 ppm respectively. Similar results have been reported by Singh, (1970), Mohapatra and Kibe, (1972) and Rajendran and Aiyer, (1982). Values obtained for exchangeable and water soluble iron ranged from 3 ppm to 24 ppm and 0.5 ppm to 13.25 ppm respectively. These values were in accordance with the values reported by Aiyer et al.(1975) and Rajagopal et al.(1977).

The values of exchangeable Al and Mn as well as water soluble Al and Mn give an indication of the concentrations at which they are present in such soils at the time of germination and growth of pulse varieties. These indications of concentrations of 50 ppm to 555 ppm for Al and 0.3 ppm to 24.7 ppm for Mn were taken into consideration in fixing the concentrations for subsequent screening trials. For this purpose, a preliminary screening trial had been conducted earlier.

2. Preliminary screening trial:-

Observations obtained from the preliminary screening trial (Table 6) indicated that increased concentration of Mn resulted in progressive decrease of the plant height. With a few exceptions, root length and number of roots followed the same pattern. With increased concentration of Mn, decrease in shoot growth has been reported by Chapman,(1975) and Helyar(1978). Hence to obtain clear gradations in treatments in actual screening work, a concentration of 30 ppm was selected.

3. Screening for Al toxicity:solution culture:-

Table 7 summarises the data obtained from the screening experiment. The results indicated that considerable varietal difference existed in all the aspects studied.

Cowpea variety S-488 and blackgram variety Velloor performed satisfactorily under toxic conditions. From the diagram presented as Plate 1, it is clear that these varieties are more tolerant than others tried. Reduced root elongation, proliferation of adventitious roots and increase in number of tertiary roots are the main symptoms of Al toxicity. These could be seen in all the varieties. But the extent of root injury was lesser in the case of tolerant varieties. The Relative Root Length(RRL) was 95.98% in the case of the tolerant variety S-488 (cowpea) and 71.35% in the case of susceptible variety, Pusaphalguni. In the case of blackgram, 91.59% was obtained for Velloor and 71.05% for the susceptible Co-2. Root injury as a result of Al toxicity has been reported by Reid (1976a) in the case of pulses and by Alice Abraham et al.(1979) in the case of rice. In the latter, it has been described that the injury is at the growing end as a result of which new rootlets emerge at points above the tip and this continuous stunting at the growing tip and emergence of roots above this, gives the appearance of a high degree of branching in the case of rice roots injured by Al toxicity.

At 2 ppm concentration, the shoot length, root length, shoot yield and root yield were comparatively better than at 0 ppm. At 0 ppm, the maximum values obtained for root length, shoot length, root yield and shoot yield in the case of cowpea were 20.5 cm, 13.5 cm, 550 mg and 1550 mg respectively and at 2 ppm, the values were 22.4 cm, 15 cm, 550 mg and 1730 mg respectively. At higher concentration of 10 ppm the values were respectively 21.5 cm, 14 cm; 500 mg and 1500 mg.

For blackgram, the values at 0 ppm were 17 cm, 11.5 cm, 340 mg and 540 mg and at 2 ppm were 22.6 cm, 12 cm, 450 mg and 670 mg respectively. At higher concentration of 10 ppm the values were respectively 20.7 cm, 10.4 cm; 270 mg and 570 mg. The increased growth at 2.00 ppm concentrations may be due to the stimulating effect of Al at such low concentrations. The stimulatory effect of minute concentration of Al has been reported by McLean _et al_. (1958) and Anonymous, (1975). This suggests that with a low to moderate rate of liming, it may be possible to keep the concentration of Al to below critical levels for toxicity and near critical levels for stimulation. This result thus lends support to the view that only moderate levels of lime should be advocated for the pulse crop from both scientific point of view of keeping down toxic concentrations of Al and Mn and from the practical stand point of economic feasibility of the recommendation.

From Table 12, it can be noted that phosphorus uptake by the pulse plants was higher than normal. The Al tolerance of S-488 and Velloor varieties can be attributed to the ability of the varieties to absorb and utilize P in the presence of excess Al. Al tolerance of plant species has been related to their ability to absorb and utilize P in the presence of excess Al by Foy and Brown, (1964) and Foy et al.(1974). But Reid et al.(1969) however, expressed the view that Al tolerance is a more genetically controlled mechanism.

Relative Shoot Yield (RSY) and Relative Root Yield (RRY) reflected a wide range in tolerance to Al toxicity. RRY and RSY were 98.03% and 86.8% respectively for cowpea variety S-488 (tolerant) and 34.3% and 36.4% respectively for Pusaphalguni (susceptible). The values for blackgram were 96.5% and 86.7% respectively for tolerant Velloor and 52.5% and 51.2% respectively for susceptible CO-2.

4. Screening for tolerance to Mn toxicity: Sand culture experiment:-

Those varieties which were tolerant to Al toxicity were rated as tolerant to Mn toxicity also based on the sand culture experiment (Table 8). Foy et al.(1973) could obtain a wheat variety which was tolerant to both excess Al and Mn. Differential tolerance of cultivars to

Mn toxicity has been reported by Reid,(1976a), Kag and Fox, (1980) and Ohki et al.(1980).

Reduction in shoot growth, the notable symptom of Mn toxicity, could be obtained at 30 ppm concentration of Mn. Reduction in shoot growth was comparatively lesser in the case of the tolerant varieties than the susceptible ones. The maximum value of shoot yield for cowpea was 1425 mg at 0 ppm and 1085 mg at 30 ppm and 400 mg and 340 mg respectively for blackgram. RSY for S-488 was 84.61% whereas for Pusaphalguni, it was only 28.89%. For Velloor it was 95.24% and for Co-2, 66.66%.

Concentration of Mn in the plant parts was high compared to its concentration in soil (Table 13). Hence tolerance to Mn toxicity may be attributed to the capacity of plants to tolerate high levels of Mn in the plant tops. Horst(1980) opined that Mn tolerance was not related to greater vigour or exclusion of Mn from uptake and translocation but depended mainly on internal tolerance of excess Mn, especially in leaf tissues. The results of the screening trial together with the data on the concentrations of Mn observed in the tops of both tolerant and recommended varieties lend support to this view.

5. Pot culture study:

5.1. Number of pods/plant

Table 10 and Appendix III indicate that between the two cowpea varieties tested, S-488 gave more number of pods than the other variety, New Era. Application of lime had a significant influence on the number of pods. The treatment combination S-488 with 0 kg lime gave yield comparable to that obtained from New Era with an application of 500 kg/ha lime. The number of pods reported by Radhakrishnan and Jebaraj(1982) for cowpea were slightly higher than the values obtained in the present study. The reason for lesser number may be attributed to the severe drought and high atmospheric temperature that prevailed throughout the period of growth of the crop in spite of the fact that the crop was maintained with irrigation. Similar results, as obtained in the present study, have been reported by Varkey and Jacob(1978) for New Era.

In the case of blackgram the variety Velloor performed better than the recommended variety T9. For blackgram, even though the number of pods obtained was slightly lesser, in respect of yield it was more satisfactory than cowpea. Severe drought has affected this crop also. Values obtained by Soudrapandian *et al.*(1977) and

Elizabeth(1983) and Sivan Pillai(1980) in this aspect were slightly higher.

5.2. Haulm yield/plant:

The data in Tables 10 and 11 & appendices III and IV present the haulm yield/plant. Cowpea variety S-488 gave more haulm yield than New Era, but in the case of blackgram, the yield obtained by the two varieties were comparable and not significantly different. Haulm yield was also affected by drought and only lesser values could be obtained in the present study than those reported. (Singh et al.(1978) for cowpea and Elizabeth(1983) for blackgram) Similar results as in the case of the present study have been reported by Sekar and Balasubramanian(1978) but in a different variety.

5.3. Grain yield/plant:

Tables 10,11 and Appendices III & IV indicate that cowpea variety S-488 and blackgram variety Velloor were superior in their ability to yield grain. As a result of a slight decrease in number of pods, grain yield also decreased and so only lower yields in general could be obtained in the present study than those reported by Subramanian et al.(1977) for cowpea and Subramanian et al.

(1977) for blackgram. But comparable yields have been reported by Radhakrishnan and Jebaraj(1982) for cowpea and Soudrapandian et al.(1977) for blackgram, for other varieties.

5.4. Number of nodules/plant:

In the case of nodule development, the two cowpea varieties differed significantly. S-488 could develop more number of nodules for all treatments, the maximum number being obtained for the highest dose of lime (312) and minimum in control pots (46). For blackgram, there was no significant difference between varieties or lime levels of treatment combinations (Table 10 and 11). Similar data on number of nodules were obtained by Elizabeth(1983) for blackgram and Sekar and Balasubramanian(1978).

5.5. Uptake studies:-

a. N uptake/plant:

N uptake/plant was certainly more in the case of S-488 (cowpea) which developed maximum number of nodules. Increased uptake/fixation of nitrogen resulted with increased addition of lime. The data obtained in this aspect when calculated to per hectare basis comes to about 300 kg/ha which is higher than the value recorded by Mathew(1980) for cowpea.

For blackgram, the data presented in Table 12 and appendix IV indicate that there was no significant difference in uptake between varieties or among treatment combinations. Results similar to these obtained in the present study has been reported by Rajendran and Krishamoorthy (1975).

N uptake was higher than P and K for both the crops.

b. P uptake/plant:

From Tables 11 and 12 it can be observed that cowpea variety S-488 and blackgram variety Velloor utilised more P than the other varieties. The maximum values of P uptake were 7.43 g/plant for New Era, 13.26 g/plant for S-488, 8.41 g/plant for T9 and 11.05 g/plant for Velloor. The observed values in g/plant were higher than the reported values in kg/ha (Rajendran and Krishnamoorthy(1975) for blackgram and Singh et al.(1978) for gram).

c. K uptake/plant:

The two selected varieties S-488 and Velloor absorbed more K than the other varieties. The maximum values of K uptake were 9.36 g/plant for New Era, 9.75 g/plant for

S-488, 8.94 g/plant for T9 and 11.79 g/plant for Velloor. The values obtained in the present study in g/plant were slightly higher than the values reported in kg/ha by Rajendran and Krishnamoorthy(1975) for blackgram and Mathew(1980) for cowpea.

5.6. Analysis of plant samples:

a. Mn content:

Mn content in the plant parts was higher than in the soil. But, between treatments there was no significant difference in Mn content for cowpea. But the results indicate that Velloor (blackgram) absorbed, retained and tolerated a higher concentration of Mn in the plant parts. The recorded values were in conformity with the reported values for soybean.(Chapman, 1975).

b. Al content:

The two varieties S-488 and Velloor have absorbed more Al than the other varieties. The maximum values were 785 ppm for New Era, 950 ppm for S-488, 750 ppm for T9 and 700 ppm for Velloor. The observed values were similar to the reported values (Beer, 1969) for crops like clover, spring barley and fodder sugar beet.

4.6. Correlation studies:

Correlations were worked out for grain yield and number of pods, grain yield and N uptake, grain yield and P uptake by cowpea and blackgram. In the case of grain yield and N uptake, significant correlation could not be obtained for cowpea and blackgram. In all other cases, significant correlations were obtained. Grain yield was significantly and positively correlated with P uptake and number of pods in both the crops. These correlations obtained only stress the close relationship between No. of pods and grain yield in pulse crops - cowpea and blackgram. In both the cases no significant correlation could be obtained between grain yield and N uptake even though some workers have got significant correlation (Elizabeth, 1983). Both the crops are N fixing by virtue of their symbiotic association with specific rhizobia. The differential uses of the N fixed for grain yield, for haulm yield, for excretion of N from the root to the surrounding soil medium etc., leads to the situation where there is no correlation between grain yield and nitrogen uptake.

SUMMARY AND CONCLUSIONS

SUMMARY AND CONCLUSIONS

Soils in upland situations and in rice fallows in Kerala are cultivated to pulse crops. The present investigation was conducted to detect the toxic factors causing acidity and locate varieties of cowpea and blackgram that would be most suited to these soil situations with a wide output-input ratio. For this purpose a large number of soil samples from fields cropped to pulse crops were analysed. This included both uplands and rice fallows. Several pulse varieties were screened for their tolerance to various toxic factors and a pot culture study was conducted to assess their productivity.

The significant results obtained and the important conclusions drawn are list below:

1. The analysis of soil samples revealed that the soils are moderately acidic in a majority of cases ~~acidic~~ and highly acidic in 30% of the soils tested.

2. These soils require enormous quantities of lime as amendment. The values of lime requirement vary from 1.6 tons to 5.8 tons.

3. The factors causing acidity in these soils are Al and Mn that are present in fairly high concentrations.

4. Cation exchange capacities of these soils are very low and to some extent contributed by Al and Mn. In several cases more than 15% Al saturation have been recorded.

5. Tolerance of several pulse varieties to Al toxicity was studied by a screening experiment by growing plants in nutrient solution. The observations thus made revealed their differential tolerance. A cowpea variety S-488 and a blackgram variety Velloor were identified as the most tolerant ones.

6. From a similar study the same varieties were found to be tolerant to Mn toxicity.

7. The productivity of S-488 was determined and compared with that of New Era, the recommended cowpea variety. As for blackgram, comparison was drawn between the productivities of Velloor variety and the recommended T9 variety. Understandably, the rate of production increased with the rate of liming in respect of all the pulse varieties under study. The variety S-488 with no lime application yielded as much as new Era with the highest dose of lime, i.e. 500 kg/ha. In respect of haulm yield, S-488 proved to be superior to New Era. This is a significant result indica-

ting possibilities of utilising plant tolerance characters for growing them with low management inputs.

8. The haulm yield of the blackgram varieties Velloor and T9 were not significantly different. Further, the yield increases due to liming appeared to be to more or less on the same incremental rate.

9. A more important aspect of the study, as it appears, is that the selected varieties S-488 and Velloor gave more grain yield than the recommended varieties of cowpea and blackgram respectively under pot culture conditions. Higher doses of lime could not raise the yield significantly in soil (S2) from 0.5 gm/plant indicating thereby that for varieties tolerant to acid soil situations liming can even be dispensed with.

10. The data on number of nodules revealed that the cowpea variety S-488 developed maximum number of nodules with the highest dose of lime. Blackgram varieties, however, did not show any significant difference in their number of nodules consequent to liming.

11. The cowpea variety S-488 fixed and absorbed greater quantities of Nitrogen than the other variety. This was more pronounced in soil from Venganoor (S2). Between the blackgram varieties significant differences in Nitrogen

fixation and absorption could not be observed.

12. Phosphorus uptake was also more for S-488 and Velloor and in the soil from Venganoor (S2).

13. Similar results were obtained for K uptake.

14. With respect to Mn content of the plant parts in cowpea neither varieties nor treatment with lime significantly affected their content.

15. Data on Al content revealed that S-488 and Velloor have taken up more Al than the other varieties.

On the basis of the present study, it can be concluded that the cowpea variety S-488 and the blackgram variety Velloor are better adapted to acid soil situations. From experiments on liming it is observed that at low rate of liming (250 kg/ha) which is less than the recommended rate of liming and in highly acid soils they perform better than the presently recommended varieties such as New Era and T9. These results have to be tested in multilocational trials or in farmer's fields both under upland and rice fallow conditions. These will enable better adoption of the pulse programme by the cultivators of Kerala, who really want a low input crop which will perform fairly well under the acid soil situations.

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APPENDICES

APPENDIX -I ABSTRACT OF ANOVA - COWPEA

Source	No. of pods	Haulm yield	Grain yield	Number of nodules	N Uptake	P Uptake	K Uptake	Mn content	Al content
1	2	3	4	5	6	7	8	9	10
Soil	0.5 NS	3.32 NS	6.93 NS	657.03 NS	101.68 **	51.36 **	129.76 **	4753.15 NS	3003.25 NS
Lime	21.5 **	3.88 NS	0.877 NS	23590.62 **	27.10 **	20.92 **	9.18 **	3401.13 NS	30919.83 NS
Variety	60.5 **	38.51 **	7.31 **	49533.78 **	87.32 **	26.90 **	28.99 **	8256.15 NS	206403.25 *
Soil x Lime	6.83 **	0.26 NS	0.71 NS	2681.53 NS	1.92 NS	1.27 NS	1.46 NS	440.45 NS	265861.4 **
Soil x Variety	8 **	0.11 NS	0.95 NS	11514.04 NS	29.03 *	0.96 NS	7.08 *	3240.1 NS	67570.3 NS
Lime x Variety	4.83 **	3.42 NS	0.17 NS	2834.28 NS	3.67 NS	6.19 NS	6.563 *	2242.12 NS	128694.75 *
Soil x Lime x variety	1 NS	8.48 *	0.15 NS	3484.86 NS	2.33 NS	4.68 NS	2.603 NS	966.13 NS	401939.07 **
Error	0.875 NS	2.34 NS	0.626 NS	2822.59 NS	3.95 NS	1.75 NS	1.573 NS	2261.63 NS	37678.06 NS

** - Significant at 5 per cent and 1 per cent level
* - Significant at 5 per cent level. NS - Not significant

CD for comparing L means at 0.05 level	0.9915	-	-	56.3157	2.107	1.402	1.329	-	-
CD " S X L means	1.402	-	-	-	-	-	-	-	290.98
CD " S X V means	0.9915	-	-	-	2.107	-	1.329	-	-
CD " V X L means	1.402	-	-	-	-	-	1.88	-	290.98

APPENDIX-II BLACKGRAM

Source	No.of pods	Haulm yield	Grain yield	Number of nodules	N Uptake	P Uptake	K Uptake	Mn content	Al content
Soil	790.03**	11.4*	24.68**	318.78NS	31.11NS	106.25**	41.7**	968NS	178503.25
Lime	169.95**	9.593*	3.51NS	2052.78NS	36.31NS	18.88**	6.65NS	3262NS	186261.5**
Variety	712.53**	7.31NS	24.68**	1937.53NS	27.84NS	59.32**	19.36**	11250**	226128.25*
Soil x Lime	13.03NS	0.42NS	0.32NS	585.36NS	11.31NS	0.44NS	2.76NS	1929.33NS	179936.42**
Soil x variety	247.52**	0.69NS	3.57NS	63.29NS	10.27NS	0.23NS	0.003NS	6272*	6903NS
Lime x variety	17.86*	0.62NS	1.25NS	789.61NS	16.22NS	2.92NS	12.36*	3563.33NS	66111.5NS
Soil x Lime x Variety	8.54NS	0.63NS	0.45NS	2046.53NS	23.54NS	1.09NS	10.09*	260NS	93103.17*
Error	4.41NS	2.316NS	1.16NS	3277.66NS	10.79NS	2.009NS	2.643NS	1109NS	21084.37NS

** - Significant at 5% and 1% levels

* - Significant at 5% level

NS - Not significant

	No.of pods	Haulm yield	Grain yield	Number of nodules	N Uptake	P Uptake	K Uptake	Mn content	Al content
CD for comparing L means at 0.05 level	2.226	1.61	-	-	-	1.502	-	-	153.91
CD " Sx L means	-	-	-	-	-	-	-	-	217.67
CD " S x V means	2.226	-	-	-	-	-	-	35.299	-
CD " V x L means	3.148	-	-	-	-	-	2.437	-	-

APPENDIX- III
COWPEA

(a) No. of pods/plant

	S x V table for means			S x L table for means			
	Newera	S-488	Total	0	250	333	500 kg/lime/ha
Soil No. 72(S1)	2.125	5.875	4	2.75	3.75	4.75	4.75
Soil No. 58(S2)	2.875	4.625	3.75	1.75	2.25	3.75	7.25
	2.5	5.25		2.25	3	4.25	6
V x L table for means C1				1.75	2	2.5	3.75
C2				2.75	4	6	8.25

(b) Haulm yield/plant

	S x V table for means			S x L table for means			
	Newera	S-488	Total	0	250	333	500 kg/ha lime
Soil No. 72	4.39	6.7	5.545	4.83	5.53	5.15	6.68
Soil No. 58	5.15	7.23	6.19	6	5.93	5.73	7.1
	4.77	6.965		5.415	5.73	5.44	6.89
V & L table for means Newera				4.65	5.38	3.93	5.13
S-488				6.18	6.08	6.95	8.65

Appendix -III contd.

(c) Grain yield/plant

S x V table for means / S x L table for means

	Newera	S-488	Total	0	250	333	500 kg lime/ha
Soil No.72	0.5	1.112	0.806	0.725	0.8	0.825	0.875
Soil No.58	1.087	2.388	1.738	1.675	1.175	1.475	2.625
	0.794	1.75		1.2	0.988	1.15	1.75

V x L table for means

	0	250	333	500 kg lime/ha
New Era	0.6	0.675	0.75	1.15
S-488	1.8	1.3	1.55	2.35

(d) No. of nodules/plant

S x V table for means / S x L table for means

	Newera	S-488	Total	0	250	333	500 kg lime/ha
Soil No.72	76	192.62	134.31	48.75	143.75	121.75	223.5
Soil No.58	123	163.75	143.38	97.5	138.75	148.75	188.5
	99.5	178.18		73.125	141.0	135.25	206.0

V x L table for means

	0	250	333	500 kg lime/ha
Newera	58.5	87.75	100.5	151.25
S-488	87.75	194.25	170	260.75

(e) N-uptake/plant

Sx V table for means | S x L table for means

	Newera	S-488	Total	0	250	333	500 kg lime/ha
Soil No.72	7.47	12.68	10.08	8.74	9.75	9.58	12.22
Soil No.58	5.81	7.21	6.51	5.12	4.90	6.26	9.75
	6.64	9.95		6.94	7.35	7.92	10.99

V & L table for means

	0	250	333	500 kg lime/ha
Newera	5.87	5.45	5.41	9.82
S-488	8.0	9.15	10.43	12.15

(f) P uptake/plant

S x V table for means | S x L table for means

	Newera	S-488	Total	0	250	333	500 kg lime/ha
Soil No.72	4.31	5.79	5.05	4.16	4.81	4.24	6.99
Soil No.58	6.49	8.67	7.58	5.79	6.94	7.27	10.35
	5.4	7.23		4.97	5.87	5.75	8.67

V & L table for means

	0	250	333	500 kg lime/ha
Newera	5	5.48	4.3	6.82
S-488	4.94	6.26	7.21	10.51

(g) K Uptake/plant

S x V table for means / S x L table for means

	Newera	S-488	Total	0	250	333	500 kg lime/ha
Soil No.72	5.99	8.83	7.41	6.42	6.81	7.21	9.2
Soil No.58	2.9	3.86	3.38	2.35	2.58	4.34	4.26
	4.44	6.35		4.39	4.69	5.78	6.73

V x L table for means

	0	250	333	500 kg lime/ha
Newera	2.49	4.35	4.23	6.7
S-488	6.28	5.03	7.32	6.76

(h) Mn content in the plants (ppm)

S x V table for means / S x L table for means

	Newera	S-488	Total	0	250	333	500 kg lime/ha
Soil No. 72	201.5	189.5	195.5	221	193	190	178
Soil No. 58	246	193.75	219.87	241.5	223	231	184

V x L table for means

	0	250	333	500 kg lime/ha
Newera	246	234	241	174
S-488	216.5	182	180	188

(i) Al content in the plants (ppm)

S x V table for means / S x L table for means

	Newera	S-488	Total	0	250	333	500 kg lime/ ha
Soil No.72	496.25	366.25	431.25	145	387.5	435	430
Soil No.58	225	676.25	450.63	627.5	317.5	500	357.5
	360.63	521.25		386.25	352.5	467.5	393.75

V & L table for means

	0	250	333	500
Newera	370	387.5	235	450
S-488	402.5	645	700	337.5

APPENDIX IV

BLACKGRAM

a) No. of pods/plant

	Sx V table for means			S x L table for means			
	Newera	S-488	Total	0	250	333	500 kg lime/ha
Soil No.72	11	14.88	25.88	7.75	10	14.25	19.75
Soil No.58	15.38	30.38	45.76	17.25	22	26	26.25
	26.38	45.26		12.5	16	20.12	23.0

V x L table for means					
	Newera	7.5	9.5	17.25	18.5
	S-488	17.5	22.5	23	27.5

b) Haulm yield/plant

	S x V table for means			S x L table for means			
	Newera	S-488	Total	0	250	333	500 kg lime/ha
Soil No.72	2.11	3.36	2.74	2.03	2.25	2.68	4
Soil No.58	3.6	4.26	3.94	3.13	2.98	3.8	5.83
	2.86	3.81		2.58	2.61	3.24	4.91

V x L table for means					
	Newera	2.2	2.48	2.48	4.28
	S-488	2.95	2.75	4.0	5.55

Appendix IV contd.

c) Grain yield/plant

S x V table for means / S x L table for means

	New Era	S-488	Total	0	250	333	500 kg lime/ha
Soil No.72	1.08	2.16	1.62	0.9	1.45	2.2	1.925
Soil No.58	2.16	4.59	3.375	2.7	2.675	4	4.125
	1.62	3.375		1.8	2.063	3.1	3.025

V x L table for means

	0	250	333	500 kg lime/ha
Newera	1.35	1.3	2.15	1.65
S-488	2.225	2.825	4.05	4.4

d) No. of nodules/plant

S x V table for means / S x L table for means

	Newera	S-488	Total	0	250	333	500 kg lime/ha
Soil No.72	75.5	88.25	81.875	65.75	64	87	110.75
Soil No.58	79	97.375	88.188	94	68.25	93.25	97.75
	77.25	92.81		79.88	66.13	90.13	104

V x L table for means

	0	250	333	500 kg lime/ha
Newera	83.5	49	87.5	89
S-488	76.25	83.25	92.75	119

Appendix IV contd.

(e) N Uptake/plant

S x V table for means | S x L table for means

	Newera	S-488	Total	0	250	333	500 kg lime/ha
Soil No.72	11.49	12.16	11.83	12.35	9.09	11.99	13.74
Soil No.58	8.32	11.32	9.82	7.02	8.54	10.07	13.65
	9.91	11.74		9.69	8.82	11.03	13.7

V x L table for means

		0	250	333	500 kg lime/ha
	Newera	9.01	9.51	10.05	10.93
	S-488	10.36	8.12	12.01	13.65

(f) P uptake/plant

S x V table for means | S x L table for means

	Newera	S-488	Total	0	250	333	500 kg lime/ha
Soil No.72	2.41	5.30	3.86	2.34	2.98	4.56	5.55
Soil No.58	6.22	8.78	7.5	6.22	6.33	7.73	9.73
	4.31	7.04		4.28	4.66	6.15	7.64

V x L table for means

		0	250	333	500 kg lime/ha
	Newera	3.49	3.76	4.33	5.69
	S-488	5.06	5.55	7.96	9.58

Appendix IV contd.

(g) K uptake/plant

	S x V table for means			S x L table for means			
	Newera	S-488	Total	0	250	333	500 kg lime/ha
Soil No.72	6.25	7.83	7.04	6.95	7.04	5.6	8.58
Soil No.58	3.99	5.52	4.76	3.59	4.63	4.97	5.84
	5.12	6.68		5.27	5.84	5.28	7.21
V x L table for means		Newera		4.65	6.68	4.05	5.10
		S-488		5.89	4.99	6.52	9.32

(h) Mn content in the plants

	S x V table for means			S x L table for means			
	Newera	S-488	Total	0	250	333	500 kg lime/ha
Soil No.72	204.5	195	199.75	211	174	183	231
Soil No.58	243.5	178	210.75	244	212	185	202
	224	186.5		227.5	193	184	216.5
V x L table for means		Newera		226	216	191	263
		S-488		229	170	177	170

Appendix IV contd.

i) Al content in the plants

S x V table for means — S x L table for means

	Newera	S-488	Total	0	250	333	500 kg lime/ha
Soil No.72	287.5	90	188.75	337.5	90	187.5	140
Soil No.58	407.5	268.75	338.12	395	225	32.5	700
	347.5	179.38		366.25	157.5	110	420

V x L table for means

	0	250	333	500 kg lime/ha
Newera	575	150	190	475
S-488	157.5	165	30	365

THE NATURE OF ACIDITY IN UPLAND AND RICE FALLOWS IN RELATION TO RESPONSE OF PULSE CROP TO LIMING

BY

SUDHARMAI DEVI. C. R.

ABSTRACT OF A THESIS
submitted in partial fulfilment of the
requirement for the degree
MASTER OF SCIENCE IN AGRICULTURE
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Kerala Agricultural University

Department of Soil Science and Agricultural Chemistry
COLLEGE OF AGRICULTURE
Vellayani - Trivandrum

1983

ABSTRACT

Soils over vast areas of uplands and rice lands in Kerala are acidic in nature. High concentrations of Al and Mn often limit the productivity of pulses when grown in these areas. The present investigation was aimed at detecting the toxic factors causing acidity and locating suitable varieties of cowpea and blackgram suited to these soil situations. It was further programmed to find out the optimum levels of lime that would be required to arrive at a low input management programme for pulses. For this purpose a large number of soil samples were analysed. Several pulse varieties were screened in respect of their tolerance and a pot culture study was conducted to assess their productivity, the results of which are summarised and appropriate conclusions drawn.

The collected soils were acidic in nature, the factors causing toxicity being high concentration of Al and Mn. The soils require large amount of lime as amendment. Cation exchange capacity of these soils is very low and to some extent contributed by Al and Mn.

Screening experiments were conducted to select varieties which are tolerant to Al and Mn toxicity. As a

result, S-488, a cowpea variety and Velloor, a blackgram variety were selected as tolerant ones.

Comparative assessment of the yielding ability of the selected varieties, with the recommended varieties New Era (cowpea) and T9 (Blackgram) revealed that they could yield as much as or even better than the recommended varieties. The recommended varieties require high doses of lime for a substantial yield whereas the selected varieties could give economic yield with practically no liming.

The observations on number of pods, grain yield, haulm yield and number of nodules revealed that the two selected varieties could excel the others in these aspects.

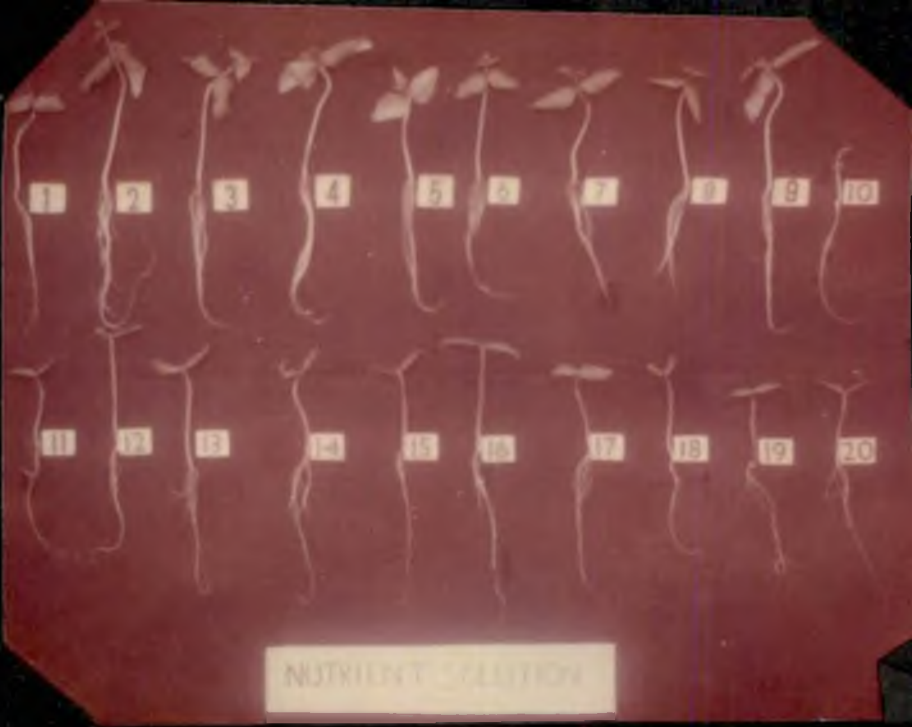
Uptake studies indicated that the increased yield in the case of the selected varieties is mainly due to the enhanced uptake and fixation of N and uptake of P and K.

From the results of the study, it was concluded that the cowpea variety S-488 and the blackgram variety Velloor can be cultivated successfully under acid soil conditions. They possess the ability to give economic yields with little or no liming. These results have to be tested in farmers' fields to evolve a low input management strategy for pulse cultivation in garden lands as a vegetable in kharif season and in the rice fallows in summer season.

1. Pulse plants grown in nutrient solution to screen varieties for aluminium tolerance.

2. Growth of the plants in nutrient solution, when 2 ppm Al was given additionally.

3. Growth of the plants in nutrient solution, when 10 ppm Al was given additionally.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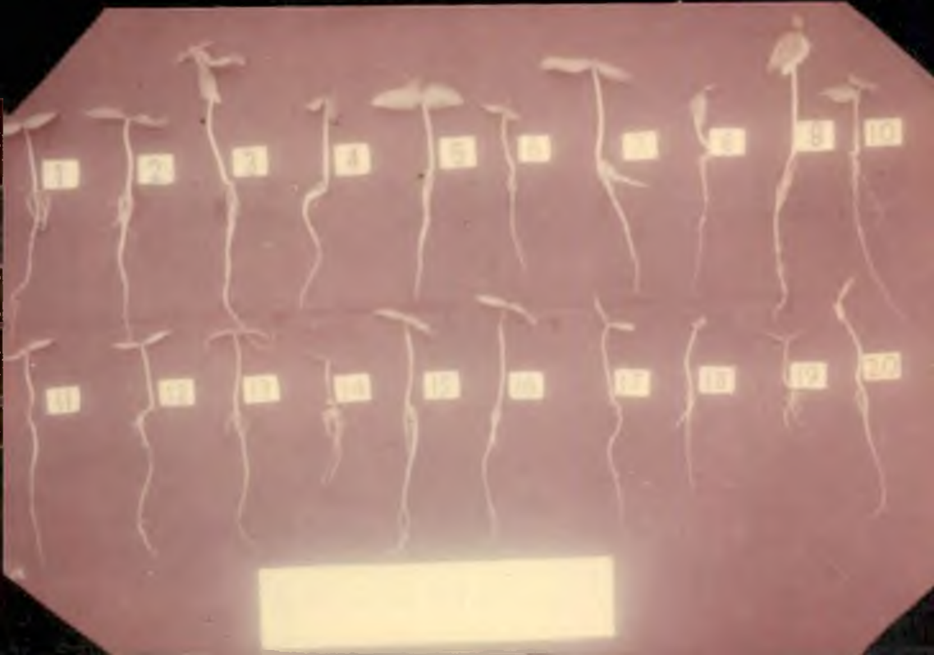
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