18 Differential Species and Varietal Tolerance to Soil Acidity in Tropical Crops and Pastures

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I INTRODUCTION

Most acid and infertile soils of humid tropics can be readily modified with lime and fertilizers and made quite productive for any climatically adapted crop

Many of these soils have excellent physical properties are well drained and are found in landscapes characterized by smooth to gently rolling topography None the less agricultural production in such soil areas continues at a low level and they contribute very little to the development process in Latin America This is doubtless due to many geographical historical cultural social and above all economic factors The costs of fertilizer and lime on the farm are high and crop prices are low because of distance to market and lack of adequate transportation arteries Inputs will always be costly until market infrastructures are developed

How can the ever increasing demand for land and employment for more and better food for rural tropical families and exploding urban populations be met? One approach to the problem of low soil productivity which does not require excessive lime and fertilizer is through the selection of species which are better adapted to the native soil environment and require a minimum of high cost inputs Many species are well adapted to extremely acid soil conditions and are also efficient at absorbing native soil nutrients Mango citrus cashew brazil nut and rubber are among the more acid tolerant tree crops There are many acid tolerant forage grasses and legumes and a number of long season starchy food crops such as cassava tropical yams and certain plantains Tropical farmers have made use of these species for centuries both for subsistence and commercial production There is however a general shortage of cereal grains and food legumes as a basis for adequate diets

In recent years a number of annuals including cereals and legumes have been shown to vary markedly between varieties and cultivars in regard to acid soil tolerance However no systematic effort has been made to screen tropically adapted species for agronomically acceptable material nor for sources of germ plasm for crop improvement programs There is no other region in the world where such varietal and species differences could be more important than in the humid tropics of the Americas

The CIAT soils program in cooperation with CIAT commodity programs initiated a screening program in 1971 at Carimagua an ICA

(Instituto Colombiano Agropecuario) experiment station in the savannah covered eastern plains of Colombia The Station is located at 4°30 North latitude and 71°30 West longitude at an elevation of 150 175 meters above sea level The mean annual temperature is estimated at 27°C The rainfall distribution from June of 1972 to September 1973 is shown in Figure 1 The trials including cassava field beans maize rice and cowpeas have been conducted on an Oxisol with the characteristics shown in Table 1

Large plots were established with lime levels of 0 0 5 2 and 6 tons/hectare The 0 5 ton level is sufficient to supply calcium and magnesium as nutrients but does not greatly alter pH nor exchangeable Al levels The 6 ton level is sufficient to neutralize most of the Al and raise the pH to approximately 5 3 The intermediate level neutralizes 30 35% of the Al while raising the pH to 4 7 (Figure 2)

In addition to annual crops a number of forage grasses and legumes are under study as part of a search for economically feasible solutions to the problem of extremely low levels of livestock production on natural savannahs under present management There is no doubt that the majority of the allic[1/] soils of the tropics will remain in pastures for a long time to come thus justifying much greater efforts than are at present being made in the area of pastures and livestock management in the tropics

II METHODS AND RESULTS

The methodology of the first year of screening for acid soil tolerance are summarized in Figure 3 There was sufficient genetic variability in most species screened to warrant further trials The results of these trials have been summarized for 1972 and 1973 and are presented below for maize rice grain legumes cassava and forage species Other species including peanuts and sorghum have received only limited attention and are not included in this report

III RESULTS WITH MAIZE

Initial screening of maize at Carimagua was carried out at all four lime levels There was little or no production without lime and near normal growth with 6 tons/ha The extremes were eliminated in succeeding tests and the 0 5 tons/ha level is now used to indicate tolerance to low pH and high aluminum levels and the 2 tons/ha level to show genetic potential at about the highest economically feasible lime treatment for this zone given present freight costs and crop prices

The step wise selection procedure is based on open pollination partial selection pressure on the male pollinators and a minimum input or professional time due to the distance of the Carimagua experiment station from CIAT s headquarters in Palmira Two hundred lines varieties hybrids or single ear selections are planted each season under the two lime levels in the introduction phase with no replication (Phase 1) These include new introductions from outside progeny from the CIAT or other

1/ Allic soils are those in which aluminum is the dominant exchangeable cation

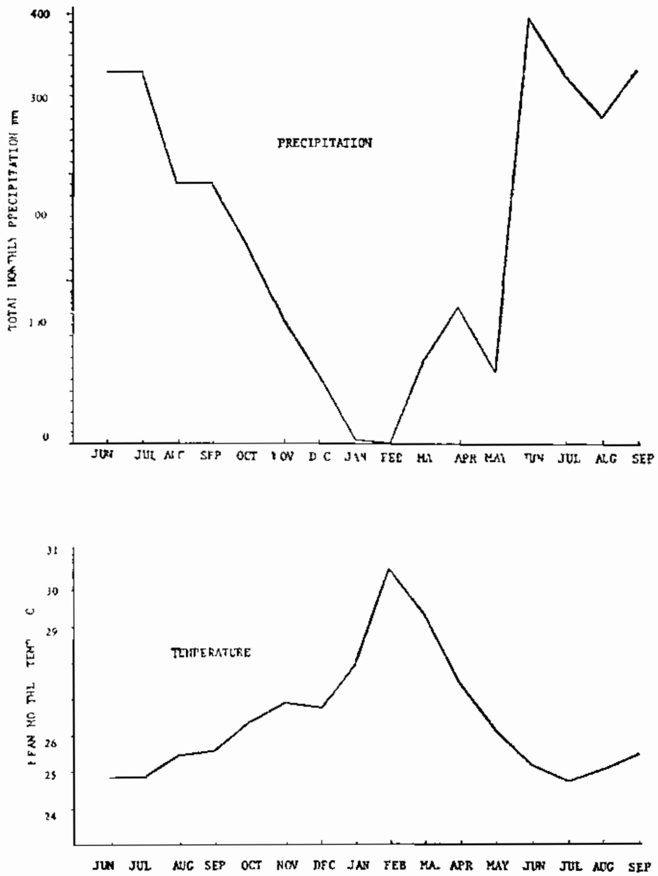


Figure 1 Precipitation and temperature in Carimagua from June 1972 to September 1973

Table 1 —Characteristics of an Oxisol from Carimagua Llanos Orientales Colombia (0 20 cm)

pH	O M	B y II P	Al	Ca	Mg	K	ECEC	Texture
		ppm			meq/100			
4 5	5	5	3 5	0 5	0 3	0 08	4 5	Clay loam

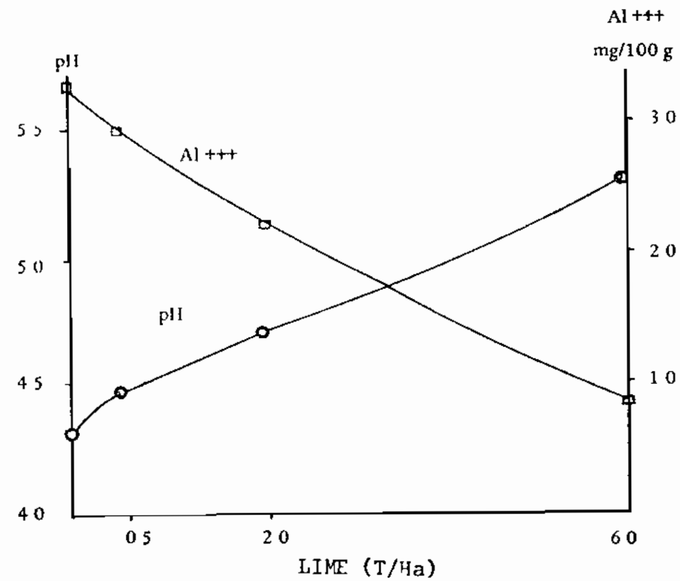


Figure 2 The effect of lime on pH and Al+++ in the Carimagua Oxisol

breeding programs or single ears selected from the previous cycle in Carimagua Fifty of the best among these introductions are planted in the following season in single row plots two replications at the 2 tons/ha lime level (Phase 2) From this replicated yield trial the five best entries are selected for semi commercial testing (1/10 ha) on the station at 2 tons/ha lime level (Phase 3) The best white and best yellow variety from this semi commercial test are distributed in the zone as experimental materials for on farm testing of yield potential (Phase 4)

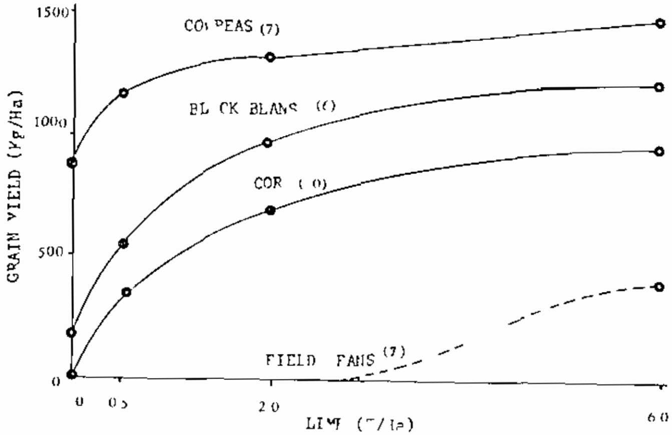


Figure 3 The effect of lime on the grain yields of species screened in 1971 at Carimagua The number in parenthesis indicate the number of entries of each species

Selection criteria in each phase include vigor and plant growth potential on these soils resistance to cutworm (*Spodoptera sp*) and stalk borer (*Diatraea spp*) resistance to foliar and ear diseases and final yield Where possible selection pressure is placed on all fields by detasseling undesirable individual plants previous to anthesis to prevent their genetic contribution to the next generation Seed for each phase is harvested from selected plants in selected rows or plots even though there is no hand control of pollination Orientation of plots in the field relative to prevalent winds assures pollen flow from more selected material (Phase 3) toward the introductions (Phase 1)

These four selection steps are carried out concurrently in each season 2 cycles per year with germ plasm moving through the four steps as quickly as possible During the second season of 1973 for example the varieties selected from phase 1 to plant in phase 2 ranged in yield from 3 3 6 0 tons/ha based on the single row plots (2 8 m²) The best yellow and white varieties selected in phase 2 for planting in phase 3 produced about 3 7 tons/ha (plot size 28 m) The best yellow variety in phase 3

during the second semester produced 3 2 tons/ha in a semi commercial field of 500 m² Seed of this variety will be tested on farms as an experimental material and compared to the white brachytic selected and distributed after the 1972 tests in Carimagua (Figures 4 and 5)

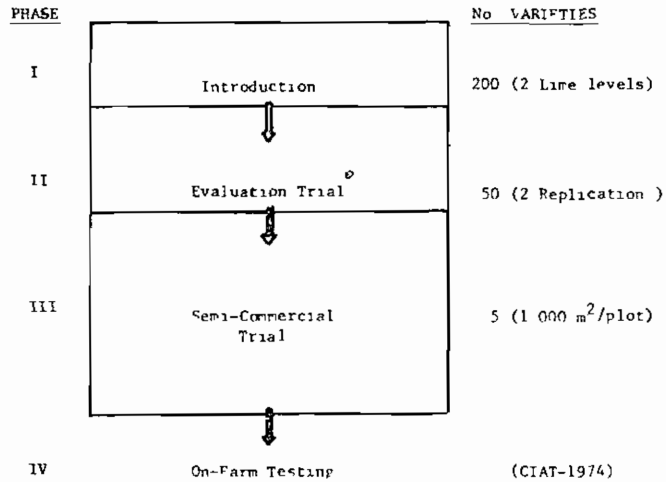


Figure 4 Crop improvement scheme

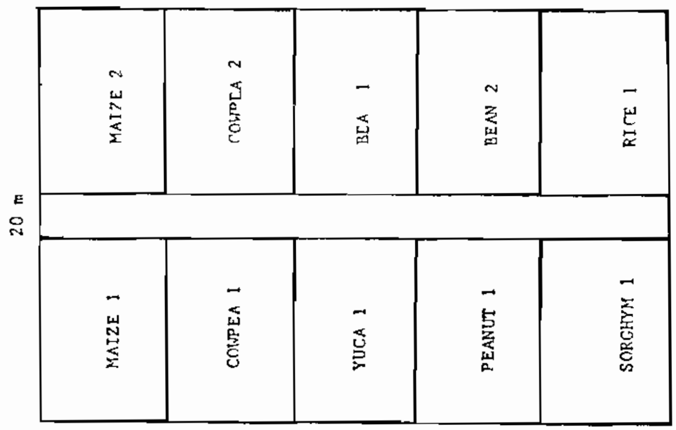


Figure 5 On farm testing of several food crops

IV RESULTS WITH RICE

In 1972 two semidwarf varieties (CICA 4 and IR 8) and two traditional tall varieties (Monolaya and Blue Bonnet 50) were seeded in a lime x phosphorus experiment at Carimagua The tall varieties responded to the first increment of 0 4 tons/ha lime but there was no positive response to higher lime applications

Yields of the semidwarf varieties were essentially nil without lime There was a very marked response to 0 4 and 4 tons/ha and slight response to 16 tons/ha (Figure 6) Figure 7 summarizes the results of a similar trial conducted in 1973 with Colombia 1 and IR 5 replacing Monolaya and CICA 4 IR 5 is mucho more resistant to blast under Llanos field conditions than CICA 4 or IR 8 The negative effect of higher levels of lime on yields of Colombia 1 is due primarily to increased lodging and bird damage

In order to identify Al tolerant varieties nearly one thousand lines from the IRRI collection and CIAT s advanced breeding lines were screened in the field at Carimagua in 1973 at lime levels of 0 5 and 6 ton/ha while nearly 40% of the varieties were also screened at 0 and 2 tons/ha At about 6 weeks of age they were visually evaluated for resistance to soil acidity and blast *(Pyricularia oryzae)* One replication was harvested at maturity for grain yield

Since field screenings are time consuming and their final results are affected by soil variations differential resistance to blast and bird damage a rapid greenhouse screening test for Al tolerance was developed Rice seedlings are grown in nutrient solutions at two Al levels of 3 and 30 ppm At three weeks of age root lengths are measured and the ratio of root length at 30 ppm Al over that at 3 ppm Al is used as an indication of Al tolerance This ratio is called relative root length (RRL) The varieties were grouped into four classes of Al tolerance according to their RRL value At present the screening of 850 varieties in the greenhouse is nearly completed A correlation analysis of RRL values of 210 varieties with their respective grain yields obtained in a field screening in 1972 resulted in a correlation coefficient of 0 64 as shown in Figure 8 Since grain yields were affected by many factors other than soil acidity such as blast and bird damage the correlation of field results and the greenhouse test seems very good A correlation analysese of RRL vs plant height gave an r=value of 0 49 indicating that in general tall varieties were more Al tolerant than short strawed varieties The same has been observed in the field The rice varieties commonly used in Colombia can be arranged in the following order of decreasing Al tolerance Colombia 1 Monolaya Blue Bonnet 50 IR 5 IR 22 IR 8 and CICA 4 The floating rice varieties are more tolerant than IR 5 while CIAT's breeding lines 1 and 8 are similar in tolerance to IR 8

V RESULTS WITH GRAIN LEGUMES

A preliminary trial of beans *(Phaseolus vulgaris L)* and cowpeas *(Vigna sinensis)* in 1971 indicated a very large difference in tolerance to soil acidity between cowpeas and beans and between black and non black

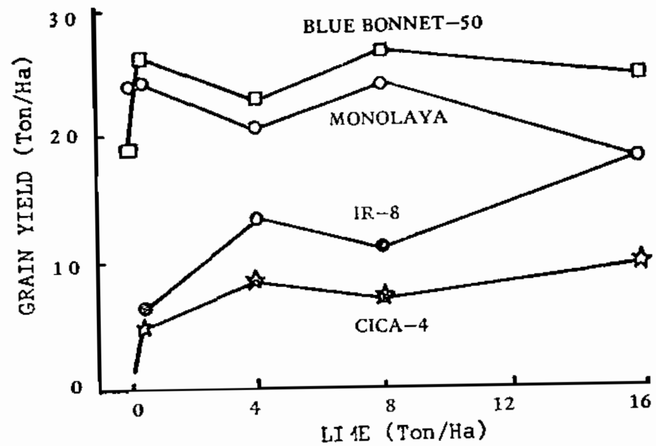


Figure 6 The effect of lime applications on the grain yields of four rice varieties grown under upland conditions in Carimagua in 1972

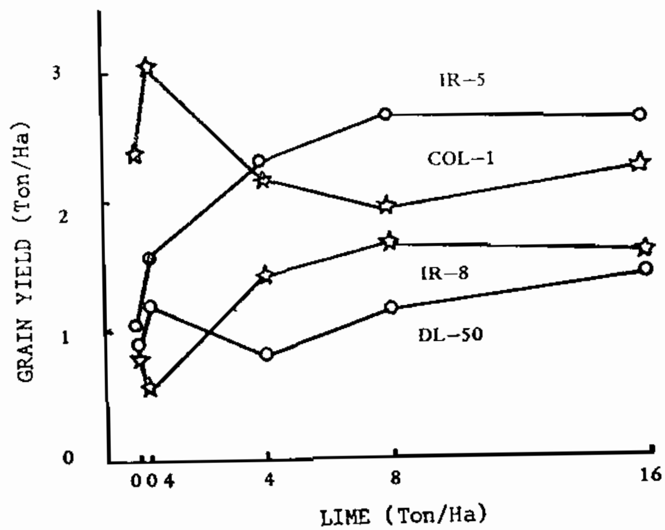


Figure 7 The effect of lime applications on the grain yields of four rice varieties grown under upland conditions in Carimagua in 1973

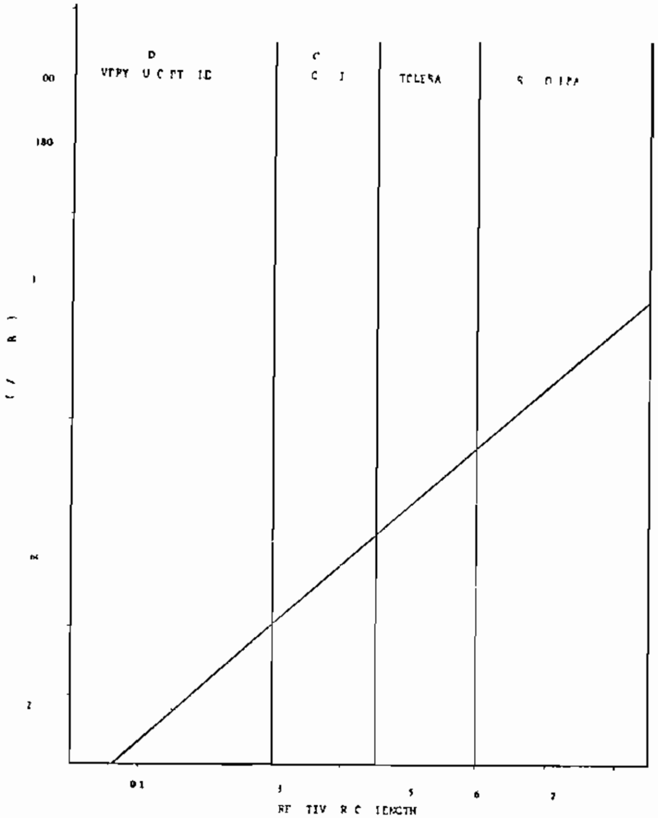


Figure 8 The correlation of RRL values (relative root length) determined in greenhouse solution culture trials and grain yields obtained in field trials of 340 lines and varieties of rice at Carimagua

beans Figure 3 summarizes the results Following this lead a collection of 50 varieties of black beans 2 soybeans and 20 cowpeas were screened in 1972 The collection was seeded at the same four lime levels of 0 0 5 2 and 6 tons/ha

Figure 9 shows the average response of the species to lime applications It is clear that all species responded to liming but the black beans and soybeans responded up to 6 tons/ha while the cowpeas responded significantly only to the first increment of 0 5 tons/ha

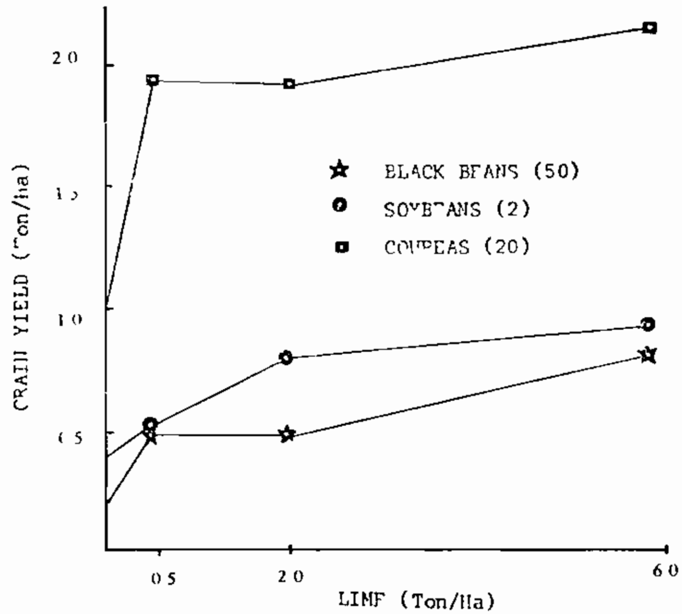


Figure 9 The effect of lime applications of grain yield of three legume species grown in Carimagua Number in parentheses indicate number of collections tested

A collection of 100 non black beans 125 black beans and 45 cowpeas was screened in Carismagua at 0 5 and 2 tons/ha lime levels during 1973 The results of the harvest just completed are very similar to the 1971 and 1972 results Very few entries of non black beans show any promise of aluminum tolerance

Cowpeas are of special interest as a source of high quality protein (dry grain) for human and small animal diets as an excellent vegetable In addition to their tolerance to soil acidity they have a high yield potential Several cultivars have yielded over 2 5 tons/ha in small plots one cultivar yielded over 3 0 tons Figure 10 compares the yield of an outstanding black cowpea of Indian origen to the average of 20 entries

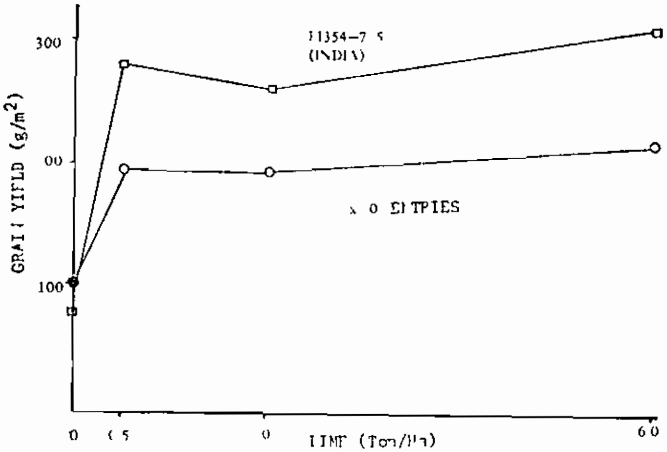


Figure 10 The effect of lime on Cowpea Grain yields in Carimagua showing the average for 20 entries and the highest yielding individual entry

VI RESULTS WITH CASSAVA

In 1972 135 cultivars were screened primarily for acid soil tolerance The entire field was seriously affected by a number of diseases including super elongation cercospora and bacteriosis However initial development was normal and plants remained essentially disease free during the first three months

The following observations were made during this early period before differences were masked by disease symptoms

1 Most of the cultivars responded visually to lime up to 2 tons/ha

2 Some cultivars performed equally well at 0 0 5 and 2 tons/ha

3 Most of the cultivars were very adversely affected by the 6 ton level of lime and some even by the 2 ton level this was thought probably due to lime induced micronutrient deficiencies There were however exceptions some cultivars were not affected by the high level of lime perhaps indicating differential varietal tolerance to low micronutrient levels

At four months after planting samples of the first fully expanded leaves were taken from four cultivars two of which were severely affected by lime levels of 2 and 6 tons/ha and two of which were apparently unaffected by the higher levels of lime It was thought that leaf content of nutrients would help identify the cause of the negative lime effect observed

The results of foliar analysis showed a very marked effect of lime on mineral content of leaves The very large positive effect of the first increment (0 5 tons/ha) on Zn Cu Mn and K was followed by an even larger negative effect at levels of 2 and 6 tons The role of lime at low application rates appears to be more as a fertilizer than as a soil amendment a source of calcium and magnesium At higher levels its effect as a soil amendment becomes evident as pH is increased and leaf content of Mn Zn Cu and K is decreased These results are different from those observed with forage legumes in the greenhouse primarily at the first level of lime where Zn and Mn content of forage was lowered even at 150 kg/ha level of lime This can be seen by comparing Figures 11 and 13

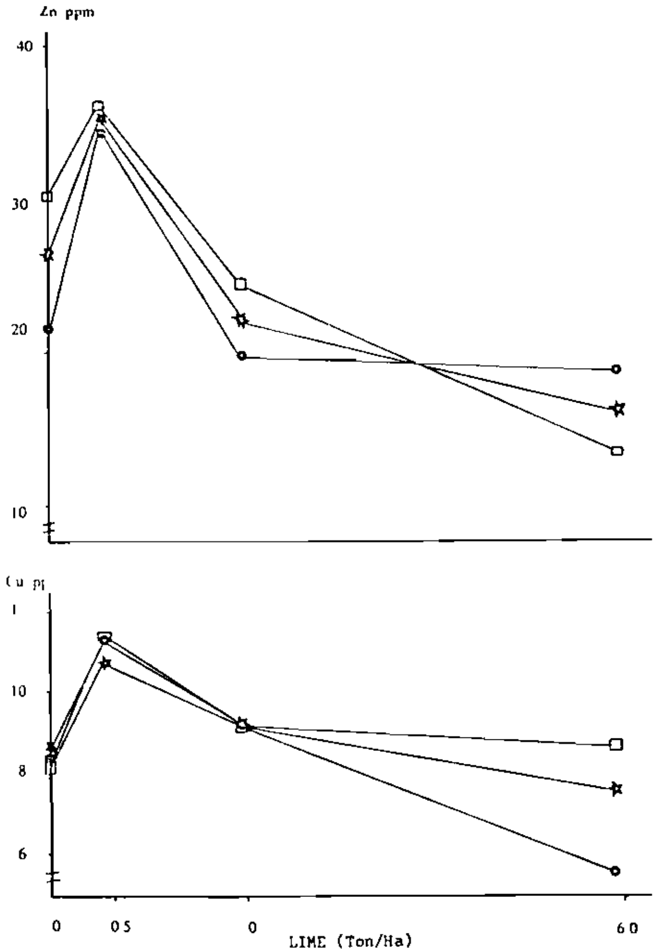
The final root yields of most cultivars in the 1972 trial were low because of disease However the effect of lime was very marked as can be seen in Figure 12 It is interesting to note that each of the four varieties sampled for foliar analysis responded in a different way to lime CMC 169 responded to lime like many other crops with maximum yield at 6 tons/ha CMC 198 responded very little to lime at any level CMC 87 responded slightly to the first increment but yields dropped to essentially nil with six tons/ha CMC 128 yielded almost nothing without lime responded very markedly to 0 5 tons/ha after which yields dropped to the original level at 2 tons/ha and there was no yield at 6 tons/ha

VII RESULTS WITH FORAGE LEGUMES AND GRASSES

A series of greenhouse experiments was conducted in 1973 at CIAT Palmira to determine optimum levels of lime for four legumes and three grasses on a Carimagua Oxisol Lime levels were 0 150 1000 2000 and 4000 kg/ha of $CaCO_3$ equivalent using the oxides of Ca and Mg and maintaining the same Ca Mg ratio (10 1) used in most of our liming experiments Figure 13 shows the results of the first cut for the four legumes Maximum yield was achieved for all four at 150 kg lime/ha The shape of the curves is most unusual probably reflecting various functions of lime The first response is likely a nutrient response to Ca and/or Mg The effects of lime treatment on the Mn Zn P and K contents of the forage are shown in Figure 14 The effect of 150 kg equivalent of CaCO on Zn and Mn is surprisingly large

The depression in yield at 1000 and in some cases 2000 kg/ha is similar to results obtained on the same soil with cassava in 1972 The high yields at 4 000 kg/ha are difficult to explain

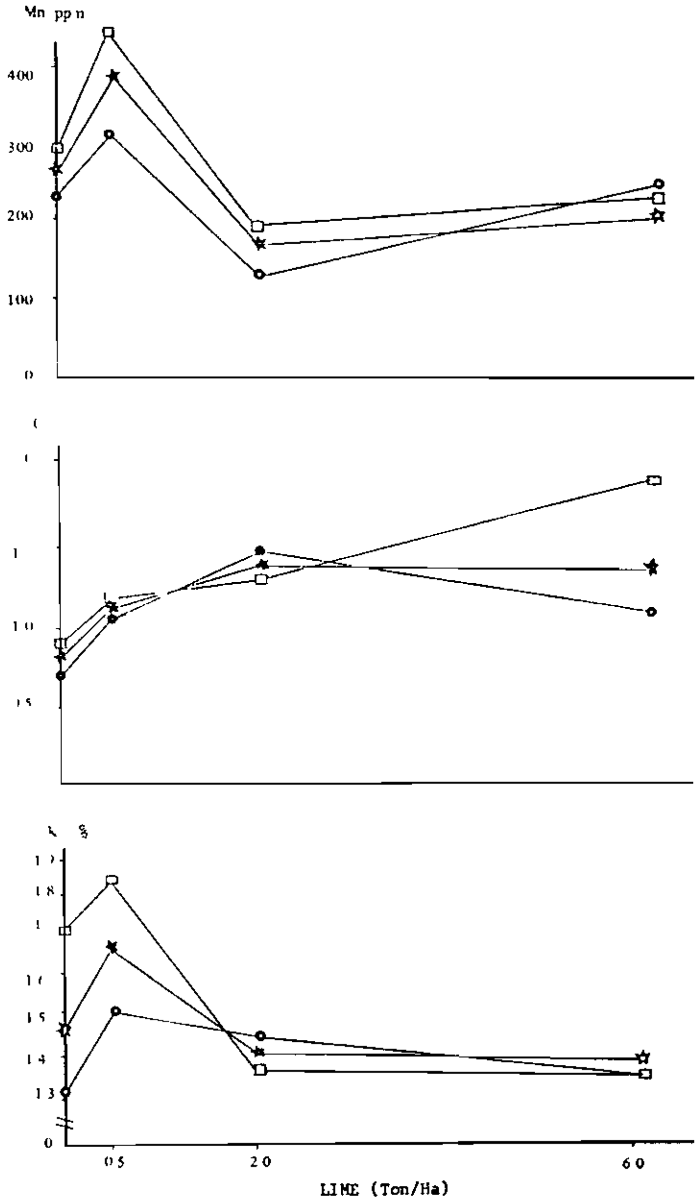
The negative effects on dry matter yield of the 1 000 and 2 000 kg/ha lime applications were not observed in the second cutting As in the first cutting maximum or nearly maximum yields were achieved with 150 kg/ha Figure 15 shows the effect of lime on dry matter yield of the four legumes averaged for all harvests

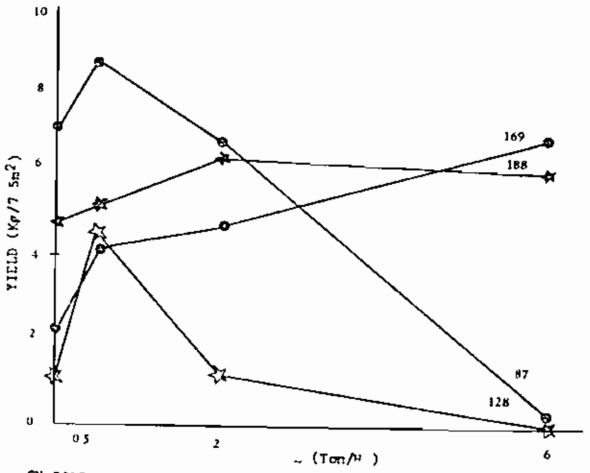


☆ AVERAGE OF FOUR VARIETIES
○ AVERAGE OF TWO VARIETIES LEAST AFFECTED BY 6 Ton LIME/Ha
□ AVERAGE OF THE TWO VARIETIES MOST AFFECTED BY 6 Ton LIME/Ha

Figure 11 The effect of lime applications on the Zn Cu Mn Ca and K content of cassava leave samples four months after planting.

F gure 11 (Cont)





SY BOLS TYP S OF RE PO ISE

- TYPE I NORMAL RFS ONSE
- TYPE II LITTLE PO TIVE OR NEGAT VE RESPO E
- TYPE III LITTLE POSIT VE RESPONSE MARKED NEGATIV EFFECT OF LI E AT 2 AND 6 Ton/Ha
- TYPE IV VFRY MARKFD INITIAL RESPONSE FOLLOWFD B DRASTIC NEGATIVE EFFECT OF LI F

Figure 12 The ffect of lim appl cations on fresh root yi lds cassava cultivars) months after planting Carima gua 1977

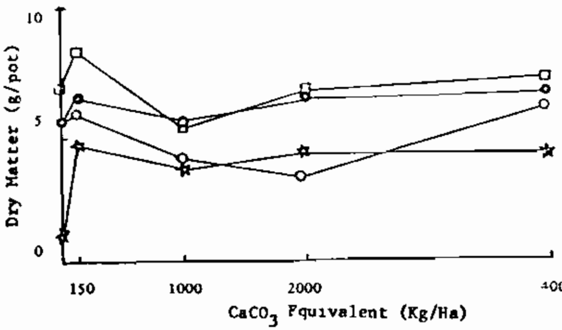


Figure 13 The effect of lime on dry matter product on of four legumes grown in a Carimagua Oxisol first cuting

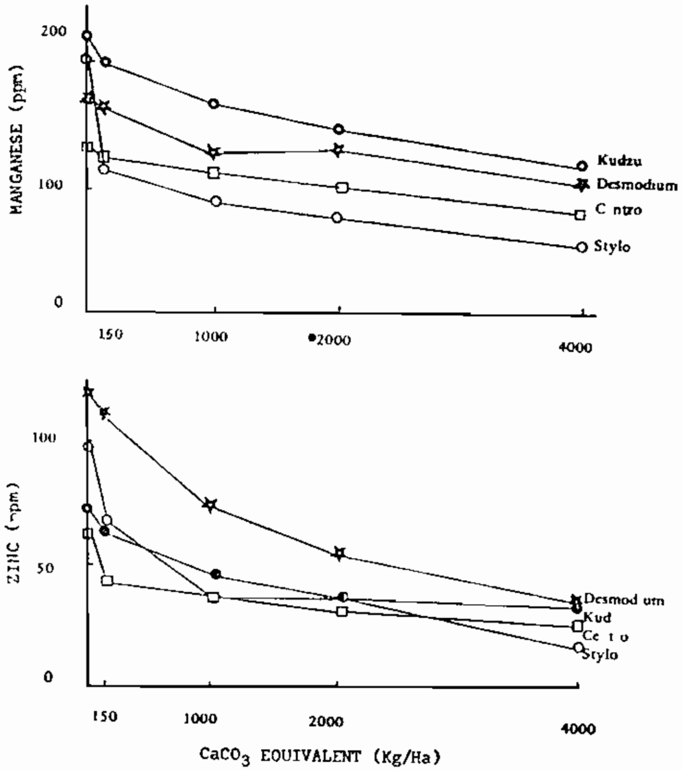
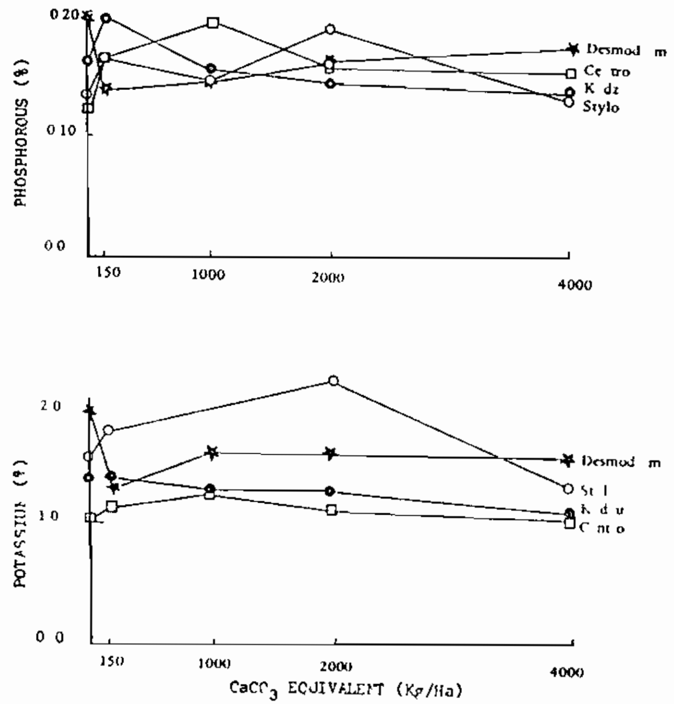


Figure 14 The effect of lime on forage composition of four legumes grown in an Oxisol from Carimagua first cutting

Figure 11 (Cont.)



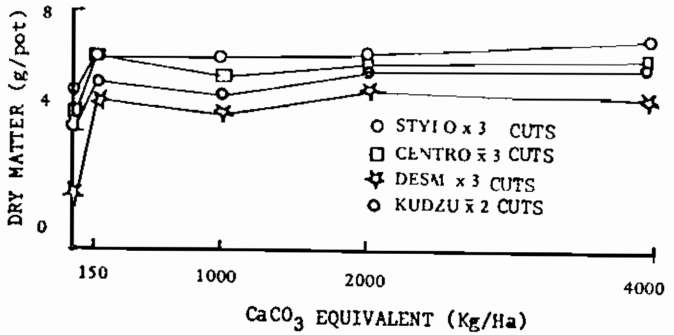


Figure 15 The effect of lime on dry matter production of four legumes Carimagua soil average of 2 and 3 cuts as indicated

The response curves for grasses are quite different from those observed for legumes for the first cutting but quite similar for the subsequent cuttings as can be observed in Figures 16 and 17

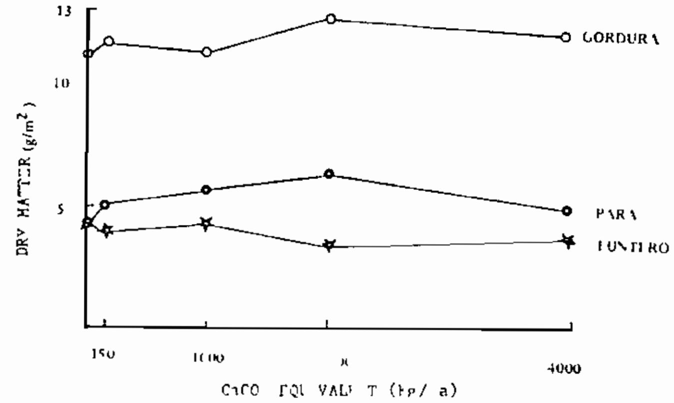


Figure 16 The effect of lime on dry matter production of three grasses grown in a Carimagua oxisol first cutting

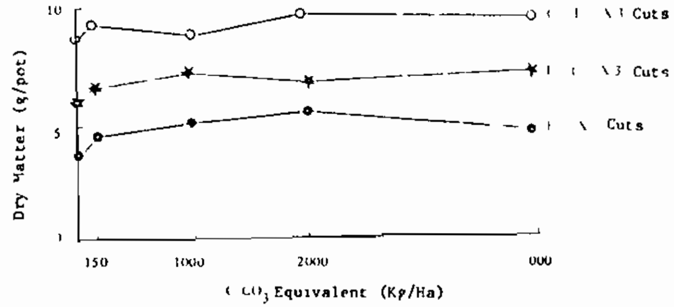


Figure 17 The effect of lime on dry matter production of three grasses average of 2 and 3 cuts as indicated

The effect of liming on the chemical composition of the four legumes and three grasses is shown in Table 2 It is clear that the effect is much less pronounced with the grasses than with the legumes

Table 2.—The effect of lime applications on forage nutrient content of four tropical legumes and three tropical grasses grown in an oxisol from Carimagua Colombia 1st harvest

Species	Lime kg/ha	N %	P %	K %	Ca %	Mg %	Mn ppm	Zn ppm	Cu ppm	B ppm
Stylosanthes guyanensis La Libertad	0	2 [illegible]	0 13	1 5	1 [illegible]	0 29	213	103	5 0	24
	150	2 3	0 1[illegible]	1 8	1 5	0 26	119	65	6 0	28
	1000	2 6	0 14	1 9	1 6	0 26	90	38	7 3	24
	2000	[illegible] 3	0 19	2 2	1 9	0 [illegible]4	79	[illegible]8	8 7	20
	4000	2 4	0 13	1 [illegible]	2 1	0 30	57	17	4 7	21
	$\bar{x}$	2 6	0 15	1 7	1 [illegible]	0 27	112	52	6 3	23
Centrosema pubescens	0	2 3	0 12	1 0	0 8	0 17	1[illegible]6	63	5 7	16
	150	1 [illegible]	0 16	1 1	1 1	0 17	126	4[illegible]	9 8	20
	1000	2 0	0 19	1 2	1 2	0 18	115	[illegible]9	10	[illegible]
	[illegible]000	1 8	0 16	1 1	1 3	0 18	104	[illegible]	10 7	2[illegible]
	4000	2 0	0 15	1 0	1 1	0 20	83	[illegible]	10 9	21
	$\bar{x}$	1 [illegible]	0 15	1 1	1 2	0 18	11[illegible]	41	9 6	1
Pueraria phaseoloides	0	[illegible] 6	0 1[illegible]	1 4	0 9	0 22	[illegible]	70	6 7	3[illegible]
	150	1 9	0 20	1 4	1 4	0 25	201	6[illegible]	7 0	41
	1000	1 8	0 15	1 3	1 4	0 20	170	47	6 0	33
	[illegible]000	2 6	0 14	1 3	1 3	0 21	147	[illegible]7	[illegible]7	30
	4000	[illegible] 0	0 13	1 1	1 5	0 [illegible]9	170	[illegible]	6 0	9
	$\bar{x}$	[illegible]	0 15	1 3	1 3	0 [illegible]3	172	50	6 5	33
Desmodium [illegible]	0	[illegible]	0 20	[illegible]0	1 0	0 29	172	120	4 0	21
	150	[illegible]	0 14	1 [illegible]	1 [illegible]	0 28	1[illegible]7	110	3 3	27
	1000	[illegible]	0 15	1 6	1 3	0 [illegible]9	1[illegible]7	7[illegible]	3 7	21
	[illegible]000	[illegible]5	0 1[illegible]	1 6	1 4	0 2[illegible]	1[illegible]4	5[illegible]	[illegible]	21
	4000	2 7	0 17	1 5	1 5	0 25	107	[illegible]5	4 0	21
	$\bar{x}$	2 [illegible]	0 1[illegible]	1 6	1 3	0 28	141	78	3 [illegible]	1
Hyparrhenia rufa	0	1 5	0 0[illegible]	1 0	0 4	0 29	166	35	7 1	16
	150	1 5	0 10	1 4	0 4	0 19	115	28	7 6	14
	1000	1 5	0 08	1 [illegible]	0 5	0 24	13[illegible]	23	[illegible]6	16
	2000	1 [illegible]	0 10	1 4	0 [illegible]	0 21	12[illegible]	21	8 0	12
	4000	[illegible]	0 10	1 1	0 6	0 22	114	19	8 0	11
	$\bar{x}$	1 8	0 09	1 [illegible]	0 5	0 2[illegible]	1[illegible]1	25	7 5	14
Melinis minutiflora (leaves only)	0	1 1	0 07	0 6	0 3	0 [illegible]7	110	73	8 0	7
	150	0 9	0 07	0 7	0 3	0 30	108	58	6 9	7
	1000	1 0	0 07	0 6	0 3	0 34	11[illegible]	49	6 7	7
	2000	1 0	0 07	0 7	0 3	0 33	97	47	6 0	7
	4000	1 0	0 07	0 6	0 4	0 45	106	48	5 0	8
	$\bar{x}$	1 0	0 07	0 6	0 3	0 34	107	55	6 5	7
Brachiaria mutica	0	0 9	0 08	0 5	0 1	0 07	31	41	10 7	5
	150	0 7	0 08	0 4	0 2	0 08	33	44	10 0	5
	1000	0 7	0 08	0 5	0 2	0 11	4[illegible]	33	9 3	5
	2000	0 7	0 09	0 6	0 2	0 1[illegible]	44	34	9 3	2
	4000	0 8	0 08	0 5	0 3	0 15	34	35	10 7	5
	$\bar{x}$	0 8	0 08	0 5	0 2	0 10	37	38	10 0	4

It appears that lime is required primarily as a source of Ca and/or Mg for the tropical forages included in these trials Many trials reported in the literature use 1 ton of lime as a first increment It may be that the most beneficial range of lime applications has often been completely bypassed

In practice sufficiente calcium as a nutrient may well be applied in the form of phosphate fertilizers Simple super phosphate contains about 20% Ca triple super phosphate about 15% Colombian basic slag (from Paz del Rio) contains 45 60% $CaCO_3$ equivalent to 18 24% Ca In all trials involving low levels of lime or calcium a non calcium source of P has been used

VIII CONCLUSIONS

High quality food crops can be economically produced on many allic soils with minimum lime requirement

Cowpeas appear to be the most tolerant food legume black beans are intermediate while the non black beans (both are *Phaseolus vulgaris*) are the poorest Rice is the most promising cereal grain crop Within each species there is considerable genetic variability as regards acid soil tolerance In the case of upland rice there are traditional varieties such as Monolaya that barely respond to the first increment of lime while many of the new semi dwarf varieties respond strikingly to lime and produce practically nothing in its absence under upland conditions Soil acidity is normally not a problem with flooded rice since pH increases markedly as the soil is reduced

Crops that are tolerant to soil acidity are also likely to be more efficient at recovering applied as well as native plant nutrients than susceptible crops even when the latter are grown on limed soils It is almost impossible to effectively lime the subsoil as a result susceptible crop roots are often limited to the plow layer even after liming Tolerant crops can develop wider and deeper root systems and thus exploit a larger volume of soil for needed nutrients and moisture

The response of many species to small applications of lime when grown on Oxisols emphasizes the importance of Ca and Mg as nutrients in soils with high exchangeable Al levels relative to exchangeable Ca and Mg The calcium content of phosphorus fertilizers may be sufficient to meet the nutrient requirements of many crops

It is clear that some cultivars of crops that have evolved in the tropical allic soil environment are extremely sensitive to over liming Most of the 138 cassava cultivars screened at Carimagua were adversely affected by 6 tons of lime/ha and the yields of many were depressed by only 2 tons of lime It has also been observed that liming of cashew trees may be very detrimental at rates as low as 1 ton lime/ha However most acid soil tolerant species and cultivars we have observed are surprisingly tolerant to a wide range of lime rates (up to 16 tons/ha)

A tentative listing of food crops suitable for allic soils is given in Table 3 along with lime requirements for the more tolerant cultivars All indications are based on experience at Carimagua on an Oxisol with the characteristics shown in Table 1 The list is not meant to include all acid soil tolerant tropical species It is drawn from personal experience and observations of CIAT s staff primarily in the American tropics

Table 3 —Food crops suitable for allic soils with minimum lime requirement Lime requirement figures are for acid soil tolerant cultivars

CROP	LIME REQUIREMENT
Upland rice	⅓ ½ T
Cassava	¼ ½ T
Plantain (topocho)	½ 2 T*
Cowpeas (vegetable)	½ 1 T
Cowpeas (grain)	½ 1 T
Peanuts	½ T
Corn (vegetable)	1 2 T
Corn (grain)	1 2 T
Black beans	2 T
Sesame	2 T*
Sorghum	1 2 T
Fruits and tree crops	
Mango	¼ ½ T*
Cashew	¼ ½ T*
Citrus	¼ ½ T*
Pineapple	¼ ½ T

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The most promising forage species for acid soils include stylosanthes *(S guyanensis)* desmodium, kudzu and centrosema among the legumes and molases grass *(Melinis minutiflora)* puntero *(Hypharrhenia rufa)* brachiaria *(B decumbens)* and pasto negro *(Paspalum plicatulum)* among the grasses

The results of our work although preliminary in nature clearly emphasize the importance of teams of researchers made up of breeders physiologists and soils specialists working together on problems of low crop and pasture productivity on the acid soils of the humid tropics in order to affect a more efficient and rational development of these regions

IX SUMMARY

The differential tolerance to soil acidity of various important food crops and pastures was studied Many species and crop varieties were screened for acid tolerance and results are given for maize rice grain legumes cassava and some forage species Maize varieties doing best with a 2 tons/ha lime treatment produced over 3 tons/ha in semi commercial fields Traditional rice varieties responded only to 0 4 tons/ha of lime while the semidwarf varieties responded markedly up to 4 tons/ha A greenhouse method is proposed to test rice varieties for Al tolerance by measuring root growth in nutrient solutions with different Al concentrations and comparing values for 3 and 30 ppm Al

It is reported that while field beans and soybeans responded up to 6 t/ha of lime cowpeas only responded significantly to 0 5 tons/ha

For cassava very large differences between cultivars were observed However most of them responded visually to lime up to 2 tons/ha and were adversely affected by 6 tons/ha Foliar mineral content was strongly influenced by liming even at the lowest lime rates

For grasses lime apparently is required primarily as a Ca source with positive results for 150 kg lime/ha and yield depressions can occure already at 1 ton/ha