A PRELIMINARY REPORT ON THE ENTRANCE INTO ACID SOIL PROBLEMS

OF THE TRAS-OS-MONTES REGION

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A Progress Report on the Research into Acid Soil Problems of the Tras-os-Montes Region

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A Progress Report on the Research into Acid Soil Problems of the Tras-os-Montes Region

The extreme acidity of the soils of Tras-os-Montes must be one of the most serious agricultural problems of the region. It not only may be affecting plant growth through aluminum toxicity and deficiencies of calcium and magnesium, but it must likewise be affecting animal and human nutrition.

Studies on acidity in the soils of Tras-os-Montes were mostly begun in 1981. Through our routine soil testing program as well as from more careful study at selected sites we now have some knowledge of the distribution of soils in the different pH ranges. It is too soon to have much information on the response to liming, but experiments are being conducted and the results available will be summarized below.

I. Pasture, Forage and Hay Studies.

1. A Survey of Pastures and Forages:

Most of the soils of the region have a low content of calcium and magnesium which could be a problem for animal and plant nutrition. We are doing a survey study of the pastures and of some of the forage crops to determine if the levels are or are not sufficient for the normal growth of plants and for animal nutrition. Samples of soil and corn (used as green feed and silage) were collected in the Noroeste and in part of the Nordeste Transmontano. Pastures and green forage were also sampled repeatedly in late winter and spring to determine the effect of season on the calcium and magnesium content.

The levels of calcium and especially the magnesium were typically low in the 58 soils sampled. Thirty three soils had less than 0.41 meq Mg per 100 g soil. In the corn plants, which are the only ones yet analysed, the magnesium levels are probably sufficient for normal plant growth (more than 0.10% Mg in the D. M.) but not enough for cattle since less than 0.20% is considered insufficient for them. Corn tissue samples taken at silking time ranged from 0.12% to 0.28% with 13 samples out of 19 having less than 0.20%.

This study is continuing.

2. Mineral Composition of Hays:

The natural pastures called "lameiros" are very important in animal feeding in Tras-os-Montes especially in the production of hays. For this reason the D.R.T.M. has installed, over the past four years, some demonstration fields with the purpose of demonstrating complete fertilization (N,P,K and lime). The hay production between the check and the treated parcels have been compared. D.R.T.M. sends tissue samples of the hays to I.N.P.D. for laboratory analysis. These samples have been analysed for protein and energy value and they are now being analysed for their mineral composition.

The results till now show that the calcium levels are generally in a good range [illegible] levels of magnesium below 0.20% in many cases. [illegible] of this study are to obtain a better knowledge of the [illegible] of the hay of the region, and to learn the effect of [illegible]. [illegible]

3. Response of Pasture and Forage Species to Dolomitic Limestone:

This pot experiment is to study the effect of three levels of liming (cal_0, cal_1, and cal_2) with dolomitic limestone on an acid (pH_{H_2O} 5.3) granite derived soil from Vila Pouca de Aguiar using as test plants three grasses (Orchard Grass, Rye Grass, Fescue) and two legumes (Subterranean Clover, White Clover). Dry matter production and calcium and magnesium content of the plants, the pH change in the soil as well as the calcium and magnesium content on the soil exchange complex are being determined.

At present we have only the dry matter production. In the first cutting only the white clover gave a dry matter production significantly greater in the limed treatments. However, in the second cutting production was greater in the limed treatments for all species excepting the orchard grass. In the third cutting all dry matter productions were significantly greater in the limed treatments. The yields obtained from level one and level two of lime were not significantly different excepting with the rye grass. For this reason we intend to repeat this experiment at lower levels of lime.

4. Calcium and Magnesium Content of Hybred Corn after a Dolomitic and Calcitic Lime Application:

Corn is growing in pots on two granite derived soils (from Teloes with pH 5.0 and from Vila Ché with pH 4.8) both from the vicinity of Vila Pouca de Aguiar. Dry matter production and calcium and magnesium content of the plants and pH change and exchengeable calcium and magnesium in the soils will be determined. No data is yet available from this experiment.

5. Liming Dryland Pastures:

In the fall of 1981 a dryland pasture of subterranean clover, orchard grass and fescue war installed in the "Hot Land" region near Mirandela in a lithosol formed from schist with a pH of about 5. Light rates of lime were applied in two different kinds of distribution (In the row and broadcast). The treatments were: Check; Broadcast at 1200, 2400, and 3600 kg per hectare; In the row at 400, 800, 1200, and 1600 kg per hectare.

The main objectives are to study the response of the pasture to the different rates of lime and to study the effectiveness of lime distributed in seeding rows.

During the growth period in late winter and spring 1982 several cuttings were made. Dry matter production showed no response this first year. Perhaps liming will show an effect in subsequent years. The tissue samples from all of the treatments have been prepared but not yet analysed for the effects of treatments or cutting times on the mineral composition. The grass versus legume composition will also be studied in subsequent years.

II. Vineyard Experiments.

Zones of weak or dying vines appear in some Tras-os-Montes vineyards. The lower leaves are red or chlorotic and often become necrotic as the symptoms advance. Symptoms first appear as early as May and are quite advanced in July and August. Soil tests for potassium and phosphorus are usually high or very high, especially for potassium. When the plants show a typical magnesium deficiency chlorosis the soil analysis have shown low exchangeable magnesium levels, sometimes near zero, and high potassium levels. Soil pH has been around 5 or lower on the areas studied. Poor root development, aluminum toxicity, aluminum induced phosphate deficiency, or magnesium deficiency accentuated by high potassium competition could all be responsible.

1. Field Studies:

In one weak zone, individual plants (22 sick and 2 healthy) were carefully photographed and noted last September. Tissue and soil was sampled from each and then treatments applied to individual plants. Dolomitic and calcitic limestone at rates up to 3 kg per plant, $MgSO_4$, and boron were used alone and in some combinations. Similar treatments were applied to rows rather than individual plants in two other vineyards.

Foliar sprays of 2, 10, and 15% $MgSO_4$ are being applied at monthly intervals. A 1% urea solution is also included for some plants. Other plants with red leaf symptoms are recieving sodium or ammonium phosphate foliar sprays. Some of these foliar treatments are being done in three vineyards

It is too early to be sure of the results of these treatments.

2. A Greenhouse Study:

An experiment in pots was begun to study the rooting problem of new plants using the rooting stocks of Vitis vinifere R99. A very acid, granite derived soil of Guizes with a pH of about 4.5 and a granite derived soil near Vila Seca with a pH of about 5.0 were used. Both soils are low in organic matter and were in zones of weak vines with rooting problems for new vines. Liming rates of 0, 6, 12, 18, and 24 grams of calcitic limestone per 5 kilograms of soil (0 to nearly 10 metric tons of limestone per 2 million kilogram hectare) were applied.

The vegetative growth is being observed on the new plants and the roots and their morphology will be examined microscopicly. Chemical analysis will be done on the tissue.

In the first three months of growth some differences are observable in top growth between the lime treatments and between the two soils. The first level of lime seemed especially important to enable rooting in the very acid schist soil.

III. Rapid Bioassay for Acid Toxicities.

This study has the four objectives of determining:

1. the prevalence of acid toxicities in Tras-os-Montes.
2. the seriousness of the toxicities.
3. the amount of lime needed to remove the toxicities.
4. the sensitivity of species and varieties used and being considered for use in the region.

Evidence of acid toxicity, predominantly aluminum toxicity, is clearest in vineyards where zones of weak vines commonly occur. An abundance of red leaves as well as chlorotic ones often characterize such areas. The literature suggests that the red color could be a phosphorus deficiency induced by high aluminum levels and that the chlorosis could be a magnesium deficiency.

1. Experiments With and Without Lime:

Potted soils, with and without limestone or other treatments, are watted to field capacity and planted to already sprouted seeds. The pots are covered to reduce evaporation and photosynthesis. After about five days the seedling plants are removed and root elongation and appearance are observed. Root differences are assumed to be from toxicities in the soils since nutrition during the short growing period is coming from the seed. The varieties used to date are Barbela wheat (a regional variety assumed to be quite tolerant to aluminum toxicity), Abe wheat (a sensitive variety) and Limagrain 21 corn (a French hybred of unknown sensitivity).

The results of the first experiments show the following:

Soils and Species	Ave. Root Length per Plant Without Lime	With Lime	% Increase from Lime
Schist derived (Guian)	pH 4.5	pH 7.0	
Barbela	34 cm	36 cm	+6
Abe	10 cm	26 cm	+260
Limagrain 21	16 cm	28 cm	+165
Granite derived (Vila Seca)	pH 4.8	pH 7.4	
Barbela	42 cm	37 cm	-12
Abe	21 cm	29 cm	+38
Limagrain 21	21 cm	22 cm	+5
Granite derived (Telons)	pH 5.0	pH 7.4	
Barbela	35 cm	28 cm	-20
Abe	9 cm	20 cm	+120
Limagrain 21	21 cm	27 cm	+29
Granite derived (Vila Chã)	pH 4.8	pH 6.1	
Barbela	29 cm	36 cm	+24
Abe	21 cm	25 cm	+19
Limagrain 21	17 cm	20 cm	+18

There is also a difference in root appearance. Limed soils produced roots with more root hairs or small lateral roots so that when the limed root systems are removed from the soil they hold a heavy coating of soil. In contrast, roots from unlimed, very acid soils are nearly clean and free of root hairs in the root zone (including the laterals which showed little proportion in root length).

2. Experiments at Increasing Lime Rates:

Another schist derived soil from Guiaes (pH 4.2) incubated for four days with lime or superphosphate and then planted to Limagrain 21 corn and Abe wheat gave the following results in five day root lengths:

	Lime (tons per hectare)					
	0	0*	1	2	4	8
Limagrain 21	18 cm	18 cm	26 cm	26 cm	35 cm	42 cm
Abe	12 cm	12 cm	16 cm	19 cm	30 cm	34 cm

* 500 kg P_2O_5 was added to this treatment as 18% superphosphate

Response to the lime continued up to the eight ton rate. Several repeats of this study at rates of 0, 2.5, 5.0, 7.5, and 10 tons of limestone per hectare gave similar results with both the wheat and the corn reaching maximum response by or before the 10 ton rate. After one month of equilibration the pH was 4.2, 4.6, 4.8, 5.1 and 5.5 respectively in the 0, 2.5, 5.0, 7.5, and 10 ton per hectare lime treatments. This soil is obviously quite well buffered even though it contains almost no organic matter and is not high in clay. This may be a buffering from the high exchange saturation with aluminum and the interlayer aluminum which would be expected in this soil.

IV. Species and Variety Sensitivity of Cereals to Acid Soils

Several varieties of wheat (Roazon and Barbela), triticale (Mapache, Beagle, INRA 532-15, INRA 532-4, and Deira 518), and rye (Vila Pouca, Montelegre and Gimonde) have been tested for tolerance to soil acidity. The three rye varieties and the Barbela wheat were included as regional varieties which should have some acid tolerance.

The experiments were done in pots using a schist derived soil from Sabrosa with a pH of 5.0 in water and 3.5 in KCl and 3.0% organic matter. Unlimed soil was compared to a treatment of 5 g of dolomitic limestone per 3 kg of soil (3.3 tons of limestone per 2 million kg hectare). The INRA 532-4 and Deira 518 triticales and the Montelegre rye were the only varieties responding to limestone on this pH 5.0 soil.

On a more acid schist derived soil from Guiães with a pH in water of 4.2 and in KCl of 3.5 and 2.8% organic matter the experiment was repeated with a slightly different group of species (Triticale varieties 532-4, 532-15, EP-5, EP-17, EP-41, EP-48, EP-295, EP-296, EP-301; Abe and Barbela wheat; Montelegre rye). The unlimed soil is compared with a treatment of dolomitic limestone at 10 g per 3 kg of soil (6.7 tons limestone per 2 million kg hectare). In the preliminary stages of growth all the varieties showed marked inhibition and poor stand establishment on the unlimed soil. As growth continued the Montelegre rye was the most tolerant of acidity but even it responded to liming; the Barbela wheat and all of the triticales were quite sensitive and responded greatly to liming; all of the triticales appeared about equal; the Abe wheat was very sensitive and showed very little growth in unlimed soil. Growth of all species and variieties was very good in the limed soil which had a pH at the close of the experiment of 6.3 . Chemical analysis and data analysis have yet to be completed on this experiment.

V. Soil and Limestone Analysis

1. Ca, Mg and Al Composition of the Exchange Complex of the Soils of the Region:

From the large number of samples being routinely analised by the laboratory samples are being selected to represent nearly all of the freguesias. These are being analised for exchangeable Ca, Mg and other paramenters which enter into definition of soil reaction (pH, organic matter, aluminum etc.)

This work is intended to detect, in connection with other work, the zones where the application of dolomitic limestone would be prefered. Thus magnesium deficiency in plants and animals could be reduced at the same time that acidity is corrected.

Analysis thus far show a great range with a few areas having high pH soils and some having high magnesium contents. However, most soils have lower pH and low magnesium contents. All of these soils are being retained for a comparative study of several lime requirement methods to be related to titration or neutralization curves of the same soils.

2. Distribution of Acidity within the Region:

An early summary based on only 1171 samples sent in by MACP and analysed in the IUTAD laboratory for the PROCALPEX program is given in the table below. Data is by agrarian zones and concelhos for values of pH in water and is given as both absolute and relative frequencies under six classes of soil reaction.

Data is grouped by concelho because grouping all data together does not adequately reflect the diversity in the region. On the other hand, grouping by smaller units, while more advisable, was not yet possible because of the limited number of samples analised from many freguesias. Even some concelhos had too few samples.

In addition, concelhos are administrative units and thus are artificial and not homogenious soil zones. This reduces confidence in the conclusions which can be drawn from this data.

A correct use of the data is to get an approximate idea of the frequency distribution of soil reactions and this should always be accompanied by the standard deviation and the number of samples considered. Thus data from some concelhos such as Chaves, Valpaços, Mogadouro and Vimioso give maximum information because of many samples and a low standard deviation. On the other extreme are Mirandela, Murça, Miranda do Douro with few samples or Freixo-de-Espada à Cinta, Moncorvo and Vila Nova de Foz Côa with very high standard deviations. These latter are certainly a result of diverse soil situations within the concelho.

Also these results are biased in that almost all are taken only from tilled agricultural land. This bias is good for our agricultural interpretations but bad for large and forest interpretations. However the bias may not be large because little lime has been used in the past.

FREQUENCIAS ABSOLUTAS E RELATIVAS DOS VALORES DE - $_pH$ (H_2O) DE SOLOS DE [illegible]

VALORES AGRUPADOS POR CONCELHOS E ZONAS AGRARIAS (DRTM)

ZONAS AGRARIAS E CONCELHOS	CLASSES DE FREQUENCIA - $_pH$ (H_2O)						DESVIO PADRÃO	[illegible]
	≤ 4,5	4,6-5,5	5,6-6,5	6,6-7,5	7,6-8,5	≥ 8,6		
BARROSO E ALTURAS	8 (10%)	69 (88%)	2 (2%)	0	0	0	-	[illegible]
MONTALEGRE	5	26	2	0	0	0	[illegible]	[illegible]
BOTICAS	3	43	0	0	0	0	[illegible]	[illegible]
ALTO DO TAMEGA	50 (15%)	261 (78%)	21 (6%)	2 (1%)	0	0	-	[illegible]
CHAVES	42	170	5	2	0	0	0,45	[illegible]
VALPAÇOS	8	91	16	0	0	0	0,44	[illegible]
ALVÃO - PADRELA	5 (8%)	44 (70%)	14 ([illegible]%)	0	0	0	-	[illegible]
V.P. DE AGUIAR	5	35	7	0	0	0	[illegible]	[illegible]
MURÇA	0	9	7	0	0	0	[illegible]	[illegible]
TERRA FRIA (BRAGANÇA)	0	13 (72%)	5 (18%)	0	0	0	0,44	[illegible]
TERRA QUENTE	5 (5%)	33 (31%)	51 (45%)	14 (13%)	3 ([illegible])	0	-	[illegible]
MACEDO DE CAVALEIROS	5	15	34	8	2	0	[illegible]	[illegible]
ALFANDEGA DA FÉ	0	10	16	6	1	0	[illegible]	[illegible]
MIRANDELA	0	8	1	0	0	0	[illegible]	[illegible]
PLANALTO MIRANDES	6 (2%)	108 (41%)	112 (43%)	33 (13%)	1 ([illegible])	0	-	[illegible]
MOGADOURO	0	49	51	26	1	0	[illegible]	[illegible]
VIRIOSO	6	53	56	6	0	0	[illegible]	[illegible]
MIRANDA DO DOURO	0	6	[illegible]	1	0	0	[illegible]	[illegible]
DOURO SUPERIOR	66 (28%)	72 (31%)	57 ([illegible]%)	21 (9%)	19 ([illegible])	0	-	[illegible]
V.N. DE FOZ COA	49	29	29	4	0	0	[illegible]	[illegible]
F.ESPADA-À-CINTA	1	9	19	9	18	0	[illegible]	[illegible]
MONCORVO	11	22	7	7	1	0	[illegible]	[illegible]
VILA FLOR	5	12	[illegible]	1	0	[illegible]	[illegible]	[illegible]
ALTO E BAIXO CORGO (REGUA)	2 (12%)	10 (62%)	[illegible]	1 (6%)	0	[illegible]	[illegible]	[illegible]
LAMEGO E LEOMIL (LAMEGO)	1 (4%)	17 (63%)	9	0	0	0	[illegible]	[illegible]
TOTAL	[illegible] (15%)	[illegible] (55%)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

The results showed that both zones have deposits of calcitic limestone ($MgCO_3$ less than 2.1%) and of dolomitic-calcitic limestone ($MgCO_3$ greater than 22.8% but less than 40.9%). All of the dolomitic-calcitic limestones had values of $MgCO_3$ around 40%.

The neutralizing value (NV) of most of the samples from the Serra do Marão were greater than the minimum required by law NP983 (NV equal to or greater than 85). All samples from Vale do Porco gave values very near 100%.

Considering only the chemical analysis, the limestones of the two zones exceed the minimum characteristics required by law for agricultural use. There is the added advantage of the dolomitic limestone being sufficient to use either for sale directly or in mixes with the calcitic limestone as the local needs for magnesium or calcium require.

VI. Summary.

The work in soil fertility at IUTAD includes 10 different research studies which relate to the acidity problem of the soils of the region. Preliminary information from these studies indicates the following:

1. Some regional soils are so acid as to be toxic to all species tested.

2. The triticale varieties being tested for use in the region appear to be fairly tolerant of acidity, about equal to the local Barbela wheat, but less tolerant than the regional ryes.

3. Forage and hay samples in survey studies indicate general low magnesium levels in plant tissue. Soils also often test very low in magnesium. Magnesium deficiency symptoms are commonly observed in plants. Thus dolomitic limestone probably should be recommended for liming in much of the region.

4. Responses to liming have occurred with a number of species on several soils in the greenhouse but evidence of similar responses in the field have not yet been obtained.

5. Preliminary analysis of the routine soil testing laboratory data shows:

   8% above pH 6.5
   24% from pH 5.6 to 6.5
   55% from pH 4.6 to 5.5
   13% below pH 4.6

Those above pH 6.5 occur almost entirely in several areas of the eastern hot dry lands of the region.

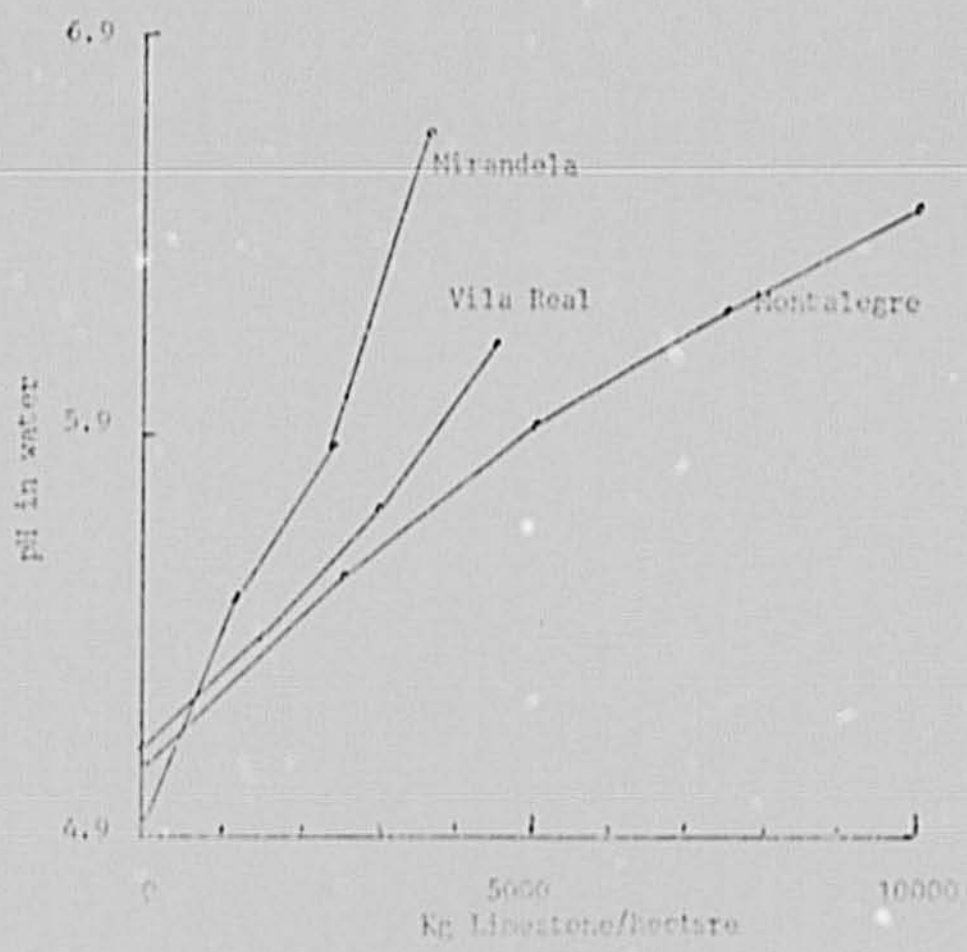
6. Limestone deposits from the Serra do Marão and from Vale do Porco have a sufficiently high neutralizing value for use as agricultural limestone. Both also have deposits high in magnesium so they could provide this needed element in the limestone.

3. Neutralization Curves for Three Soils of Trás-os-Montes:

Three field experiments were installed in the Fall of 1981 at Montalegre, Mirandela, and Vila Real. Since the experiments included several levels of liming they were sampled at regular intervals to follow the neutralization of the soil over time. Aluminum will be determined also. The three soils all had pH in water between 4.8 and 5.0 but the organic matter content and exchangeable aluminum were quite different.

Mirandela	0.5% O.M.	0.5 meq Al/100 g
Vila Real	1.5% O.M.	1.8 meq Al/100 g
Montalegre	5.0% O.M.	2.0 meq Al/100 g

The titration curves at seven months after application are shown in the graph below:



In later results we will be able to compare these results with the various laboratory lime requirement methods and with the incubation methods in the greenhouse.

4. Analysis of Trás-os-Montes Limestone Deposits:

Of the various limestone deposits in the Trás-os-Montes region those which have been of most interest for development have been the deposits of Serra de Marão ([illegible] and [illegible]) and the deposits of Vale da Pena ([illegible]).

[illegible]