Report to PROCALFER Coordinating Committee

SOIL TESTING IN PORTUGAL - STATUS AND RECOMMENDATIONS

Prepared by:

William C. Dahnke
Professor of Soil Science
North Dakota State University

For:

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I. Introduction

a. Background

In connection with the Portuguese Government's plan (PROCALFER) to increase the efficiency of agricultural production a study was made in 1981 (1) of the soil testing laboratories.

At that time recommendations were made on soil test procedures and equipment that would increase the capacity of the laboratories to handle samples rapidly. During the past year several of the recommendations on changes in soil test procedures were studied, the equipment was ordered and recently received by the laboratories.

b. Objectives

The objective of this report are:

1. Review the results of the studies made by the laboratories on suggested procedural changes.
2. Review in detail the methods of soil sample handling and the use of the equipment that was ordered.
3. Suggest ways to improve lime and fertilizer recommendations.

II. Present status of soil testing laboratories

a. Laboratory Rebelo da Silva - This Ministry of Agriculture and Fisheries (MAP) laboratory in Lisbon had an increase in the number of samples from 7,800 in 1980 to 16,400 in 1981. So far this year they have received 8,300 soil samples. The Rebelo da Silva Lab compared 2, 4 and 24 hour equilibration times for the lime requirement test and found that there was very little difference in the results.

They concluded that it would be possible to go to a 4 hour calibration time. They also have compared the SMP buffer lime requirement test with the method presently used and found the results to be similar. Since the SMP buffer lime requirement test is simpler they may use it instead of the method they are now using.

They also have made a study comparing the present method of colometrically determining extractable phosphorus with the use of ascorbic acid as the reductant. They found a correlation coefficient (r^2) of .99. They therefore plan to use ascorbic acid as the reductant since it is faster and results in a more stable color than the present method.

A new soil sample information form has been developed that could be used by all the soil testing laboratories in Portugal. With a few small modifications this form can be used if and when the laboratories starts using a computer to make fertilizer and lime recommendations based on the soil test results.

With respect to the equipment that has been purchased to speed up the analysis of soil samples this laboratory has decided on the following:

1. They will make 200 trays to hold the farmers soil samples. Each tray will hold 5 rows of 10 samples in paper bags that the laboratory will supply to the farmer. It would be good if all of the soil testing laboratories in Portugal would use the same size soil sample bag.

2. Four sets of 5 racks (each rack holding 11 Erlenmeyer 125 ml flasks) will be constructed to be used to extract phosphorus and potassium. The flasks will be mounted in racks with a spacing of 7cm on center.

3. They will also mount 2 sets of 33 funnels 7cm on center so that a complete batch of soil samples can be filtered at one time.

4. Twelve sets of 3 racks with each rack hold 11 plastic bottles (7cm on center) will be constructed. Four of these will be used to hold the Egner-Rheim filtrate for potassium analysis. Four ml of the Egner-Rheim extract will be transferred to another 4 sets of bottles to be used in the phosphorus test. The remaining 4 sets of bottles will be used for the pH test.

About one day was spent in discussing the interpretation of field studies and the making of fertilizer recommendations to farmers. This will be covered later in this report under specific recommendations to improve the laboratories service to farmers.

b. Department of Pedology, Estacao Agronomica Nacional, Oeiras. Dr. E. Menezes de Sequeira is of the opinion that:

1. Less than 10% of the soil in Northern Portugal may have enough soluble aluminum to result in lowered crop yields.

2. On the average an application of 2 ton per hectare of lime would correct the problem on these soils.

3. There are some soils in the North that are deficient in boron, molybdenum, Zinc and copper but he did not have an estimate of the area. In general fields that receive applications of manure are seldom if ever deficient in these nutrients.

c. MAP Laboratory in Tavira-Eng. Manuel Souteiro Goncalves of the Rebelo da Silva Laboratory and I took most of the equipment ordered for this laboratory with us when we went to Tavira. We showed them how to use the equipment and explained how to organize the laboratory for efficient soil sample analysis. The number of samples received by this laboratory in 1981 was less than in 1980.

We also met with Eng^{a}. Maria Isabel Palmilha of the Extension Service to discuss fertilizer recommendation. She makes fertilizer recommendations for vineyards but not for other crops. Fertilizer recommendations are usually made by local extension personnel.

d. University of Evora

At this university we visited with Dr. Carlos Alberto Ferreira de Miranda, Head of the Chemistry Department and Dr^{a}. Maria de Lourdes Pimenta da Silva, both chemists. They are in the process of setting up a soil testing laboratory with the hope that this will help get popular support for the university from the people in the Alentejo. They have a new technicon Autoanalyzer and a new Perkin - Elmer atomic absorption spectrophotometer with an automatic sampler. These instruments have not been set up yet because the laboratory building is not finished. These expensive pieces of equipment are well suited for research but result in a decrease in the efficiency of a routine soil analysis laboratory. I would therefore recommend that, since the 5 present routine soil testing laboratories in Portugal can adequately handle the sample load for the forseeable future, this laboratory not be encouraged to get into routine soil analysis. The University of Evora could best gain popular support from the people of the Alentejo by doing practical soil fertility research while training graduate students. Since they have a great interest in molybdenum they could start with a field study in which they would try to demonstrate if a molybdenum deficiency actually exists for crops grown in the area. If or when they find deficiencies another project could be to do some soil test correlation studies to determine what molybdenum soil test best predicts molybdenum deficiency for crops. Other needed research projects that would be of benefit to farmers will be discussed in another part of this report.

e. Quimigal Laboratory, Centro de Desenvolvimento Agricola, Sacavem.

The number of samples received (2000) by this laboratory decreased in comparison to last year. Eng. Antonio Vaz Milheiro feels that the reason the number of samples at Quimigal decreased while the number at the Rebelo da Silva Laboratory increased is due to the fact that farmers are eligible for the lime subsidy when extension agents collect samples for the MAP laboratories. Extension agents do not send soil samples to Quimigal. The laboratory equipment

ordered for this lab had been received and they ran a test to compare soil test results when samples are crushed mechanically vs. by hand. Their results indicated no significant difference.

The Quimigal organization does a lot of practical soil fertility research. Some of the significant studies that we discussed were:

1. Influence of extractable aluminum on plant growth.

   When soils are extracted with pH 4.8 ammonium acetate they found that when the amount of extractable aluminum was greater than 1000ppm corn yields are depressed. Although it is well known that extractable aluminium in general increases as pH decreases they found a poor correlation between the amount of extractable aluminum and soil pH. In other words it cannot be assumed that all soils with a relatively low pH will have high amounts of soluble aluminum. About 4% of the soil samples tested by Quimigal that had a pH(H_2O)$<$5.8 had $>$1000ppm extractable aluminum.

2. Nitrogen fertilizer requirement for wheat - Yield trials conducted by Quimigal indicate that approximately 1 kg of nitrogen will result in a wheat yield increased of 25kg of wheat. This is very similar to the data for wheat in the Great Plains of the U.S.A. Although there seems to be little interest in studying residual nitrate in the soil I am confident that by taking soil nitrate-nitrogen into consideration, nitrogen fertilizer recommendations could be greatly improved.

f. University of Vila Real

A group of young faculty members led by Eng. Joao Coutinho, Eng^a. Ester Portela and Eng^a. Ana Pires with the able advice of Dr. James Alhrich are conducting several experiments that will give support to the soil testing program. Some of the trials being conducted are:

1. Comparing the response of corn to calcitic and dolomitic lime

in the greenhouse. They found a response to magnesium.

2. Small grain varietal response to lime. Of 12 varieties 3 responded to lime in the greenhouse.

3. A field trial comparing a broadcast vs. band application of lime for corn. The soil had a pH (H_2O) of 5.0 but there was no response to lime after 1 year.

4. Root studies to learn more about toxicity at low soil pH. Roots of small grains grown on low pH soils have short roots and very few root hairs. After liming the roots are longer and covered with root hairs. This may be the influence of toxic levels of aluminum.

This group of researchers is outstanding in that:

1. They are working on several projects that are of practical significance.
2. They are enthusiastic about their work.
3. They cooperate with one another.

The equipment ordered for this laboratory has all arrived with the following exceptions:

1. Selenium lamp for the atomic absorption spectrophotometer.
2. Samples changer for colorimeter.

They are in the process of trying to get a chimney and an acetylene reduction valve for the atomic absorption unit.

g. MAP Laboratory in Porto

This laboratory has not received the following pieces of equipment:

1. 1 Eberbach shaker and 2 transformers.
2. Sample charger for colorimeter.

The pH meters that were purchased for this laboratory and for the Quimigal laboratory do not work.

The number of soil samples received at the Porto laboratory so far this year is about the same or slightly down in comparison with the same time last year (5,200 samples Jan. thru May 1982).

III. Recommendations

At each of the soil testing laboratories several suggestions were discussed that could improve soil testing in Portugal. The following is a summary of these suggestions.

a. Laboratory

1. Portuguese soil testing committee - Last year we had a meeting with representatives of each of the five soil testing laboratories to discuss a few specific matters related to soil analysis. Since there are many things related to soil testing that need to be discussed on a regular basis I am suggesting that representatives of the 5 soil testing laboratories set up a committee that will meet on a regular basis at least once each year. The chairman should be from a different lab each year. The first year a chairman and a secretary could be elected from the group. The following year the secretary would become the chairman and a new secretary would be elected. Keep the group small and remember that your final objective is to provide the farmer's of Portugal with prompt and useful fertilizer recommendations.

2. Soil test summaries - A summary of the soil test results of farmers fields for each the agricultural zones of a country can often give an indication of where problems exist and also where a problem may occur in the future. For instance, if the percentage of fields testing very high in phosphorus increases each year it can be an indication that phosphorus recommendations are too high. Table 1 is a summary of pH (H_2O) tests from the University of Vila Real. This table is for a total of only 1171 samples and therefore is given only as an illustration.

Table 1. Relative number of soil sample falling in several pH(H20) categories for the 2nd Agricultural Region

Area	pH (H20) categories					Total Samples
	< 4.5	4.6-5.5	5.6-6.5	6.6-7.5	7.6-8.5	
	%					
Barroso e altoso	10	88	2	0	0	79
Alto Tamega	15	78	6	1	0	334
Alvao Padrela	8	70	22	0	0	63
Terra Fria	0	72	18	0	0	18
Terra Quente	5	31	57	13	3	106
Planalto Miranda	2	41	43	13	1	260
Douro Superior	28	31	24	9	8	235
Alto e baixo Corgo	12	62	20	6	0	16
Lamego e Leorril	4	63	33	0	0	27
Total	13	55	24	6	2	1171

At the first Portuguese soil Testing Committee meeting the format for the soil test summary tables should be established so that the summary tables from all of the laboratories can be combined.

3. Soil sampling and soil testing fees - The present rules for soil sample collection require that an extension person take the soil sample if the farmer wants to be eligible for the lime subsidy. When this is done the soil sample is also analyzed free of charge. If a farmer takes his own sample he has to pay to have it analyzed. This system has the disadvantage of making the extension person a soil sampler which is very time consuming. The number of farmers therefore that can be helped by soil testing will always be limited by the number of extension agents and the amount of time they have for taking soil samples.

It would be much more advantageous to have the extension agents teach groups of farmers how to take their own soil samples. Another alternative would be to train some professional soil samplers who would have a business of soil sampling. Unless something is done in this area I doubt that the number of farmers that can be helped by soil testing will increase very rapidly.

A recent German report (3) suggested that soil testing fees should be raised. Raising the fees under the present rules would only mean that more people would have the extension person take their samples. My opinion is that the soil testing fee should remain the same or be lowered and have everyone pay a fee. If it cannot be demonstrated that the soil test will not save or make a farmer at least 100 escudos per field then maybe there shouldn't be a soil testing program.

b. Soil test calibration

1. Phosphorus and potassium - Several people have indicated that the present interpretation of the phosphorus and potassium soil tests results in an over prediction of the possibility of a response to fertilizer. In other words fields that should be rated as high in these nutrients are now falling in the medium or low testing categories. Therefore I am recommending that in the next several months a concentrated effort should be made to collect all available soil test calibration data (some of this data has been published (4,5,6,7,) but I suspect much of it is in files and has not been studied). After the data has been collected current methods of analysis, such as those outlined by Waugh et al. (8), should be used to reconfirm or modify the present interpretation of the soil test.

2. Lime - As was mentioned in my report last year (1) a lime requirement test determines the amount of lime needed to raise an acid soil from one pH to a higher pH. The assumption is made that below a certain pH the yield of the most sensitive

crop in a rotation will be reduced when pH is below a certain level. In the U.S. one of the most sensitive crops to low pH is alfalfa. Farmers try to keep the pH up to 6.5 when they have alfalfa in the rotation. When a farmer does not grow alfalfa on his farm the pH can be lower than 6.5. Most crops grown in Portugal can grow at a pH(H20) of much less than 6.5.

It is quite well accepted that in general it is the aluminum ion that becomes toxic at lower pH's. Information from Eng. Antonio Vaz Milheiro at Quimigal indicates that when the amount of aluminum extractable with pH4.8 ammonium acetate exceeds 1000ppm it reduces the growth of corn. Of 245 soil samples with a pH of <5.8 they found that only 4% had>1000ppm of extractable Al. When this percentage is compared with the figures in table 1 you can see that potential lime needed would be quite large based only on pH but quite small if based on extractable Al. I am therefore recommending that a major effort be made to determine if some measure of extractable Al would be a better test for lime requirement than pH. Due to the high initial cost of lime and the high cost of transportation it becomes very important to a farmer to more accurately know whether or not he will get a response to lime and how much he need apply.

3. Fertilizer recommendation tables - The lime and fertilizer recommendation tables that are being used at the present time use soil type and soil test as the basis for making fertilizer recommendations. While soil type can be important this system does not take into consideration the management ability of individual farmers. In other words all farmers will not end up with the same yield when farming the same soil type. I therefore recommend that new fertilizer recommendation tables be constructed based on yield goals and soil test. The amount of fertilizer recommended would increase in direct proportion to the yield goal and fields testing very low would get a high recommendation while field that test very

high would get a recommendation of no fertilizer.

4. Making lime and fertilizer recommendation - At the present time the soil test laboratories only make the soil test. The soil test results are then sent to the extension person for recommendations. The extension person then takes the recommendation to the farmer. I think that it would be more efficient if the laboratory would make the fertilizer recommendation then send one copy of the report to the farmer and one copy to the extension person. If the extension person thought the recommendation needed some modification or that the farmer needed help in understanding the report a visit with the farmer could be arranged. Those farmers that had received previous reports or had more experience with fertilizers would not have to be visited.

c. Soil testing/fertilizer recommendation research. Following are some more suggestions of basic research projects that could improve fertilizer recommendations:

1. Subsoil fertility - In areas with highly variable soils, like Portugal, soil test recommendations can sometimes be improved but knowing if the subsoil in an area is high or low in a nutrient. While surface soil fertility can rapidly change due to a farmers management subsoil nutrient levels are quite constant and once they are known can be used for a long time to adjust fertilizer recommendations. For example, if two farmers each have a field that tests very low in extractable phosphorus but one field is located on a soil with very high levels of subsoil phosphorus and the second is located on a soil with a very low level of subsoil phosphorus, the second field would get a higher recommendation than the first field. If it was found that the subsoil levels for phosphorus, potassium, etc. are the same for all soils in Portugal the process of making fertilizer recommendation is much simpler.

2. Testing for nitrate-nitrogen - Nitrogen is the nutrient that most often gives the greatest crop yield response but it is

also the nutrient that is usually ignored in testing soils. As farmers start using more nitrogen the occurance of residual nitrogen after harvest will increase. The use of a nitrate-nitrogen test will determine if some available-nitrogen is left over from the previous crop. Residual nitrogen is more likely to occur in the Alentejo but could also occur in other parts of the country.

3. Relationship between soil test and nutrient addition - In most instances a soil test is an index value that has to be related to crop growth in the field to be useful. For example, a phosphorus soil test of 20Kg/ha does not mean that the soil contains 20Kg of phosphorus and that after the crop takes up 20Kg the soil test will be zero. The question that needs to be answered is whether or not a response to phosphorus can be expected at a particular "index value" and whether or not this "index value" will increase, and by how much, when phosphorus is added to the soil. There are some soils in brazil on which as much as 400 lb P_2O_5/acre have to be added before any change occurs in the soil test level. If this situation occurs for phosphorus or any other nutrient on any Portugal soils it should be known. If this does occur it could explain why poor responses to phosphorus sometimes occur on very low testing soils.

IV. Summary

The equipment that was ordered last year was recently received by the laboratories. This was therefore an ideal time to explain how to use the rapid analysis equipment. We also discussed how to organize sample handling and analysis to obtain results rapidly.

The possibility of increasing the number of farmers being helped by soil testing will probably increase in direct proportion to the number of extension persons hired under the present regulations for taking samples. It is therefore recommended that extension agents teach farmers how to take samples rather then spending their time taking soil samples.

The final success of any soil testing program is determined by the promptness and quality of the advice it gives to farmers. The equipment and knowledge is now in place or soon will be to get rapid soil analysis. The emphasis should now be on improving the fertilizer recommendation tables and on getting the recommendation to the farmer.

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Addendum - Soil Testing in Portugal - Status and Recommendation

William C. Dahnke

June 1 - July 1, 1982

Training

A. In this report it is recommended that all soil fertility field trial data for Portugal be compiled and reevaluated. The evaluation should include soil test calibration and fertilizer recommendations. Each field trial should be summarized on a separate sheet. The summary data should include the following:

1. Year, crop and location of the trial.
2. Soil test data.
3. N, P_2O_5 and K_2O applied in kg/ha for each treatment.
4. Yield for each replicate of each treatment.
5. Data on weather, weed control or other factors that may have had an unusual influence on the results.

The collection of the above data should start immediately so that a meeting could be called in early November of the Portuguese Soil testing committee. At that time I would like to meet for up to 2 weeks with the following:

1. Eng. Soveral Dias
2. Eng. Joao Coutinho
3. Eng. Antonio Vaz Milheiro
4. Eng. Seculino Loureiro
5. Eng. Faustino Barradas

Although I would prefer to keep the group small, the people named above are only suggestions, the Procalfer Coordinating Committee should decide if other people should attend. The purpose of our meeting would be to discuss the methods used to interpret soil fertility data and then to construct fertilizer recommendation tables for the crops grown in Portugal.

It is hoped that the Procalfer Project would give financial aid, if necessary, for the above session.

B. Eng. Soveral Dias told me that he plans to visit some plant analysis laboratories in the USA in October 1982. When he is in the USA I think it would be useful if he could visit the soil testing laboratory at North Dakota State University in Fargo for at least one week. I am therefore suggesting that the Procalfer Project consider this in their plans for technical training.