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# SOIL FERTILITY EVALUATION REPORT

BY:

DR. ROBERT W. PEARSON

(Aug. 17 - Sept. 6/1980)

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## SUMMARY

1. The present status of the soil fertility program in Central America ranges from very good in Costa Rica, good in Guatemala, fair in Honduras and Panama to poor in Nicaragua. That in El Salvador is unknown at present due to inability to contact reliable sources of information and inadvisability of visiting the country at this time. Nicaragua's poor rating reflects a tremendous penalty of the recent political unrest. Panama's rating is not based on personal observation, but is probably reasonably close. Both Honduras and Costa Rica's status have improved distinctly over the past three years. In all the countries fertilizer recommendations are being made based on chemical soil tests and field experiment results from well-designed tests. Correlation data are still inadequate for best results but this is gradually being improved. Sulfur deficiency is endemic in the region and will become more common as the use of S-free high analysis fertilizers increases. The National soil fertility programs still definitely need backstopping to varying degree. CATIE's failure as yet to replace Dr. Rufo Bazán as Soil Fertility Coordinator to assist them with field experiment planning and interpretation is a serious threat to CATIE's influence in the general area of Soils. Also, upon Bazán's departure in 1978 the very active and promising regional soil analog project desintegrated, and the collection of maps, charts, data and computer program work stored at Turrialba where they remain.

The number of well-trained Soil Scientists in the region is increasing noticeably, especially on the various National Soils staffs. This, as well as the encouraging status of soil fertility expertise is undoubtedly a reflection of the strong impact of the Soil Fertility Project, which will continue to be felt for years to come.

2. The original Soil Fertility Project Laboratory has been merged with the CATIE Soils and Plant laboratories in Turrialba and is now designated simply as "Central Lab" under the direction of Ing. Díaz-Romeu. The facilities are adequate as are subprofessional personnel with the exception that he needs full-time services of a secretary. Ing. Díaz-Romeu is doing an excellent job of maintaining close contact with the various National soils labs, training their technicians as necessary and helping them with instrumentation, methodology interpretation, and correlation of field and lab results. There is a good relationship between this activity and the broad aspects of the National Soil Fertility programs in general. The Central Lab represents essentially the only contact between CATIE and the National Soil Fertility programs, of particularly Honduras and Panama. However, the Central Lab is tending to become a service lab for CATIE

graduate students' theses and SFCS sample analyses. This service does not as yet appear to have seriously restricted Ing. Díaz-Romeu in meeting regional requirements.

3. With the exception of Costa Rica and Guatemala CATIE's relationship to the various National Soil Fertility program is essentially limited to the contracts between the Central Lab and the National soils labs. The working relationship here is excellent. Ing. Díaz-Romeu also works with field fertility test data in helping correlate chemical results, thus providing some contact between CATIE and the entire National Soil Fertility programs. However, this does not fill the gap caused by lack of assistance in planning and interpreting field experiments.

There is no reluctance of National soils program people to release data for information of colleagues in other Central American countries, but there seems to be little activity of this kind, primarily, I think due to the absence of a coordinator. CATIE's assistance is welcomed by all the people contacted. One exception seems to be the Guatemalan regional technology transfer groups which have not released field test data even to the Soils Dept. there.

4. Undoubtedly, CATIE has the basic capacity to understand and utilize accumulated soil fertility information in this region. All of the Country Residents directing the SFPS program are good, experienced Soil Scientists or, in Dr. Mateo's case, an Agronomist with strong soils background. Dr. Burgos, who is in charge of that project is a well recognized Soil Scientist. The problem is not one of lack in expertise but one of priorities. Time is not usually available for the SFCS staff to meet their assigned responsibilities and still devote sufficient effort to planning and interpretation of National fertility tests to be of significant help. An exception was found in Guatemala, where Dr. Donald Kass is working closely with the Soils Department on known fertility problem while carrying out his duties as SFCS Country Resident.

5. Technical assistance to the National programs for improving their capacity to make specific fertilizer recommendations is being provided primarily through Ing. Díaz-Romeu working with both lab and field test staffs on correlation. At present this is the only support provided, and significant improvement will probably await the appointment of a Coordinator.

6. Soil fertility expertise is definitely increasing throughout the region and is being incorporated into on-going National programs. There is no doubt in my mind that the impact of the S.F. Project is being felt and that it will be a sustained effect, as evidenced by

the increasing numbers of people entering the field via advanced training. There are now 11 professional Soil Scientists on the Costa Rican Soils Department staff for example. A Soil Science Society of Costa Rica was established and had its first meeting this year. This example, no doubt, will be followed by other countries in an approach to orderly progress.

7. The Soil Fertility Project program is already incorporated into National soil fertility efforts. This extends from the use in practically all cases of the discontinuous model for field experiments to the lab methodology, interpretation of results, and recommendation of fertilizer to be used by farmers.

8. CATIE's response to regional soil fertility problems is chiefly in the efforts of the Central Lab, except in Guatemala and Costa Rica. However, CATIE has the expertise and I found a positive attitude toward soil fertility needs. Policy, according to Dr. Oñoro, is to address the problem of regional coordination of field experiments by appointment of a successor to Dr. Bazán as soon as possible. Plans are being explored for a project to evaluate the role of organic matter, e.g., crop residues and green manure crops, in plant nutrient turn over and conservation. Another step toward contact and coordination of soil fertility programs is the Soil Fertility Seminar being planned for early Spring, 1981. Dr. Héctor Muñoz, Technical Director of CATIE, stated his concern with soil fertility problems in the region and indicated that an experienced Soil Scientist will be appointed to fill the position of Soil Fertility coordinator. He said that as a minimum CATIE will continue support of the Central Lab for regional training and coordination, and toward transfer of technology and planning and interpretation of field experiments.

## RECOMMENDATIONS

1. The position of regional soil fertility coordinator vacated by Dr. Rufo Bazán in 1978 should be filled with an experienced Soil Scientist at the earliest possible time.

2. The soil fertility coordinator should give especial attention and on-site time to assisting the National programs in Nicaragua and Honduras in planning and interpretation of field experiments.

3. Dr. Oñoro should take appropriate steps to insure that each SFCS Resident is in contact with his country's soil fertility program such as inviting soil fertility specialists to participate in the SFCS annual planning conferences. 1/

4. CATIE should request permission of the Costa Rican government for a limited number of control soil samples to be brought into the Central Soils Lab without incineration. Methyl bromide treatment could substitute as a fumigant for roya.

5. CATIE should send experienced Soil Scientists, e.g., Ing Díaz and Mateo, to Honduras to review breakdown in communication there and develop specific plans for strengthening collaboration with their field experiment effort.

6. Ing. Díaz-Romeu should be sent to the States for several weeks during the coming year for refresher training.

7. The Central Lab should address the problem of prediction of sulfur deficiency in soils of C.A.

8. Ing. Díaz-Romeu should be sent to survey soil lab facilities and technician training needs in Nicaragua as soon as is convenient.

9. The upcoming Soil Fertility Seminar being planned by CATIE should:
   a) Have a slot-allocation plan that will favor countries in greatest need, e.g., Nicaragua and Honduras.
   b) Place emphasis on field experiment planning, interpretation and correlation with lab test data.
   c) Schedule, with Dr. Burgos' concurrence, at least one lecture by each SFCS Resident on his program.

1/ Four of the SFCS leaders are Soil Scientists and the fifth an agronomist with strong soils background. Thus they would have much in common with the national soils program staffs.

10. The Soil Analog effort should be rejuvenated as soon as possible, and before the keen interest of participating National scientists has dissipated.

General

Upon completing this evaluation and before completing my report I had a 2-hour visit with Dr. Héctor Muñoz, Technical Director of CATIE. Dr. Muñoz asked that I brief him on the results of the evaluation, conclusions reached, and suggestions as to ways that CATIE could be more effective in meeting soil fertility needs of the Region within its present budget. This I did and found Dr. Muñoz interested and sympathetic. He had an excellent suggestion in response to the observed need for improved contact between the SFCS Country Residents and the National soil fertility staffs. Every year CATIE holds a planning conference in each country for SFCS and counterpart staffs. Hereafter, Dr. Muñoz said, invitations will be sent to the National Soils Dept. to attend the planning conference for their country's SFCS program. I requested him to make the invitation "to participate in". Another point on which I feel there is agreement, and on which action can be expected, is the need for a Soil Fertility Coordinator to fill the position vacated by Dr. Bazán. Dr. Muñoz said that an experienced Soil Scientist will be appointed to coordinate soil fertility programs throughout the Region. He also said that as a minimum, CATIE will continue support of the Central Lab toward meeting training and coordination needs; and toward transfer of technology to various countries and helping them plan and analyze their fertility experiments. To do more would require adding positions and the money is not available at this time.

We discussed the situation in Panama and I learned that their soils lab is only temporarily located in Divisa. A site has been acquired in Santiago and construction scheduled already. The agricultural center will be located there. Dr. Muñoz pointed out that Ing. Bejarano, country SFCS Resident in Panama, has 3 field experiments that include fertility levels.

Regarding El Salvador and Nicaragua, he said that nothing is left the same, and that both countries are going to need help urgently. Nothing can be done in Salvador until stability has returned and there can be some confidence that the organizations and their leaders are going to remain for some time.

In general I was impressed with Dr. Muñoz's expressed concern over improving the status of soil fertility information and expertise in the region, and his intention to improve coordination and contacts.

Evaluation Methodology:

This evaluation was made by Consultant Robert W. Pearson during a three-week period (August 17 - September 6, 1980), with assistance from Mr. Roberto Díaz-Romeu, the only remaining member of the Soil Fertility Project Staff, and various persons on the CATIE, University of Costa Rica, and Ministry staff who were closely associated with the Project over a period of several years. A list of the persons contacted is included as Appendix A of this report. Guidelines for the evaluation include the following:

1. Present status of the soil fertility program in Central America. This was accomplished through review of soil fertility work plans of CATIE and of cooperating Central American countries with a view to assessment of their validity for meeting requirements of the region.

2. Central Laboratory utilization. The questions addressed by this phase of the evaluation were: a) What use is being made by CATIE of the laboratory?, b) How does this use relate to cooperating national soil fertility programs? and c) Are the facilities adequate to meet requirements?

3. Relationship to National soil fertility programs. This critical point was addressed by attempting to answer several questions with reference to each cooperating country: a) Is information on soil fertility being exchanged among CATIE and the various national staffs?, b) Has CATIE maintained and strengthened necessary contacts with national staffs?, c) Is CATIE's assistance welcomed? and d) What steps could be taken to improve relations?

4. Technical support and coordination. Basically, this point involved evaluation of CATIE's capacity to utilize information accumulated by the Soil Fertility Project in providing technical support and coordination throughout the region, and depends essentially upon the attitude and technical understanding of the CATIE staff regarding soil fertility problems of the region.

5. Technical assistance to Central American countries with respect to increasing capability for making specific fertilizer recommendations.

6. Present status of soil fertility expertise and national on-going soil fertility programs.

7. Incorporation of the Soil Fertility Project program into national efforts.

8. CATIE progress relative to soil fertility problems and response to suggestions for strengthening soil fertility work at CATIE.

Documents to be revised to reflect decisions noted on page 1

None.

Background

(See Appendix B for early background). The transfer of the Soil Fertility Project from ROCAP to CATIE was processed as scheduled in March of 1978 and terminal reports prepared and submitted as itemized in Appendix C. Since then, Dr. Rufo Bazán, one of the two soil scientists on permanent CATIE appointment has resigned and, of course, the contract expiration of Drs. Walker and Stryker has left the Project with only one professional staff member, Mr. Roberto Díaz-Romeu. In addition, the political convulsion in Nicaragua and the present unsettled conditions in El Salvador have had very serious detrimental effects on the on-going soil fertility programs in those countries.

Country Analysis

Costa Rica

My instructions were to contact Mr. Robert McColaugh at ROCAP upon arrival in Costa Rica. Since I arrived Sunday evening, August 17, and he is not listed in the telephone directory, I made several other contacts by phone after finding a hotel and set up tentative appointments for Monday afternoon and Tuesday morning with acquaintance familiar with the project.

On Monday morning I located the ROCAP offices and had an orientation visit with Mr. McColaugh. He said his information was that I would know what the evaluation consisted of as outlined in the scope of work and would leave it at that except for an offer of assistance in travel arrangements, appointments and in preparation of my report as secretarial time may permit. Mr. McColaugh also said I should sign a contract which his office was in process of preparing, and an appointment was made for mid-afternoon to do so.

In the meantime I asked for assistance in locating Dr. Rufo Bazán, a former key person to the Soil Fertility Project who, I understood, was no longer with CATIE. McColaugh said Bazán is now employed by IICA and that he (McColaugh) had to make a trip to IICA offices shortly. So I was able to make contact with Bazán immediately. I was especially anxious to get this interview, since upon the transfer of the Soil Fertility Project from ROCAP to CATIE he was to be the person upon whom most of the leadership responsibility would fall. I hoped to get considerable information regarding activities of the project subsequent to my review just prior to the Project transfer and subsequent to the transfer to CATIE. Naturally, I was disappointed to learn that he had left CATIE almost immediately after the Project transfer, and his position has not been filled even as yet. The Project has thus been operating without aggressive leadership or coordination. Dr. Bazán did show the copies of the terminal report submitted around the time of the transfer (see Appendix C).

This report consists of a basic section supplemented by 27 Annexes - a mass of material which I have as yet been barely able to begin to scan. I was especially interested in reading any responses to those reports in order to orient my own understanding of past events, but learned that none had been received. I was particularly interested in the reports dealing with the soil Analog work and with the workshops held in connection with this phase of the project's activity. Since its inception I have believed that the Analog approach offered the most promising basis for a broad extrapolation of the soil analysis and soil fertility information being accumulated across the Region both by the Central Lab and by the various national programs. The correlation of soil chemical analysis results with plant response to applied fertilizer, and the extrapolation of this information to analogous sites not so tested is the key to any successful, broad-based fertility program. I was naturally dismayed to learn that after a most encouraging beginning, this work had been abruptly discontinued. Some of the leading soil scientists in the Region, Marín of Nicaragua, Rico of El Salvador, Alvarado of Costa Rica and Burgos of CATIE, believe that this approach has real promise, in fact, a planning conference was held in El Salvador in July 1977, which set things in motion for a full scale working conference held in March 1978, and was attended by four representatives from each Central American country, including Panama. This group brought together soil, climatic, geologic and ecological maps available in the Region, made arrangements for adjustments to a uniform scale, and reached an agreement with the Salvadorian officials for use of computer facilities and development of a program to begin data processing. At that point leadership in the person of Dr. Bazán was lost and nothing further has been done. However, it should be underscored that this multinational group in their recommendations requested CATIE to accept leadership and coordination of this effort which would be tantamount to coordinating all soil fertility activities in the Region.

Dr. Bazán's present responsibilities as Coordinator, American Tropics Task Force, Interamerican Institute of Agricultural Sciences, OAS, does not include Central American countries at present, so he is no longer in close contact with those organizations with whom he worked in Soil Fertility Project. For this reason he was not able to fill me in on recent events, but was quite pessimistic with regard to the continuing impact of the Soil Fertility Program on these countries' national programs. He did feel strongly that a scientist of Dr. Jim Walker's stature would be essential to the long term success of the project.

After the visit with Dr. Bazán, I had a visit of several hours with Dr. Elmer Bornemisza, who is an exceptionally capable Soil Scientist with the University Graduate School and has been most cooperative whenever called upon by the Soil Fertility Project people. He was especially helpful in giving me an up-to-date picture of the interrelation of the Ministry soils group, the University staff and CATIE. I was happy to learn that a close relationship exists and that Bornemisza feels that the Soil Fertility Project has had a strong impact on the Costa Rican National program. He was of the opinion that the National staff is now strong enough and sufficiently well established to carry on alone if it comes to that. Costa Rica has and is training soil scientists of a quality any country would be proud of. I am certain that this situation is in no small measure due to the influence of the Soil Fertility Project over the past number of years.

I subsequently, on Friday, had an opportunity to visit with Alfredo Alvarado, one of the most promising soil scientists on the University staff, who is returning to Raleigh to resume work on his Ph.D. immediately. He was one of the prime movers in the Soil Analog phase of the Fertility Project and I was particularly interested in getting his views on CATIE's performance in assisting the national groups. He was much less than complimentary except that cooperation has been very good with the Central Lab. He is President of the Costa Rican Soil Science Socitey, which had its first meeting this year, attended by quite a number of soils specialists from other Central American countries. The formation of this Society is a most definite step toward orderly procedure and cooperation among related science oriented groups. It is without doubt another spin-off gain from the S. F. Project activities. Alvarado said that in a special session on the analog project those attending were in agreement that they need not expect much assistance from CATIE in the area of Soil Fertility beyond that rendered by the Laboratory. I think that this certainly indicates that CATIE should attempt some fence mending if it hopes to keep the confidence and cooperation of Central American Soil Scientists.

I also visited the Ministry soils group and found an encouraging situation there. In the first place the Soils effort has been recently consolidated by executive order, placing fertility, classification and conservation all in one department under Dr. Cordero. There are 11 professional Soil Scientists in this Department. And in the second place, Dr. Cordero, who is a recent Ph.D. graduate of North Carolina State, has just been named coordinator of graduate programs between CATIE and the University. I imagine that this association may well help somewhat in bringing the Soils people into even closer contact with CATIE.

I also visited with Mr. Coward, who is in charge of the laboratory. Based on a tour of the lab I would say that it is adequately equipped and well run. Around 5000 samples were processed during the past year. Mr. Coward told me that the nominal charge has been put on each soil sample submitted by farmers and that, interestingly, they are getting fewer samples but from the same number of farmers. A check had shown many farmers were sending several samples from the same small plot or field. Now they tend to send only one or two per field.

Cordero, echoed Bornemisza's feeling that Costa Rica has a very active and effective soil fertility program and will be little affected by CATIE policy. They do collaborate closely with the Central Lab., sending control samples from time to time and exchanging equipment and supplies in emergencies. Cordero lectures at times to CATIE classes. Although Mr. Coward, a chemist, runs the lab, interpretation and fertilizer recommendations are made by Cordero and others familiar with the field correlation results. Their most pressing problem at present is minor element deficiencies in certain areas, especially B, Zn and Mn. These deficiencies are usually diagnosed by visual symptoms and/or foliar analysis. Of course, there is no problem of rate of application of minor elements so the procedure seems sound.

One final note from the Cordero discussions. He was also one of the strong supporters of the Soil Analog project, and expressed great disappointment in what he called the "dead project", recalling the work that had been done by quite a number of people in compiling data, collecting and correlating available pertinent maps and adjusting mapping scales. He did feel that interest among the same group could be rekindled and support rebuilt provided a competent Soil Scientis, especially one already familiar with the project, were assigned responsibility for coordination.

A visit with Dr. Peter Duisberg, who was consultant to ROCAP on the Soil Analog Project, developed about the same picture already obtained during discussion with members of the Costa Rica and CATIE

staffs. He said leading Soil Scientists had held two sessions to consider this work, the first (exploratory) in Costa Rica in September 1977 and the second in El Salvador to make specific plans and recommendations in March 1978. Four scientists from each country attended the second session, including representatives from Panama. The outcome was a strong expression of confidence in regional utilization of accumulated soil fertility information that could be realized by analog application and some specific recommendations including one that CATIE gives this project leadership and coordination across the Region in all phases of soil fertility and soil classification efforts. This would appear to be the very kind of opening CATIE would be looking for. In reply, CATIE asked Dr. Oñoro, who had been sympathetic to the soil analog program to prepare a reply, and he requested Dr. Duisberg to prepare a report giving outline of what CATIE could do to follow up on these recommendations. I read a copy of Dr. Duisberg's report, but have found no further record of action taken. Project was let die.

The Central Soils Laboratory and Ing. Díaz-Romeu are apparently the only identifiable physical remnant of the Soil Fertility Project. I feel that as long as they survive with an appropriate mandate, there is hope for at least maintaining the level of laboratory expertise attained in the cooperating National programs. Ing. Díaz is certainly doing a commendable job of maintaining contacts among the national staffs, even though his regional duties are being diluted (Appendix D) as a result of a consolidation of the Central Soil Fertility Lab with the CATIE Soils Lab under his supervision. Thus, I do feel that the Central Soil Fertility Lab is gradually assuming essentially a service role to CATIE's different programs. While this service is certainly essential, it should not become the dominant charge of the laboratory. For this reason I think it would be appropriate to outline my own ideas of what the responsibilities of the laboratory should be, in order of decreasing priority:

1. Training. There is a constant turnover in the National soil fertility programs personnel, and a continuing need to provide in-service training in laboratory procedures, data processing and interpretation.

2. Research

   a) Methodology, e.g., comparing results from procedures that differ somewhat from one National lab to another.
   b) Calibration, e.g., identifying critical levels especially of those nutrients such as sulfur that are very poorly understood.
   c) Extrapolation, particularly in assisting with a hopefully rejuvenated soil analog effort.

3. Service. The lab is called upon as noted above and for analytical assistance on special projects by both CATIE and University personnel and by cooperating countries. Equipment maintenance is a very important function. Mr. Díaz-Romeu is called on by National labs whenever they have equipment breakdown they cannot correct. He is very competent in this area.

In conneccion with training I think it is time Mr. Díaz-Romeu had some refresher work. This might well take the form of an extended visit to several labs in the States that have well established and successful soil testing programs. North Carolina, Florida, Alabama and Texas might be among those considered. I mentioned this to Mr. Díaz-Romeu and learned that something of this kind is being considered.

The Central Laboratory has been enlarged with improved arrangement of space. Also Mr. Díaz-Romeu has adequate assistance in the way of technicians and subtechnical personnel. However, he does need very badly the exclusive service of a secretary. Further, CATIE has acquired a more sophisticated computer and the lab can now process data not only more rapidly but far more completely than before. The appointment of Dr. Henao to direct computer programming and use will be a big help in making best use of data.

One serious problem faced by the laboratory and the National programs in making effective use of the Central Lab for control of analytical work is the impossibility at present of transporting control soil samples across national boundaries without them being subjected to sterilization procedures that drastically alter results of chemical analysis. The most common procedure for soil sterilization is autoclaving which is unacceptable for soil samples for chemical testing. There are alternatives to autoclaving which would effectively destroy disease organisms without significantly affecting chemical or minerological structure. Even more desirable, would be an agreement by which a recognized scientific agent (CATIE, for example) could be authorized for designated persons on their staff to hand carry a limited number of foreign control samples of soil to the Central Lab, and for their safe handling and eventual destruction with proper records being kept of each operation. This procedure works in the U.S. I have on many occasions in the past obtained permission to bring research soil samples from foreign countries to my lab without sterilization and be responsible for their proper and safe disposition.

Ing. Díaz-Romeu usually plans for one or two training sessions in the Central Lab each year, usually to be held during the slack crop season in July or August. It seems to me, in view of the relatively small number of people usually enrolled, one regular session a year should

be adequate. This would leave more time for taking care of the special and emergency training situations that arise from time to time, e.g., the present urgent need of new, inexperienced Nicaraguan lab technicians for training.

Ing. Díaz-Romeu said that there is very little transfer of soil fertility information between National programs except for that which accompanied the conduct of work on the Soil Analog Project. There is no obvious reason for this except, perhaps, inertia. Even the Central Lab has difficulty getting field response data and accompanying soil analytical results for correlation study.

In visiting around the laboratory and greenhouses I was shown some interesting pot work in progress on effects of different levels of aluminum on corn and bean root development. This kind of information is useful in setting critical toxic levels of aluminum for purposes of liming recommendations. However, it seems to me that there are other problems that should be given at least equal importance, in view of the relatively minor extent of severely acid soils in the Region. For example, critical levels of sulfur and correlation of extractable sulphate with plant requirements is a very important area that has been neglected throughout the region.

Since the Soil Fertility Project transfer, CATIE has undergone one or more shifts in organization, with the result that all its technical activity is now grouped into four Programs: Annual Crops, Perennial Crops, Animal Production, and Natural Renewable Resources. The Cropping Systems Project and the Soil Fertility Project are under the Annual Crops Program, headed by Dr. Pedro Oñoro, who is apparently soil fertility conscious at least to the extent of recognizing the necessity of insuring adequate plant nutrient level and balance for successful crop production in either monoculture or more complex cropping systems. He pointed out that there are four Soil Scientists with excellent training working in the Small Farms Cropping Systems Project: Carlos Burgos, Coordinator; Washington Bejarano, Panama Country Resident; Donald Kass, Guatemala Country Resident; and Aníbal Palencia, Country Resident in Costa Rica. In addition, Nicolás Mateo, who is Country Resident in Honduras, has his Ph.D. in Agronomy with good background in soil fertility. This is an impressive list of able and experienced Soil Scientists, coordinated by a truly outstanding young man. It lays to rest the question whether CATIE has the technical capacity to utilize information accumulated by the Soil Fertility Project and being made available through the various National soils programs and the Central Laboratory. Yet it emphasizes the fact that no procedure by which information from fairly well-correlated soil associations in one country can be confidently extrapolated to similar soils in other countries where information is

lacking. Also, and perhaps more importantly, the Country Residents are loaded to capacity with duties involved in carrying out the SFCS field work that they have very little, if any, time to keep abreast of soil fertility developments and respond to requests for assistance in the design, conduct and interpretation of experiments in this area of effort.

In the past, of course, the National Program staffs have leaned heavily on Jim Walker and his people for help in planning and interpreting field fertility experiments, and for coordinating these results with chemical analyses. Now there is a void here because Dr. Bazán has not been replaced and Roberto Díaz-Romeu has all one man can do in running the Central Lab.

Most of the National program people interviewed expressed disappointment over CATIE's failure to put more emphasis on soil fertility. Without exception they emphasized that under Bazán's leadership the soil analog project was moving smoothly and rapidly, and that it had strong support among leading scientists in every country who were convinced that if he had been continued in his position with CATIE the analog project would have been successful.

At this point it seems that filling Bazán's position on the CATIE staff either by bringing him back or by putting in one of the soil scientists who is already acquainted with the region eg. Bejarano, Marín or Burgos would be a wise move by CATIE. Any one of these scientists could provide the soil fertility contracts and coordination for SFCS with National fertility programs, and could give assistance in planning and interpreting field experiments for those countries with especial deficiencies in these capabilities.

In discussions of the status and needs of the soil fertility aspect of regional programs with Carlos Burgos of the CATIE staff, an extremely able and agressive young man, I learned that there have been numerous discussions among the CATIE staff of the broader aspects of "extrapolation" of information to include all the parameters of crop production. He said the argument was that since this is our ultimate goal so why not shoot for it directly. However, it appeared to me that he felt this would be taking too large a bite out of an extremely complex problem. I certainly am of that opinion. To begin with, the objective of determining analogs for cropping systems involves an almost infinite number of variables of which soil productivity and adaptability and climatic factors are among the most important. Why, then, not begin with a smaller, but essential, segment of the larger problem with the expectation of being able to show significant progress not only in solution of the soil-climate segment but in the process in the final systems extrapolation? The idea proposed by espe-

cially ardent supporters of the new Taxonomy, developed by Dr. Guy Smith of the U.S.D.A., that soil categories in this system at the family level constitute analogs has yet to be proved for land use and management requirements. For example, soil profile development is in many cases a process of almost geologic time dimension during which climate may change significantly in a given area.

I was fortunate to catch Ing. Agr. Aníbal Palencia in Turrialba en route to his SFCS experiments in the Siquirres area. Since he is an ex-member of the Soil Fertility Project team and is now CATIE's Country Resident for SFCS in Costa Rica, he should have good insight into the events that have transpired since transfer of the SF Project to CATIE. His field experiments, about 18 in all, are all with maize and root crops (2 crops of maize one year followed by a root crop the second), but there are no fertilizer variables included. Some of the tests are on the local experiment station and others on farmers' fields, but since his group is responsible for installation and execution, the results should be dependable. Regarding capability of the Costa Rica National soil fertility staff and the quality of that program Palencia gave about the same picture as had already developed from other contacts. Field fertility trials are carried out chiefly on the Pacific slopes and lowland (in addition to work with coffee in the Meseta). He felt that most of the experiments were well enough designed and carried out, and that this program could carry on under its own power, regardless of what direction CATIE may take. There is, however a good and mutually useful relationship between the two groups, and Palencia feels that contact between his projects and the National soils program would be closer if it were not for the high degree of compartmentation in the Ministry.

Since the Central Soil Fertility Lab is located here in Costa Rica and there is constant contact and close working relations between Ings. Díaz-Romeu and Palencia, the latter depends entirely on the lab for his soil and plant analyses. Thus the need for close contact with the National program is not present. I think that this relationship could well be expanded a bit to the advantage of all by Palencia paying especial attention to any plant symptoms of sulfur or minor element deficiencies that he may observe as he travels around the country. Whenever deficiency or toxicity symptoms appear, he could bring soil and plant tissue samples together with normal plant and corresponding soil samples on his next trip to the Lab for use in establishing critical levels of these nutrients in soils.

At the time of the last Soil Fertility project evaluation there were plans to initiate a research project on the role of organic matter in soil fertility and conservation in the tropics, including stubble-mulch

farming and systems of crop residue management. ROCAP was looking for a qualified scientist to prepare a project proposal and probably to lead it. This is an extremely important area of soil management and fertility and a recommendation was made that it be implemented as soon as possible. After various inquiries during the present evaluation, I located a copy of a report made by Ing. Agr. Fernando Abruña of Puerto Rico to Latin American Programs, ERS, recommending initiation of such studies (Summary of Abruña's report included as Appendix E). Following up on this with Dr. Oñoro I was told that he has plans under development in the Annual Crops Program for a Soil Management Specialist, who would function separately from both Soil Fertility and SFCS. This project, he said, would be charged with organic matter-soil fertility relations, crop residues-soil conservation, and other aspects of soil management. This development was followed by information from Ing. Díaz-Romeu that Dr. Robert Volk, Organic Soils Specialist with the University of Florida, spent a couple of weeks in Central America in July 1980, working out of CATIE in Turrialba, where he examined possible areas of cooperation between the University of Florida and CATIE on organic matter studies. A recent note from him stated that he was preparing several project proposals.

Nicaragua

I was informed that since the political upheaval in Nicaragua, the soil fertility program there had simply ceased to exist. Ing. Díaz-Romeu said that he had been unable to establish contact with the laboratory in Managua and advised against spending time there. Instead, he did get in touch with Ing. Eduardo Marín, who was Head of the Soils Department until the revolution and is now Soils Specialist, IICA-PIADIC, in Managua. Marín had plans to come through San José on August 22 and readily agreed to spend a couple of hours with us. It was an interesting session though not very instructive with regard to Nicaragua's present soil fertility program. He reported that all the people in soil fertility lab have dispersed, and although the laboratory is in business, it is being run by completely inexperienced and poorly trained technicians. The field experiments which three years ago comprised an impressive group of well designed and managed tests, have been completely abandoned. However, Marín did express hope that conditions are stabilizing and that definite improvement may be on the way. He emphasized the present urgent need for training of the inexperienced lab staff, and asked Ing. Díaz-Romeu to make a short survey visit as soon as possible to evaluate their problems, then help them plan how to handle the situation.

In spite of all these problems, however, Marín is still interested in the soil-climate analog concept, in which he had been so active earlier. He insists that there is adequate soil classification and climatic information available in all the Central American countries to permit carrying through on this project. He pointed out that van Wambeke had strongly endorsed the project during a session on soil-climate analogs during the Costa Rican Soil Science Society Meeting earlier this year, and gave me a copy of the specific project proposal discussed. I attach it (Appendix F) as representing the most recent ideas among the Central American Soil Scientists.

Marín made one interesting observation about emerging national policy in his country to the effect that there is a growing trend to put more emphasis on the large farming operations in the interest of increasing national production.

Honduras

We spent two days with the Soils Department, which is organized into four sections: Soil Fertility, Soils Lab, Soil Classification, and Soil Conservation. All are under Ing. Jorge René Medina. Dr. Nicolás Mateo, SFCS Resident, could not be reached for a visit as he was at a distant site where he has field experiments.

All the time here was spent with Ings. Medina, Valdés, and Fernández. Valdés is assistant to Medina and in charge of the field experiments, and Fernández is head of the Soils Lab. The camaradie that obviously exists among Ings. Díaz-Romeu, Medina, Valdéz and Fernández was adequate evidence for me of an excellent working relationship. That and the frank discussion of problems and answers to questions.

First, I can report most encouraging, although surprising, progress made by this program during the past three years. They had problems due to movement of the lab to its present location in Tegucigalpa during the past year, and the transfer and installation of all facilities are not yet complete. But they are back in operation in a new building with ample, suitable space accessible to the rest of the Department. This is a tremendous improvement and will no doubt be reflected in performance.

The field experiments all use the discountinuous model with N, P and K as variables. Unfortunately none have a S or minor element variable, although S deficiencies can be expected to become widespread with the increasing use of high analysis fertilizers and minor elements are known to be deficient in some areas. Valdéz said that he has been having a problem with prediction of P response. In a number of instances where lab analysis indicated low P there was no response by plants in field test. Ing. Díaz-Romeu advised him on adjustment of estimated critical level. They planned a more detailed review of this problem later.

Valdéz has 30 field experiments in progress with maize, rice, beans and sorghum located throughout the country in areas of intense farming. All are in farmers' fields, usually where a fertility problem was suspected. He is over half-way through with a report summarizing field and lab results from 83 experiments completed since 1977.

Fertilizer recommendations are made by Valdéz, who keeps in close touch with the lab. He said he wished CATIE would send someone from time to time to help him in planning and interpretation of his field experiments. I told him to ask CATIE for help when he needs it.

Review of the Lab's activities over the past showed that the number of samples analyzed has remained about constant at about 2000 for a

number of years prior to 1974. It jumped to 4500 in 1975 and has remained between 4 and 5000 since then. This extensive use of chemical soil analysis for fertilizer recommendation is another reflection of the S.F. Project impact on National programs. Fernández said that nearly all the samples processed are from small farmers' fields. The fact that the number of samples has remained constant since termination of the S.F. Project as such, is evidence that the National fertility program is maintaining its momentum.

When asked what the chief function of the Central Lab should be both Valdéz and Fernández in separate interviews replied "training in lab methodology and correlation". Fernández added that he does need technical assistance from time to time when especially difficult problems come up with instrument performance or data interpretation. Both these men commented very favorably on the usefulness of Soil Fertility Seminars for both training and coordination.

Significant progress is also being made in soil classification, which is an important adjunct to extrapolation of soil fertility information. A recent survey and report for the entire country was published in 1977 and detailed surveys of intensively farmed areas have been completed since then. The work is being supplemented and supported by CATASTRO.

The preceeding paragraphs review the favorable aspects of the National soil fertility program, which Medina stated emphatically are a result of lifting themselves by their own bootstraps. He actually seemed hostile when I tried to explore cooperative relationships with both the SF Project and CATIE, past and present. However, when confronted with training given some of his technicians and assistance in lab methodology he had to admit there has been collaboration. This amazed me because the 1977 evaluation failed to uncover a problem of this kind. Ing. Martínez, who was Soils Dept. Head at that time, was given ample opportunity and ecouragement to express himself. At any rate, when I asked Medina what contracts he has had with CATIE he replied flatly "none". He then listed a series of complaints going back 3 or 4 years that are too serious to be dismissed lightly by CATIE. I am listing the following which seem to me to be the most serious of his criticisms:

1. Dr. Ron Stryker when stationed here a Soil Fertility Coordinator by the S.F. Project, refused the invitation to occupy office space in the Soils Dept., and set up his office in IICA. Soils people were never able to get response to repeated requests for assistance in field experiment design and interpretation of results, according to Medina. He said they usually were unable to even get in touch with him.

2. The field experiments that Stryker reported as S.F. tests under his coordination at Copán, Danlí and Comayagua were said to be National program tests planned and carried out without assistance. Valdés at this point said that he was personally conducting the experiments at Danlí and he did not have assistance from Dr. Stryker.

3. No copies of any field results obtained in Honduras by either the S.F. Project or CATIE have been sent to the Soils Dept. prior the publication, although reports have listed the Department as collaborating.

4. The Soils Dept. was not given an opportunity to participate in preparation of any of the reports issued by S.F. Project or CATIE.

5. When Bejarano was sent to Honduras as S.F. Coordinator he did not identify with the Soils Department but set up office with SFCS Resident. Medina said he was not even informed that Bejarano was in the country as a S.F. specialist.

Ing. Medina is apparently an intelligent and effective Department Head receptive to cooperation with his field test program. Whether he was actively seeking it, is another matter.

Ing. Díaz-Romeu was as surprised as was I at this turn of events because he said that he had never had any problem collaborating with the Soils Lab and had not heard there were problems elsewhere in the organization. So one can only attribute this situation to an unfortunate breakdown in communication somewhere along the line - perhaps combined with some personal imcompatibilities. In any event CATIE needs to send someone to try and straighten things out. But it will take more than mere lip service. I would suggest that Mateo and Díaz-Romeu plan a visit for this purpose. Díaz already has a history of effective collaboration and Mateo is newly stationed there. Certainly SFCS will be needing soil samples analyzed and can use the accumulated experience of men like Valdéz.

I regret that we were not able to contact Mateo, in spite of attempts by phone and relayed message both prior to leaving Turrialba and while in Honduras.

Panama

I am including Panama even though an indirect approach will have to be used. Ing. Díaz-Romeu has tried unsuccessfully for a week to get in touch with Ing. Bejarano, SFCS Country Resident there and then learned that he was away on vacation. In the meantime I had read the Panamanian terminal soil fertility report (Annex No. 27 of Appendix C) and found a fairly extensive and apparently well conceived soil fertility program underway. I was told by Ing. Díaz-Romeu that Ing. Benjamín Name who wrote the report and was at that time -one year ago- Department Head, is no longer in that position. I then had a talk with Ing. Burgos to learn what he might know of this National soil fertility program through Bejarano's reports to him as coordinator of SFCS. Burgos was surprised to learn that Panama has a soil fertility program at all, having seen no reference to it in Bejarano's reports, and said that at the first opportunity he would visit the lab and get acquainted with the people there. One likely reason for the apparently low profile of that program is the fact that the Soils Department moved its locations to that of the Agricultural School of Divisa some three or four years ago. They have been in touch with the Central Lab at CATIE, having sent a technician Lic. Alfonso Singh to be trained here during the past year.

Attendance records of the Soil Fertility Seminars show that Panama has sent four people, and has been well represented at other regional soil fertility sessions, including the task force on soil analogs. Thus, the Country has participated in and contributed to the S.F. Project efforts in no small measure.

According to Ing. Name's report, they had around 55 field experiments with varying N, P and K levels on rice, corn, sorghum, tomatoes, onions, potatoes, cane and beans, on sites to which each crop was considered to be adapted. Results are summarized and made available to extension and educational services. These figures are for the past two years.

The Soils Lab analyzed around 5000 soil samples per year during the last two years of the report. Ing. Name estimated the lab's capacity to be in the order of 20,000 if fully staffed. His report showed a very high percentage of the samples are P -deficient, whereas K -deficiency is just the reverse.

Ing. Name stated that his country needs principally two types of assistance from CATIE in the area of Soils:

1. Technical assistance in planning and carrying out field laboratory and greenshouse experiments, and

2. Training and coordination, through means of courses or seminars.

I think it is quite obvious that the regional soil fertility program has had a very definite impact on Panama's National soil fertility program, and believe that with the expenditure of even modest effort to improve contact CATIE can maintain this relationship in both field and lab phases.

Guatemala

In Guatemala we visited with Dr. Donald Kass, SFCS Country Resident, Dr. Emilio Escamilla, Soils Dept, Head, Ing, Mario Breauner, Director of Soils Lab, and Ing. Ricardo del Valle, Region 7 Director for ICTA.

The country is divided into 7 Regions under ICTA, each with its own headquarters Experiment Station and staff, and each with its own program headed by a Director who has final word on the program in the Region.

Since 1975 Guatemala (ICTA) has had a commodity oriented research program which places Soil Fertility in a subordinate position - strictly one of service. The entire Soils Dept. has only three, or perhaps four, professionals. It consists primarily of the Soils Lab and the Department Head. The Soils Lab appears to be well-staffed with experienced technicians, and is processing a surprising 15,000 samples. Nearly all of these are sent directly by farmers or through their country agents. Field experiment samples are analyzed here, eg., those from Dr. Kass' experiments and from the different Regional ICTA experiments. Ing. Breauner makes the fertilizer recommendations based on soil test and results of the field experiments run by the S.F. Project from about 1964-1975. Field test data accumulated since then within ICTA by the different Regional programs, but I could find little solid information about the number of fertility experiments under way in each Region that would be useful for specific fertilizer recommendations. These agencies then release bulletins giving generalized fertilizer recommendations within the Region based on a combination of soil test data, management practices to be used, and general experience. Escamilla said that the farmers who send samples to the lab have more faith in the specific recommendations as evidenced by usually following them. Recently a new Technical Director was appointed by ICTA and I was told that he has been concerned by the lack of collaboration between Regional soil programs and the Soil Dept. During the past year Escamilla was permitted to carry out a number of simple fertility tests in Region 5 and said that the results showed that recommendations made from soil analysis are more accurate than general recommendations. As a result he feels that the ice may have been broken and that the Soils Dept. may have a more active role in the general Soils program in the future.

Lab facilities are being upgraded by construction of a new building, which is badly needed. Otherwise the facilities seem adequate for the number of samples being processed. Instruments are standard types used by the S.F. Project and appear in good working order. Dr. Escamilla emphasized the problem of coordination with the Central Lab of CATIE due

to not being able to exchange control samples. He also said that he desperately needs help in detailed soil mapping for extension of soil fertility data, and deplored the termination of the Soil Analog project.

Sulfur and minor element deficiencies, especially Boron, are known to occur in many parts of the country, but are included in the recommendations only upon reported appearance of deficiency symptoms. This is about the best that could be expected at present, as routine B determination is not feasible and a satisfactory, reliable S diagnostic procedure is lacking for tropical soils.

On the second day Dr. Kass took me on a field trip to visit the Region 7 Experiment Station at Chimaltenango and to see several of the field experiments that he is directly supervising. He has 80-odd experiments around the country in which he is involved and a number have fertility variables. He told me that subsistence crops in general are seldom fertilized, but must make-do on the residual effects of that applied to a cash crop in the sequence, such as potatoes in the Altiplano. This is strictly a matter of economics - not enough money to fertilize a crop that won't bring a cash return. The farmers would readily fertilize if they could as they are well aware of the response usually shown by subsistence crops like maize. Another problem is the government's subsidy of wheat production to avoid the loss of foreign exchange by having to import wheat for domestic use. Much of the time the crop is lost to rust and the fertilizer applied is wasted.

Phosphorus is the most common limiting nutrient, being very widely deficient. Calcium, magnesium and potassium are seldom deficient in this country.

I spent a couple of hours with Ing. Ricardo del Valle, Director of the Region 7 program. He is definitely conscious of the soil fertility problems and eager to address them. He said that the Soils Dept. could have the labor, space and other needs to carry out experiments in his Region. From the visits with him and with Dr. Kass I came to the conclusion that much of Soils Dept. Head Escamilla's problem of "non cooperation" probably lies at this own doorstep.

Regardless of the internal problems reported in the preceeding paragraphs, I feel certain that the overall status of the National soil fertility program here is good. The impact of the S.F. Project is very much in evidence in the lab methodology and the reliance still being placed on field trial results accumulated between 1964 and 75. They do need to continue adding to their field results to keep their field-lab correlations up-dated. I also feel that the close working relationship between Dr. Kass and the Soils Dept. has been very helpful to them.

## APPENDIX A

Persons contacted in making this evaluation:

Dr. Héctor Muñoz
Technical Director
CATIE

Dr. Rufo Bazán
Coordinator, American Tropics Task Force
IICA - OAS

Dr. Elemer Bornemisza
Coordinator, Graduate Program
University of Costa Rica

Dr. Alvaro Cordero
Head, Soils Dept.
Ministry of Agriculture
San José

Ing. Alfredo Alvarado
Asst. Prof. of Soils
University of Costa Rica

Dr. Peter Duisberg
Consultant
San José

Ing. Héctor Coward
Director, Soils Lab.
C.R. Ministry of Agriculture

Dr. Pedro Oñoro
Chief, Annual Crops Program
CATIE

Dr. Carlos Burgos
Project Leader, SFCS
CATIE

Dr. Gonzalo de las Salas
Forest Soils Specialist
CATIE

Ing. Roberto Díaz-Romeu
Director, Central Lab
CATIE

Ing. Eduardo Marín
Soils Specialist
IICA-PIADIC
Managua

Ing. Aníbal Palencia
Costa Rica Resident, SFCS
CATIE

Ing. Jorge René Medina
Head, Soils Program
Tegucigalpa

Ing. Antonio Valdéz
Soil Fertility Head
Tegucigalpa

Ing. Ferliciano Paz-Fernández
Director, Soils Lab
Tegucigalpa

Dr. Donald Kass
Guatemalan SFCS Resident

Ing. Emelio Escamilla
Soils Dept. Head
Guatemala

Ing. Mario Breauner
Director, Soils Lab
Guatemala

Ing. Mario Breauner
Director, Soils Lab
Guatemala

Ing. Ricardo del Valle
Director, Region 7
ICTA
Guatemala

Dr. Frank Martin
Technical Consultant, SFCS, ROCAP
Costa Rica

## APPENDIX B

## EARLY

## BACKGROUND

The highly weathered and leacked state of soils in humid tropical regions make the establishment and maintenance of adequate levels and balance of plant nutrient elements, and the correction of phytotesis levels of elements such as aluminum and manganese, tentamount to most effective use of these soils for agriculture. This equally true whether crops are grown in monoculture or in various sequences or combinations during a given season. Chemical soil analysis is a tool that can provide useful information regarding the fertility status of soils, but for the results to be at all reliable they must be correlated with those from actual field trials where crop response to levels of fertilization has been established for different soil categories. Greenhouse tests can be useful in identifying the existence of deficiencies or toxicities, buy cannot substitute for field tests in final correlation.

The International Soil Testing Project, initiated in the mid- 60's was charged with establishing soil testing laboratories in the five Central American countries, providing equipment, describing uniform procedures, and training technicians to operate them. Much later, a revision of this project specified that attention be devoted to establishment of field fertilization trials and that the results be correlated with laboratory data. Thus, the correlation phase has lagged behind the chemical analyses. While the various national soil fertility programs have included field trials that generated data that could be used for correlation, they have generally been inadequate, and site identification often incomplete in recorded data. Another relevant point in considering the soil fertility project background is the fact that although in all its forms, past and present, it spans about 15 years, when broken down to project professional time devoted to this program in each country one finds that an average of about 2 1/2 man-months per year per country have been put into it. This extremely modest input has in fact produced an amazing advance in soil fertility expertise in the region.

The purpose of this project was to develop through a regionally coordinated Central American soil fertility research program the capability of synthesizing fertilizer use alternatives suited to the cropping systems of small farmers of the area. The project is actually a continuation of the soil fertility evaluation and improvement project previously carried out under contract with NCSU. This project had in turn been preceeded by the International Soil Testing Project, also under contract with NCSU. The present Soil Fertility Project was initiated in 1975 and is scheduled to terminate in March, 1978.

In order to insure continuity of the program after termination of the project, initial project plans called for preparation by CATIE to assume leadership, supervision and backstopping of the on-going soil fertility research after ROCAP funds allocated to this activity have been disbursed.

The project agreement between ROCAP and CATIE, signed in June 1977, provided the basis for CATIE's assumption of responsibility for providing a continuing Central American soil fertility research program. This agreement emphasizes that CATIE will continue to provide technical assistance to the Central American countries in order to develop capabilities to make specific crop and soil fertilizer recommendations, and that these activities will continue in all five countries, but that special attention will be given where National Programs are relatively weak, such as in Honduras and Nicaragua. It also specified that efforts will be focussed during the period of the agreement toward 1) transferring to CATIE past NCSU experience and expertise built up over the years of earlier soil fertility research project activities, and 2) concentration of research efforts, with CATIE participation, toward solving the problem faced by small farmers in the use of fertilizer in their cropping systems.

Thus, at the termination of the ROCAP Soil Fertility Project in March, 1978, CATIE was expected to have developed the necessary contact with National Soil Fertility Programs, and to have absorbed the accumulated NCSU/AES soil fertility experience to perform effectively in providing technical support and coordination in soil management and crop production research efforts in the five Central American countries.

## APPENDIX C

Terminal reports prepared for the Soil Fertility Project by the Staff.

Informe Final

Annexes to Final Report:

| No. | Title |
|---|---|
| 1. | Metodología de muestreo de suelos, análisis químico de suelos y tejido vegetal e investigación en invernadero. |
| 2. | Estudios de invernadero. |
| 3. | Proyecto de sistemas de producción para pequeños agricultores: Caracterización de los suelos de los sitios experimentales. |
| 4. | Uso práctico de los modelos discontinuos para interpretación rápida de la respuesta de cultivos a la aplicación de fertilizantes. |
| 5. | El manejo y resumen de datos de experimentos con fertilizantes en Centroamérica y su relación con los estudios de identificación de suelos con características semejantes de manejo. |
| 6. | Resumen del análisis y breve interpretación de los experimentos de fertilización de El Salvador, Honduras y Nicaragua. 1960-1975. |
| 7. | Soil fertility investigation in Honduras. 1977. |
| 8. | Reseña del trabajo sobre suelos análogos en América Central. |
| 9. | Metodología utilizada en el aspecto bioclimático. |
| 10. | Metodología utilizada en el aspecto suelos. |
| 11. | Primera aproximación de suelos análogos de Centro América. |
| 12. | Resultados obtenidos de la computación de las variables consideradas para comparar los suelos de El Salvador. |
| 13. | Analogías de suelos en Honduras. |
| 14. | Los suelos agrícolas de El Salvador de 0 a 500 metros sobre el nivel del mar. |
| 15. | II Reunión regional sobre fertilidad y análogos de suelos. El Salvador, marzo 13-18, 1978. Informe Final. |

| No. | Title |
|---|---|
| 16. | El Proyecto de Fertilidad de Suelos del CATIE. |
| 17. | Consultant's final report to CATIE and ROCAP on completion of soil analog subproject. |
| 18. | Soil Science in Costa Rica. Classification, fertility and conservation. |
| 1-. | Soil Science in El Salvador. Classifiaation, fertility and conservation. |
| 20. | Soil Science in Guatemala, Classification, fertility and conservation. |
| 21. | Soil Science in Honduras. Classification, fertility and conservation. |
| 22. | Soil Science in Nicaragua. Classification, fertility and conservation. |
| 23. | Soil Science in Panamá. Classification, fertility and conservation. |
| 24. | Programa Nacional de Fertilidad de Suelos del Ministerio de Agricultura y Ganadería de Costa Rica. |
| 25. | Análisis del Departamento de Suelos CENTA. MAG. El Salvador. |
| 26. | Programa de Manejo y Conservación de Suelos. Proyecto de fertilidad de suelos. Ministerio de Recursos Naturales, Honduras. |
| 27. | Informe sobre el estado de los programas de fertilidad de suelos IDIAP. Panamá. |

APPENDIX D

## DESCRIPCION DE CARGO

| | |
|---|---|
| Nombre: | Roberto DIAZ ROMEU |
| Escalafón: | Personal Profesional Internacional |
| Clase: | P3/Escalón 1 |
| Título del cargo: | Jefe del Laboratorio de Suelos |
| Supervisor inmediato: | Jefe del Programa de Cultivos Anuales, o el técnico que éste designe. |

### Objetivos

Procurar una labor eficiente del Laboratorio de Suelos, que asegure la continuación del servicio y un uso adecuado de los recursos asignados.

### Deberes y responsabilidades

1. Dirigir las actividades del Laboratorio, en la preparación de muestras de suelos y plantas, calibración de equipo, instrumental de análisis múltiples y de equipo electrónico para análisis rápido de suelos y plantas, incluyendo la unidad de absorción atómica.

2. Utilización de métodos analíticos modernos y apropiados para análisis de suelos y plantas, así como la correlación de resultados de laboratorio y ensayos de invernadero y de campo.

3. Realizar y dirigir investigación en metodología de análisis de suelos y plantas, con interpretación de resultados y recomendación de prácticas de fertilización.

4. Asesorar los laboratorios de suelos de los países del Istmo Centroamericano, en la organización y procedimientos analíticos acordes con los procedimientos aplicados en el Laboratorio de Suelos del CATIE.

5. Participar en actividades docentes del Programa de Estudios de Posgrado, al igual que en la capacitación del personal técnico de los laboratorios de suelos de los países del Istmo Centroamericano.

6. Mantener en buenas condiciones de trabajo el equipo e instalaciones a su cargo, y supervisar al personal bajo su mando en el cumplimiento de las labores asignadas, en salvaguardia de los intereses del CATIE.

7. Colaborar en las diversas actividades dentro de su especialidad, que le solicite su superior inmediato.

## APPENDIX E

Sumary of report by Fernando Abruña, of Puerto Rico, to Office of Latin American Programs of the Foreign Development Division, ERS, on current organic matter stubble mulch soil management needs and practices being used by small tropical farmers of Central America:

After visiting the research facilities and field trials and after talking to research scientists, directors and farmers around Costa Rica, Nicaragua, Honduras, El Salvador and Guatemala, the following conclusions and observations are in order:

(1) There is unanimity among research scientists and program directors of every Central American country visited that there is an urgent need for research work evaluating mulches, crop residue recycling and green manure crops. Farmers' opinion, on the other hand, vary from eagerness to indifference. Directors and technicians agree that this piece of research work must be integrated to the current Soil Fertility Project and the Small Farmer Cropping Systems.

(2) There is not much research work being done alone this line in most of the countries visited, although there is some information available at CENTA, in El Salvador. In spite of the fragmented research, small farmers in certain countries, especially in Guatemala and Honduras, are making use of green manure crops and composts as means of building up the fertility status of the soil.

(3) The research work suggested, in many cases is just a guideline and not necessarily has to be carried out exactly as it is recommended. In many instances the cover crop or green manure crops suggested can be changed to comply with local conditions. Mulching materials like filter press cake from the sugar industry, coffee pulp, dry coffee shells and rice hulls are extremely useful either as source of nutrients, a moisture conserving material or both, and whenever available must be considered with priority if the organic residue research project recommended is finally implemented.

(4) The project on Cropping Systems for Small Farmers, although is rendering a valuable service to them, is not producing the research data it should. The use of only 2 replicates per farm tends to introduce a high degree of variability mainly because cultural practices are performed by farmers on a very variable way and timing. Moreover, any local factor sometimes out of control, that may influence yield, is many tolds more determinant with 2 replicates than if more replicates are used. It is suggested that the number of sites be reduced in favor of fewer more replicated tests. If area available is not enough the area of the experimental plot can be reduced accordingly.

(5) There is a generalized opinion among Directors and to some extent among scientists, that the way CATIE is handling the cooperative work on Soil Fertility and Cropping Systems for Small Farmers is not the best. The most common complaint arises from the common practice of laying out experimental work without consulting with local people in terms of experimental design, objectives, number of replications, etc. They complain that CATIE high-level staff at Turrialba are completely negative in providing specialized technical expertise to the other countries. Some of the technical people and directors interviewed seriously believe that "if CATIE high echelons do not change their present attitude toward local programs, the organization is headed to a similar downfall as happened with IICA". Everybody claims for a real integration of efforts, but with CATIE hearing to what the local people have to say in terms of national needs and programs.

APPENDIX F

# METODOLOGIA PARA ESTABLECER ANALOGIAS EN BASE DE LA CAPACIDAD DE USO DE LA TIERRA Y ZONAS DE VIDA

PREPARADO POR:

Eduardo Marín Castillo
Especialista en Suelos
IICA-PIADIC

Trabajo presentado en la XXVI Reunión del PCCMA celebrado en Guatemala del 29 al 28 de Marzo de 1980 y en el VII Congreso Latinoamericano de la Ciencia del Suelo y IV Congreso Agronómico Nacional, celebrado en San José, Costa Rica, del 30 de junio al 5 de Julio de 1980.

# METODOLOGIA PARA ESTABLECER ANALOGIAS EN BASE DE LA CAPACIDAD DE USO DE LA TIERRA Y ZONAS DE VIDA

Por: Eduardo J. Marín C.

## I INTRODUCCION

Es evidente el marcado interés que tienen los Gobiernos de los países Centroamericanos para obtener un mejor rendimiento de la tierra por medio de programas de investigación y transferencia de tecnología. Para lograr estos propósitos se requiere de una adecuada información de las determinantes naturales de la producción como lo son el suelo y el clima , de tal forma que se puedan establecer mecanismos que permitan el intercambio científico-tecnológico.

## II OBJETIVOS

Para contribuir con ésta inquietud se propone como una aproximación más, una metodología que permita establecer analogías en base de la capacidad de Uso de la Tierra y las Zonas de Vida de Holdridge, complementada en conceptos de Hargreaves, a fin de lograr los siguientes objetivos:

1-Unificar criterios de clasificación de tierras en función de establecer parámetros permisibles para cada Clase de Capacidad y definir subclases específicas.

2-Establecer unidades de uso y manejo mediante la agrupación de tierras con cualidades o limitaciones similares en cuanto a parámetros edafo-climáticos.

3-Obtener la información edafológica adecuada de áreas específicas para la formulación de alternativas tecnológicas de producción.

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Especialista en Suelos- IICA-PIADIC Nicaragua

4- Orientar la planificación de la investigación a nivel de países en una base adecuada y confiable que permita la intra y extra-polación de resultados experimentales o comerciales y sitemas de manejo de suelos, evitando la duplicidad de efuerzos técnicos y económicos.

5- Orientar la política del crédito agrícola en función de avisos que garantice la recuperación económica y fomenten la producción agropecuaria.

6. Establecer políticas sobre legislación de los recursos naturales renovables de tal forma que se proteja y conserve el patrimonio Nacional.

## III CRITERIOS

La metodología se fundamenta en los criterios de la inter-relación del sistema SUELO-AMBIENTE ya que éste determina el habitat de las plantas cultivadas o nativas y las variaciones que se suceden en el mismo establecen diferencias en la adaptabilidad y producción de los cultivos.

Por lo tanto para establecer analogías es necesario establecer parámetros edáficos y ecológicos que permitan hacer comparaciones entre ellos.

## IV METODOLOGIA

La metodología que se propone como una aproximación más para alcanzar los objetivos señalados, se basa en la caracterización de la ecología y de la tierra como factores determinantes en la producción agrícola.

La caracterización ecológica se fundamenta en los principios de la clasificación Mundial de Zonas de Vida de L.R. Holdridge, complementada por conceptos agroclimáticos propuestos por G. Hargreaves en investigaciones realizadas sobre el Clima y la Producción Agrícola en diferentes países Centroamericanos.

La caracterización de la tierra, se basa en los conceptos del Sistema de Clasificación de Tierras por Capacidad de Uso del U.S.D.A.(Manual 210), con parámetros claramente definidos para las condiciones de los países Centroamericanos.

A continuación se establecen las bases ecológicas y edáficas que determinan los parámetros de comparación para definir analogías.

## 1- Bases Ecológicas

La unidad de comparación ecológica que se propone es la Zona de Vida, transiciones y asociaciones atmósfericas más relevantes. La zona de vida se considera como una unidad Bi Bioclimática,, porque es la que mide la relación que existe entre el clima y la vegetación considerando por lo tanto todos los elementos que controlan esta relación como lo son: la precipitación, temperatura ambiental, temperatura de las plantas (biotemperatura), humedad, latitud, altitud y efectos colaterales de otros elementos que influyen en la producción agropecuaria.

De acuerdo a los mapas ecológicos preparados por L. R. Holdridge y J Tossi en los países Centroamericanos se han establecido la presencia de las siguientes Zonas de Vida, para lo cual se propone presentarlas con una letra mayúscula de la siguiente manera:

### 1.1 Zonas de Vida

| Símbolo | Nombre de la Zona de Vida | Símbolo Original |
|---|---|---|
| A | Monte Espinoso Tropical | me-T |
| B | Bosque Muy Seco Tropical | bms-T |
| C | Bosque Seco Tropical | bs-T |
| D | Bosque Húmedo Tropical | bh-T |
| E | Bosque Muy Húmedo Tropical | bmh-T |
| F | Bosque Pluvial Tropical | bp-T |
| G | Bosque Premontano Húmedo Tropical | bh-PT |

| | | |
|---|---|---|
| H | Bosque Premontano Muy Húmedo Tropical | bmh-PT |
| I | Maleza Desértica Subtropical | md-S |
| J | Monte Espinozo Subtropical | me-S |
| K | Bosque Seco Subtropical | bs-S |
| L | Bosque Húmedo Subtropical | bh-S |
| M | Bosque Muy Húmedo Subtropical | bmh-S |
| O | Bosque Pluvial Subtropical | bp-S |
| P | Bosque muy Húmedo Montan- Bajo Subtropical | bmh-BMS |
| Q | Bosque Muy Húmedo Montano Bajo Tropical | bmb-MBT |
| R | Páramo Tropical | p-T |
| S | Páramo Subtropical | p-S |

## 1.2 Transiciones

Debido a que las zonas de vida se presentan en el diagrama de clasificación en forma de exágenos, los cuales son delimitados en forma tridimensional por las líneas guías de biotemperatura, precipitación y relación de evapotranspiración potencial, se presentan seis transiciones con las zonas de vidas adyacentes por medio de triángulos isóseles, los cuales se presentan con las siguientes letras minúsculas y son:

Térmicas: Aquellas que presentan una biotemperatura mayor o menor de los límites de cada región latitudinal para cada zona de vida y se presentan así:

| Símbolo | Transición | Símbolo Original |
|---|---|---|
| c+ | Transición a basal o biotemperaturas más cálidas que el límite de la zona de vida. | |
| f- | Transición a temperaturas más frescas que el límite de la zona de vida. | |

**Humedad:** Son aquellas en que cambia la provincia de humedad dentro de cada zona de vida en pequeños valores (mayor o menor)

h= Transición a una provincia más húmeda

s= Transición a una provincia más seca

<u>Precipitación</u>: Son aquellas en que los valores totales de precipitación anual, cambian ligeramente a mayor o menor cantidad.

p= Transición a mayor precipitación que el límite de zona de vida.

m= Transición a menor precipitación que el límite de la zona de vida.

## 1.3 <u>Regímenes de Temperatura</u>

La temperatura es un elemento muy importante en vista de que hay cultivos que se adaptan a condiciones de altas, medias o bajas temperaturas y su producción óptima está en función del efecto de calor o frío.

Se han establecido tres regímenes de temperatura en relación con la biotemperatura que son las más comunes en las regiones agrícolas de los países del área.

| | |
|---|---|
| <u>Normal</u> (No lleva símbolo) | Cuando la temperatura media anual y la biotemperatura son aproximadamente iguales todo el año (Condiciones tropicales con diferencias menores de 2º C). |
| Caliente C | Cuando la temperatura media anual es significativamente más alta que la biotemperatura (condiciones subtropicales con diferencias mayores de 2ºC.) |

Fresco : Cuando la temperatura media anual es igual a la biotempratura(condiciones de altitud ó latitud en que la temperatura es menor de 24º C, pero mayor de 18º C).
(No lleva símbolo)

## 1.4 =Regímenes de Precipitación y Distribución de llUvias

Para establecer analogías en cuanto a alternativas tecnológicas de producción, es necesario considerar la cantidad total anual de precipitación y la distribución de las mismas durante el transcurso del período de lluvias. Para tal fin las unidades bioclimáticas o zonas de vida se han complementado y subdividido con datos agrometeorológicos basados en los Indices de Humedad Disponible(MAI), propuestos por el Dr. George Hargreaves en los estudios de climatología y producción agrícola para El Salvador y Nicaragua.

SE ESTABLECEN LOS SIGUIENTES REGIMENES DE PRECIPITACION

X- Monzónico: Cuando la época lluviosa ocurre durante 5 a 6 meses, siendo el período de la estación seca muy prolongado(6 a 7 meses). Dentro de éste regímen de precipitación se han clasificado d acuerdo a los índices de humedad disponible (MAI), los siguientes tipos de distribución de lluvias:

X1- Buena : La precipitación se distribuye normalmente entre junio y octubre con adecuada humedad disponible (MAI, entre 0.90 y 1.20 ó más) presentando un período canícular benigno entre julio y agosto, con índices moderados de humedad(MAI de 0.40 a 0.79), no mayor de 20 días.

X2- Moderada : La precipitación se distribuye normalmente entre junio y octubre con adecuada humedad disponible (MAI de 0.80 a 1.20 ó más ), pero presenta un período canícular moderado con humedad disponible deficiente(MAI menor de 0.39) no mayor de 30 días entre julio y Agosto.

X3- Regular : La precipitación se distribuye con humedad moderada (MAI entre 0.40 y 0.79) de junio a agosto; en septiembre y octubre es adecuada y la canícula se presenta entre Julio y Agosto con un ligero descenso de la humedad, pero sin llegar a valores deficiantes.

X4- Irregular : La precipitación se distribuye irregularmente con índices de humedad moderada (MAI de 0.40 a 0.79) en junio y adecuada en septiembre y octubre(MAI de 0.80 a 1.20). Presenta un período canícular marcado, con índices deficientes de humedad(MAI, menor de 0.39) entre julio y agosto.

X5-Mala : La precipitación se distribuye irregularmente durante casi todo el período de lluvias, con índices de humedad moderado de junio a octubre (MAI entre 0.40 a 079) y presenta un marcado período canícular entre julio y agosto, con índices deficientes de humedad (MAI menor de 0.39) algunas veces muy prolongado.

Y- Tropical Lluvioso: La precipitación se distribuye regularmente durante 7 a 9 meses, con índices de adecuada a excesiva humedad y sin período canícular.

W - Tropical Muy Lluvioso: La precipitación se distribuye regularmente casi durante todo el año y en la mayoría de los meses la humedad es excesiva. El período seco es menor de 2 meses.

## 1.5 Humedad Disponible

Varios autores han demostrado que la producción y la y la productividad de los cultivos agrícolas son una función de la disponibilidad de agua. El incremento de la producción está estrechamente relacionado con el incremento de agua o la evapotranspiración potencial del cultivo.

Es importante calibrar algunos de los modelos de rendimiento de cultivos como: El Stewar, Hanks, Hall-Butcher etc., para lo cual se debe incluir en la investigación a agroclimatológica.

Hargreaves propone la siguiente clasificación de la humedad disponible:

Deficiente: MAI menor de 0.39. Se requiere de riego para producir.

Moderada : MAI entre 0.40 y 0.79. Se requiere de riego suplementario para mejorar la producción.

Adecuada : MAI entre 0.80 y 1.20. La humedad es suficiente para la producción.

Excesiva : MAI mayor de 1.21. Se requiere de drenajes para mejorar la producción dependiendo del cultivo, del tipo de suelos y de la topografía.

Nota:

Los rangos de los valores de MAI son arbitrarios y no es válido para todos los cultivos, ni para todas las condiciones de suelos.

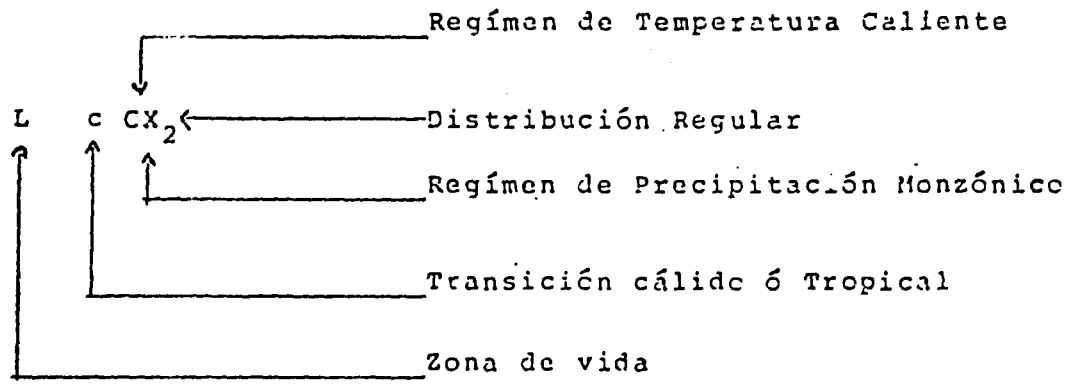
A veces un ajuste o modificación puede ser necesario. Sin embargo, la clasificación provee un buen índice para compraciones en distintas unidades bioclamáticas y poder hacer extrapolaciones más confiables sobre alternativas de producción.

NOMENCLATURA ECOLOGICA

La forma de representar cartográfimamente las unidades bioclamáticas ó zonas de vida se hace por medio de la siguiente simbología:

Una letra mayúscula que indica la zona de vida, seguido de una letra minúscula que indica las transiciones, separado por un guión. Se representa con letras mayúsculas el regímen de precipitación y distribución de la humedad disponible.

Ejemplos:




Bosque Humedo Subtropical

2- Bases Edáficas

La categoría más amplia del sistema es la clase de capacidad de uso, seguida de la subclase que son grupos de limitaciones dentro de cada clase y finalmente la unidad de capacidad que agrupa suelos de similar potencialidad de uso y manejo.

La unidad de comparación edáfica que se propone es la subbase específica, la cual define tipos de restricciones para cada subclase y permite la fácil agrupación de suelos con cualidades o limitaciones similares, dando una base confiable para la intra y extrapolación de normas de uso y manejo de los suelos.

Para determinar las subclases específicas se proponen las las variables más importantes y se establecen las parámetros para cada variable a fin de facilitar la clasificación por medio del auxilio de una tabla. (Adjunta)

El sistema propuesto ha sido preparado para estudios a niveles de detalle y semidetalle, sin embargo se puede aplicar para estudios de reconocimiento agrupando parámetros para dar mayor generalidad.

En el caso de que las variables consideradas no sean suficientes para comparaciones de analogías, como por ejemplo: fertilidad, se propone utilizar los parámetros auxiliares como: estructura, pH, capacidad de intercambio catiónico, etc.

## 2.1 VARIABLES Y PARAMETROS EDAFICOS

### TOPOGRAFIA Y PENDIENTE

| Símbolo | Características | Rango | Clase |
|---|---|---|---|
| A | Plana o casi plana | 0 - 2 | I |
| B | Suavemente inclinada y/o ondulada | 2 - 5 | II |
| C | Moderadamente inclinada y/o ondulada | 5 - 10 | III |
| D | Fuertemente inclinada y/o ondulada | 10 - 15 | IV |
| E | Moderadamente escarpada | 15 - 25 | IV[x] - VI |
| F | Escarpada | 25 - 35 | VI |
| G | Fuertemente escarpada | 35 - 50 | VII[xx] |
| H | Montañosa | 50 - 75 | VII[xxx] |
| I | Precipicio | - 75 | VIII[xxxx] |

x/-No mecanizable-xx/Pastoreo muy extensivo o Bosques de Producción.

xxx/Bosques de producción/protección xxxx/Bosques de protección.

### PROFUNDIDAD EFECTIVA

| | | cms, | |
|---|---|---|---|
| 0 | Muy profundo | -150 | I |
| 1 | Profundo | 100 -150 | I |
| 2 | Moderadamente profundo | 75 -100 | II |
| 3 | Poco Profundo | 50 - 75 | III |
| 4 | Superficial | 20 - 50 | IV |
| 5 | Muy Superficial | - 20 | VI-VII-VIII |

### LIMITANTE DEL DESARROLLO RADICULAR

No se anota a profundidades mayores de 100 a 150 cms.

| | | |
|---|---|---|
| 1 | Arena gruesa, grava, guijarros o piedaras | |
| 2 | Arcilla masiva | |
| 3 | Gley o Pseudo-gley | |
| 4 | Agua | |
| 5 | Toba suave o Talpetate | |
| 6 | Toba dura | |
| 7 | Panes endurecidos(hardpan, claypan, etc) | |
| 8 | Material parcialmente meteorizado(hrizonte C) | |
| 9 | Lecho rocoso | |
| | 9a-Rocas ácidas | |
| | 9b-Rocas básicas | |
| | 9s-Rocas Sedimentarias | |
| | 9m-Rocas metamórficas | |
| | 9g-Rocas graníticas | |
| | TEXTURA-SUPERFICIAL (hasta 30 cms.) | |
| 0 | Muy gruesa (arena gruesa, grava fina) | VIII |
| 1 | Gruesa (amf- af - am - aF) | III |
| 2 | Moderadamente gruesas (aF - Fa) | II |
| 3 | Medias (Fa - F - FL - L) | I |
| 4 | Moderadamente fina (FAa-FA-FAL) | I |
| 5 | Fina (A - AL - Aa) | II |
| 6 | Muy fina (A+60% de arcilla) | V-VI-VII |
| | TEXTURA DE SUBSUELO | |
| 0 | Muy gruesa | VI-VII-VIII |
| 1 | Gruesa | IV |
| 2 | Moderadamente gruesa | II |
| 3 | Media | I |
| 4 | Moderadamente fina | I |
| 5 | Fina | I |
| 6 | Muy fina | VI-VI-VII |

Abreviaciones: F-Franco; A-Arcilloso; L-Limoso; a-arenoso;mf-Muy fino; f-fino; m-medio.

DRENAJE NATURAL

| | | |
|---|---|---|
| 0 | Excesivo | VII-VIII |
| 1 | Moderadamente excesivo | III |
| 2 | Bueno | I - II |
| 3 | Moderadamente bueno | III |
| 4 | Imperfecto | IV |
| 5 | Pobre | V - VI |
| 6 | Muy pobre | VII-VIII |

EROSION HIDRICA

| | | |
|---|---|---|
| | No identificada | I |
| h1 | Leve | II |
| h2 | Moderada | III |
| h3 | Fuerte | IV-VI |
| h4 | Severa | VII |

EROSION EOLICA

| | | |
|---|---|---|
| | No identificada | I |
| e1 | Leve | II |
| e2 | Moderada | IV |
| e3 | Fuerte | IV |

TABLA DE AGUA FLUCTUANTE

| | | cms. | |
|---|---|---|---|
| - | Muy profunda | 150' | I |
| w1 | Profunda | 100 -150 | I |
| w2 | Moderadamente profunda | 75- 100 | II |

| | | | |
|---|---|---|---|
| .w3 | Poco profunda | 50-75 | III |
| w 4 | Superficial | 20-50 | IV |
| w5 | Muy superficial | 5-20 | V-III-VII |
| w 6 | En la superficie | - 5 | VIII |

INUNDACIONES

| | | | |
|---|---|---|---|
| | No hay peligros | | I |
| i1 | Leve | | II |
| i2 | Moderada | | III |
| i3 | Severa | | IV |
| i4 | Fuerte o Extrema | | V-VII-VIII |

SALINIDAD

| | | | |
|---|---|---|---|
| | Sin sales o libres | - 2 | I |
| s1 | Leve | 2 -4 | II |
| s2 | Moderada | 4 -8 | III |
| s3 | Fuerte | 8 -12 | IV |
| s4 | Muy fuerte | 12- 16 | V-VI |
| s5 | Severa | - 16 | VII-VIII |

ALCALINIDAD

| | | | |
|---|---|---|---|
| | Libres o normales | - 5 | I-II |
| a1 | Leve | 5- 15 | III |
| a2 | Moderada | 15-35 | IV |
| a3 | Fuerte | 35-50 | V-VI |
| a4 | Severa | -50 | VII-VIII |

GRAVAS O GUIJARRONES EN LA SUPERFICIE

Ausentes

| | | | |
|---|---|---|---|
| g1 | Escasos | 5-15 | II |
| g2 | Moderadamente abundantes | 15-40 | III |
| g3 | Abundantes | 40-60 | IV |
| g4 | Muy abundantes | 60-80 | V-VI-VII |
| g5 | Extremadamente abundantes | >-80 | VIII |

GRAVAS O GUIJARROS EN EL PERFIL

| | | | |
|---|---|---|---|
| | Ausentes | < 5 | I |
| G1 | Escasos | 5-10 | II |
| G2 | Moderadamente abundantes | 10-15 | III |
| G3 | Abundantes | 15-40 | IV |
| G4 | Muy abundantes | 40-60 | V-VI-VII |
| G5 | Extremadamente abundantes | >-60 | VIII |

PIEDRAS EN LA SUPERFICIE

| | | | |
|---|---|---|---|
| - | Sin piedras | | I |
| p1 | Escasas o leves | <- 1 | II |
| p2 | Moderadas o pocas | 1 - 3 | III |
| p3 | Fuerte o abundantes | 3 - 15 | IV |
| p4 | Muy fuerte o muy abundantes | 15-40 | V-VI |
| p5 | Severo o pedregoso | 50-80 | VII |
| p6 | Excesiva o muy pedregoso | >-80 | VIII |

PIEDRAS EN EL PERFIL

| | | | |
|---|---|---|---|
| - | Sin piedras | <0.1 | I |
| P1 | Pedregocidad leve | 0.1-1 | II |
| P2 | Pedregocidad moderada | 1-3 | III |
| P3 | Pedregocidad fuerte | 3-15 | IV |
| P4 | Pedregocidad Muy Fuerte | 15-50 | V-VI |
| P5 | Pedregocidad Severa | 50-80 | VII |
| P6 | Pedregocidad Excesiva | >-80 | VIII |

AFLORAMIENTOS ROCOSOS

| | | |
|---|---|---|
| - | Sin afloramiento | I |
| R1 | Leve | II |
| R2 | Moderada | III |
| R3 | Fuerte | IV |
| R4 | Muy Fuerte | VI- VII |
| R5 | Excesivo | VIII |

## 2.2 EVALUACION DE OTROS PARAMENTROS AUXILIARES PARA ESTABLECER ANALOGIA DE TIERRAS.

ESTRUCTURA

| | |
|---|---|
| Optima | I |
| Buena | I-II |
| Regular | III |
| Deficiente | IV-V |
| Inapropiada | VI-VII |

| PERMEABILIDAD | Cm/h | |
|---|---|---|
| Moderada | 2-- 6.25 | I |
| Moderadamente lenta | 0.5-2.00 | II |
| Moderadamente rápida | 6.25-12.00 | II |
| Lenta | 0.12-050 | III-IV |
| Rápida | 12.50-25.00 | III-IV |
| Muy rápida | >-25.00 | VI-VII |
| Muy lenta | <-0.12 | VI-VII |

| INFILTRACION | Cm/h | |
|---|---|---|
| Media | 0.8- 2 | I-II |
| Alta | 2 -6.3 | III-IV |
| Baja | 0.4-0.8 | III-IV |
| Muy alta | >6.3 | VI-VII |
| Muy baja | <-0.4 | VI-VII |

HUMEDAD APROVECHABLE

| | | |
|---|---|---|
| Muy alta | >- 20 | I |
| Alta | 15 - 20 | II |
| Media | 10 - 15 | III |
| Baja | 5 - 10 | IV |
| Muy Baja | <- 5 | VI-VII |

REACCION (pH)

| | | |
|---|---|---|
| Neutro o ligeramente ácido | 6.1 - 7.3 | I |
| Medianamente alcalino | 7.4 - 7.8 | I-II |
| Medianamente ácido | 5.6 - 6.0 | I-II |
| Moderadamente alcalino | 7.9 -8.4 | III |
| Fuertemente ácido | 5.1 - 5.5 | III |
| Fuertemente alcalino | 8.5 - 9.0 | IV-VI |
| Muy Fuertemente ácido | 4.5 - 5.0 | IV-VI |
| Extremadamente ácido | <- 4.5 | VI-VII-VIII |
| muy fuertemente alcalino | >- 9.1 | VI-VII-VIII |

CAPACIDAD DE INTERCAMBIO CATIONICO(CIC)

| | | | |
|---|---|---|---|
| Muy alta | >-(1) 60 | >-(2) 25 | I |
| Alta | 40 - 60 | 15 - 25 | I-II |
| Media | 24 - 40 | 7.1 - 14 | I-II-III |
| Baja | 16 - 24 | 4.1 - 7 | III-IV |
| Muy Baja | <- 16 | <- 4 | VI-VII |

PORCIENTO DE SATURACION DE BASES (%)

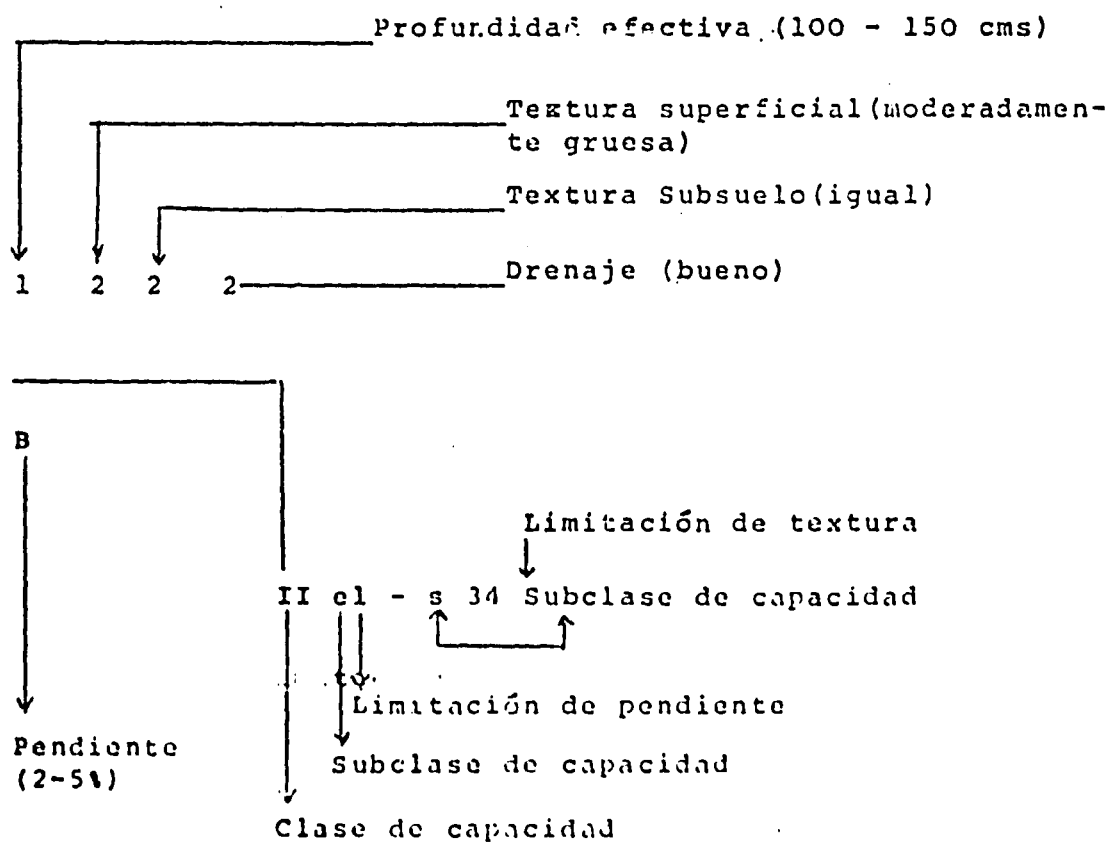
| | | |
|---|---|---|
| Muy alto | >- 80 | I |
| Alto | 50 - 80 | I-II-III |
| Medio | 35 - 50 | I-II-III-IV |
| Bajo | 20- 35 | V-VI |
| Muy Bajo | <- 20 | VII-VIII |

(1) Suma de cationes (2) Suma de bases

## 2.3 Nomenclatura Edáfica

Para poder utilizar la tabla de clasificación de parámetros para evaluar la capacidad de uso y establecer las subclases específicas se deben de representar las variables y parámetros por medio de una simbología cartográfica preliminar que se presenta en un quebrado, donde la profundidad, textura y drenaje se colocan en el numerador y la pendiente y otras limitaciones en el denominador.

Ejemplo:




Para abreviar esta fórmula, la representación final en mapas de analogías se puede presentar solamente la subclase específica así:

II el - s34

Nomenclatura Edafo-ecológica

El objetivo principal de la motodología es la comparación de la relación del sistema de Suelo-Ambiente para establecer analogías. Por lo tanto se propone la representación de las características ecológicas por medio de la simbología ecológica, seguida de la simbología edáfica.

Ejemplos:

1- Lc-Cx2/II el-s34 contra Lc-Cx2/II s34: Son análogos, solamente que cambia un poco el manejo por variaciones en la pendiente.

2- Lc-Cx2/II s-34 conta Lc-Cx2/II s 25: Son análogos en cuanto a condiciones ecológicas, pero no lo son en cuanto a características del suelo.

3- Lc-Cx2/II s 25 contra Kf-Cx3/II s 25: Son análogos en cuanto a características edáficas, pero no lo son en cuanto a condiciones ecológicas.

4- Kf-Cx3/II s 25 contra Kf-Cx3/II s 25: Son análogos en cuanto a características edáficas y condiciones ecológicas en cualquier región o país que se encuentren.

# TABLA DE CLASIFICACION DE PARAMETROS PARA EVALUAR LA CAPACIDAD DE USO DE LA TIERRA

| Clases y Subclases | Pendiente | Profundidad | CLASE TEXTURAL | | Drenaje Natural | EROSION | | Tabla de agua | Inundaciones | Salinidad | Alcalinidad | MATERIALES GRUESOS | | | | Otras Limitaciones |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Superficie | Subsuelo | | Hídrica (agua) | Eólica (viento) | | | | | Superficie | | Perfil | | |
| | | | | | | | | | | | | Gravas | Piedras | Gravas | Piedras | |
| I | A | 0 – 1 | 3 – 4 | 3 – 4 – 5 | 2 | – | – | – | – | – | – | – | – | – | – | |
| II | A | 0 – 1 | 3 – 4 | 3 – 4 – 5 | 2 | h1 | e1 | w2 | i1 | s1 | | g1 | p1 | G1 | P1 | |
| | B | 2 | 5 2 | 2 5 | 2 | h1 | e1 | w2 | i1 | s1 | | g1 | p1 | G1 | P1 | |
| Subclases | e1 | s1 | s2 s3 | s4 s5 | – | e2 | e3 | h1 | h2 | s6 | – | s7 | s8 | s9 | s0 | |
| III | A – B | 0 – 1 – 2 | 2-3-4-5 | 2 3 4 5 | 2 | h2 | e2 | – | i2 | s2 | a1 | g2 | p2 | G2 | P2 | |
| | C | 3 | 1 | | 1 3 | h2 | e2 | w3 | i2 | s2 | a1 | g2 | p2 | G2 | P2 | |
| Subclases | e1 | s1 | e2 | – | e3 h1 | e2 | e3 | h2 | h3 | s4 | s5 | s6 | s7 | s8 | s9 | |
| IV | A – B – C | 0-1-2-3 | 1 2-3-4-5 | 2-3-4-5 | 2 – 3 | h3 | e3 | w2 | i3 | s3 | a2 | g3 | p3 | G3 | P3 | |
| | D E | 4 | 1 4 5 | 6 1 | 4 | – | – | w4 | i3 | s3 | a2 | g3 | p3 | G3 | P3 | |
| Subclases | e1 e2 | s1 | s2 – | s3 s4 | h1 | e3 | e4 | h2 | h3 | s5 | s6 | s7 | s8 | s9 | s0 | |
| V | A | 0-1-2-3 4 | 2-3-4-5 | 2-3-4-5 | 2 | – | – | – | i4 | s3 | a3 | g4 | p4 | – | – | |
| | A – B C | 0 1 3 | 6 | 6 | 3 4 5 | – | – | w5 | i4 | s3 | a2 | g4 | p4 | | | |
| Subclases | e1 | s1 | e2 | e3 | h1 h2 | | | h3 | h4 | s4 | s5 | s6 | s7 | | | |
| VI | A a D | 1 5 2 | 2-3-4-5 | 2-3-4-5 | 2 | h3 | – | – | – | – | – | – | – | G3 | P3 | |
| | | | 0 | 1 | 1 | – | – | – | – | – | – | – | – | – | – | |
| | F | 3 4 | 6 | 6 | 4 5 | – | – | w5 | i4 | s4 | a3 | – | – | G3 | P3 | |
| Subclases | e1 | s1 s2 | s3 s4 | s5 s6 | – h1 | e2 | | h2 | h3 | s7 | s8 | | | s9 | s0 | |
| VII | A a D | 1 5 2 | 2-3-4-5 | 2-3-4-5 | 2 | h4 | – | – | – | – | – | g5 | p5 | G4 | P4 | |
| | | | 0 | 0 | 1 | – | – | – | – | – | – | – | – | – | – | |
| | G | 3 4 5 | 6 | 6 | 5 | – | – | w5 | i4 | s5 | a4 | – | – | – | – | |
| Subclases | e1 | s1 e2 | e3 e4 | e5 e6 | h1 | e2 | | h2 | h3 | s7 | s8 | s9 | s0 | sG | sP | |
| VIII | A a D | 1 5 | 2-3-4-5 | 2-3-4-5 | 2 | h4 | – | – | – | – | – | g5 | p6 | G5 | P5 | |
| | H I | 3 4 | 0 | 0 | 0 6 | – | – | w6 | i4 | s5 | a4 | | | | | |
| Subclases | e1 e2 | e1 | e2 | e3 | e4 h1 | e3 | – | h2 | h3 | s5 | s6 | s7 | s8 | s9 | s0 | |