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9. ABSTRACT

Specific objectives of this project will be to correlate crop yields to land potential and capability on a network of upland tropical soils, and to establish, through experimentation and demonstration, methods of transferring agricultural technology from Hawaii and other tropical regions and among these regions. Experimental sites for the Hawaiian project will be in one African and two Asian countries as well as in Hawaii. Sites for the companion Puerto Rican project will be in three or four Latin American countries as well as in Puerto Rico. The soil families in Hawaii and Puerto Rico will be identical so that eventually a network of tropical soil families can be developed throughout the tropics. The hypothesis for the transfer methods will be tested through linked-parallel fertility experiments. Each experiment will be made on sites with the same soil family. The test crop at all sites will be maize, and the "best adapted" variety will be grown at each location. Additional information about management practices required for a particular soil will be obtained in an experiment with seven management variables.

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A Project to Determine Crop Production and Land Capabilities of a Network of Tropical Soil Families*

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INTRODUCTION

In recent years, authoritative sources have stated that major emphasis must be placed on increasing productivity per unit of land if the world food needs are to be met. Through research and extension, the temperate regions of the world have achieved high productivity in agriculture. The Green Revolutions in wheat and rice in Mexico, India, Pakistan, and the rice bowls of Asia give clear indication that such advances are also possible in the tropics. What is most needed is an identification of the specific regions in tropical countries where it is possible to concentrate immediate food production efforts. Throughout Tropical Asia, Africa and Latin America, crop yields on the upland soils are very low. Existing national knowledge, therefore, is no guide to the true potential of these soils. Thus, if it can be shown that profitable crop yields can result--yields two or three times greater than are presently thought possible--without consequent soil deterioration, a modern agricultural system can be developed without the necessity of 50 years of experimentation and extension.

Experience has shown that although agricultural technology developed for temperate zone soils can be directly transferred to other temperate zone areas, it is not directly transferable to soils of the tropics. But evidence has not yet been obtained to determine the extent to which agricultural technology developed under high levels of management in tropical regions can be transferred to other tropical soils. Recent progress in soil classification related to questions of transfer of technology and research in Hawaii give considerable hope that this can be done.

The U.S. Soil Taxonomy, essentially completed in 1971, has as its major purpose the establishment of relationships among soils, and between soils and their natural and cultural environments. Through proper use of the classification, predictions can be made about soil behavior by relating properties of soils for which we lack experience to properties of soils on which we have conducted research. Charles E. Kellogg (1964) pointed out that the soil family category is related to many characteristics that are important in plant growth and engineering. Therefore, the soil family provides the link between soil classification and land capability groupings. Soils in the same family should require essentially the same management practices. Therefore, once soils in different countries are classified into common families, it should be possible to use the maximum production results of one soil as production targets for all soils in the same family.

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BENCHMARK SOILS PROJECT

Since soils in Hawaii have been extensively classified and crop production in Hawaii is high--two to three times higher for the same crops than in many other tropical countries--it was decided to determine the feasibility of the transfer of agrotechnology among tropical countries. A proposal with these objectives was sent to AID, and after extensive review, the proposal was accepted and recently funded.

The specific objectives of the project are:

1. To correlate crop yields to land potential and capability on a network of upland tropical soils.

2. To establish by experimentation and demonstration the transferability of agricultural technology between Hawaii and other tropical regions and among those regions.

The project proposes to locate sites in upland soils (Oxisols and Ultisols) of similar soil families in several foreign countries, i.e., one country in Africa and two in Asia as well as in the same soil family in Hawaii. In addition, the University of Puerto Rico has a companion project and will have sites in three or four countries in South America as well as in Puerto Rico. Sites will be selected so that at least two countries will have sites on the same soil family. The soil families in Hawaii and Puerto Rico will be the same so that eventually a network of tropical soil families will be developed across the tropics.

The hypothesis of transferability will be tested through linked-parallel fertility experiments each with two variables, i.e., P and pH, N and P, etc. The same experiment will be installed on sites of the same soil family. All other management factors such as irrigation, plant protection, plant population, etc. will be at high levels so that they are not limiting. These experiments will allow evaluation of the hypothesis of transferability of agrotechnology as well as provide information to local governments on the potential of particular soil familes. This information will assist governments in making policy decisions regarding future development of resources in the area.

The test crop at all sites will be maize, and the "best adapted" variety will be grown at each location. Other crops of interest to the local governments may also be grown. The experimental design selected is the 5^2 partial factorial modification by Escobar described by Laird and Turrent (1974). This design, shown in Figure 1, has many desirable properties including the magnitude of the bias error, number of treatment combinations, magnitude of variance error and coverage of the factor space. Coded values for treatments are presented in Table 1. A variety experiment will be conducted at each location with a few top varieties to assure that the "best adapted" variety is used in the fertility experiment.

Additional information regarding management practices required for a particular soil will be obtained in an experiment with seven management variables, at two levels each--with and without. These variables include irrigation, lime, weed control, insect and disease control, N, P, and K. An experiment to assess the optimum plant density for maize or other test crops will also be carried out at each location.

It is realized that past management practices, local weather conditions and variability in soil properties can affect the response of a particular soil in a family so that its response differs from that of other soils in the same family. Therefore, it is

essential that as many of these parameters as possible be measured at each site so that adjustments can be made in the yield equations to account for this. It is planned to measure a range of soil, climatic, management and plant parameters to allow adjustment for their effects.

Figure 1. Treatment Design for 5^2 Partial Factorial Modification by Escobar

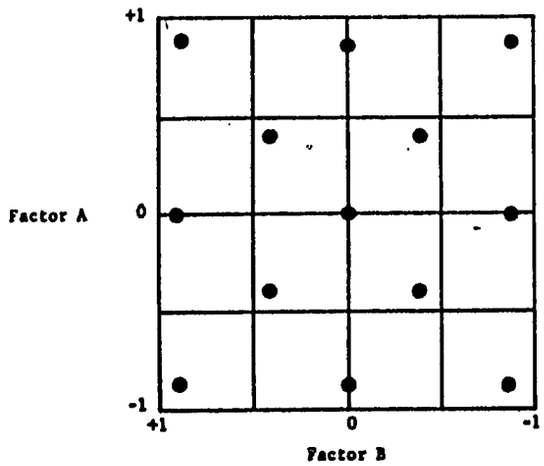

Table 1. Coded Values for the Treatments in the 5^2 Partial Factorial Modification by Escobar

Treatment Number	Factor A	Factor B
1	-0.85	-0.85
2	-0.85	+0.85
3	+0.85	-0.85
4	+0.85	+0.85
5	-0.40	-0.40
6	-0.40	+0.40
7	+0.40	-0.40
8	+0.40	+0.40
9	0	0
10	-0.85	0
11	+0.85	0
12	0	-0.85
13	0	+0.85

Productivity (yield) is a function of soil, climatic, management, and plant parameters, and yield equations for each site will be developed using modern methods of data processing. Relationships between crop yields and these various parameters will be described in production functions which will be compared between sites within a country and between countries. Evaluation of production functions between sites and countries will indicate the extent to which agrotechnology can be transferred between members of the same soil family. In addition, these production functions can be solved to determine derived demand equations for each of the management variables as well as the optimal input combinations for specific conditions.

POSSIBLE PROBLEMS

There are many problems associated with a project of this magnitude. Among them is the task of locating soils of the same family in various countries of the tropics. Many tropical countries do not have detailed soil maps which could indicate the location of possible sites. However, some soil information is available in many countries and it is hoped that together with local soil scientists, we will be able to identify soils of

similar families. The logistics of setting up experimental sites with the required weather instruments, fertilizers, farm machinery, and research equipment are complex, and considerable planning and organization are required. Installation and maintenance of field experiments under relatively primitive conditions can also be a problem. Processing the large amounts of data that will be collected at each site would be impossible without the use of modern computer techniques.

IMPLICATIONS OF THE PROJECT

If the concept of transfer of agrotechnology is demonstrated in this project, tropical countries will not have to spend two decades or more doing research to attain the yield levels found in the more developed countries. Instead, they will be able to transfer the management practices on soil families of these high-producing countries to soils of the same soil family in their country to realize a significant increase in the yields of these soils. This of course, assumes proper classification of soils in these countries. Further refinement of these practices will undoubtedly be required to compensate for local conditions. However, this transfer will not necessarily be limited to transfer of information from more developed countries to less developed countries, but also among less developed countries.

The importance of proper classification of soils on which research is conducted is emphasized by this project. Knowledge of the soil family to which the results of a particular experiment apply makes it possible to use that information in many other areas in which that same soil family occurs, provided information about possible modifying conditions is also available. This should result in maximum utilization of experimental results throughout the tropical world and help increase the productivity of the tropics.

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