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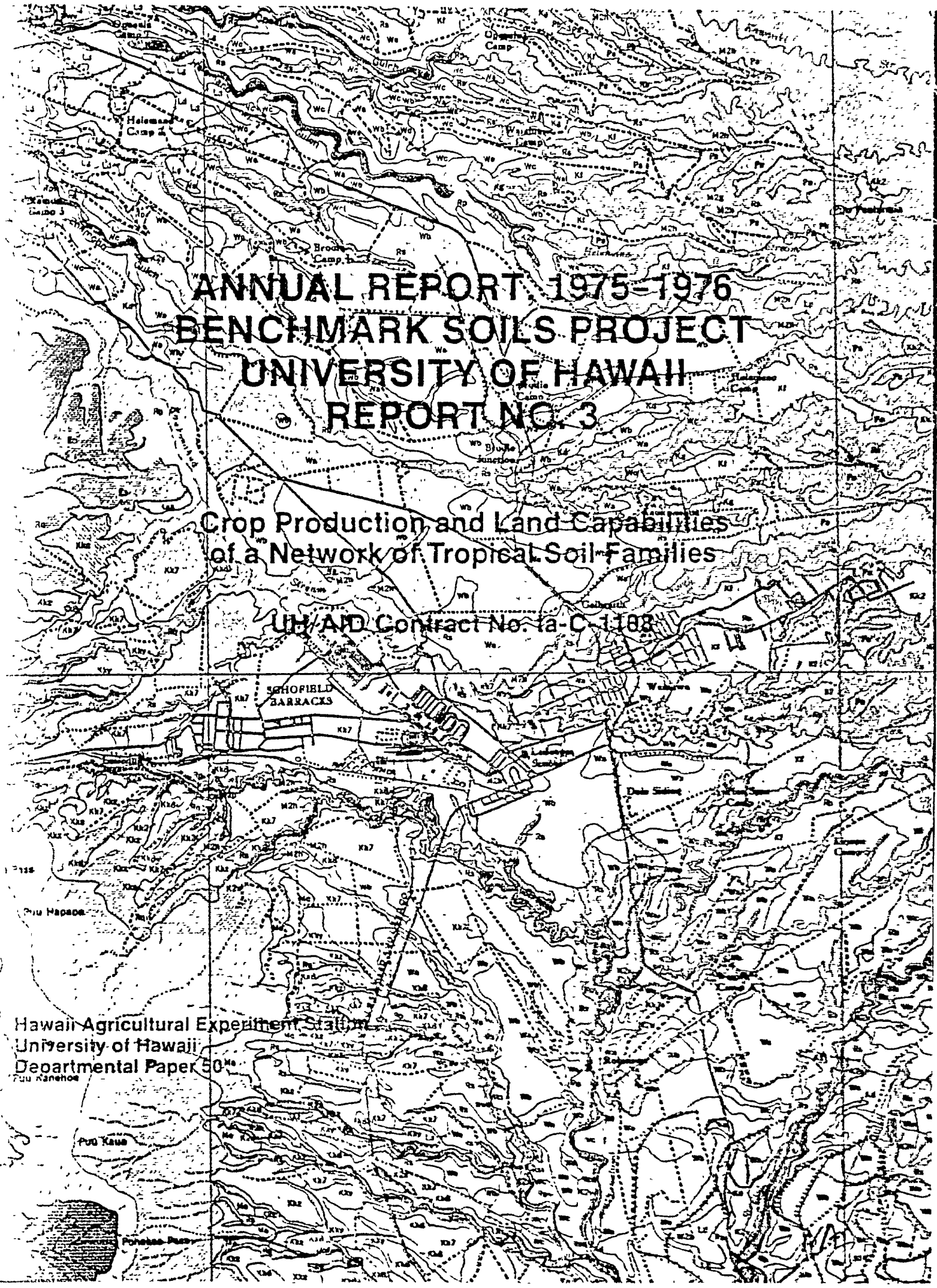


ANNUAL REPORT, 1975-1976
BENCHMARK SOILS PROJECT
UNIVERSITY OF HAWAII
REPORT NO. 3

Crop Production and Land Capabilities of a Network of Tropical Soil Families

UH/AID Contract No. ta-C-1188

Hawaii Agricultural Experiment Station
University of Hawaii
Departmental Paper 50

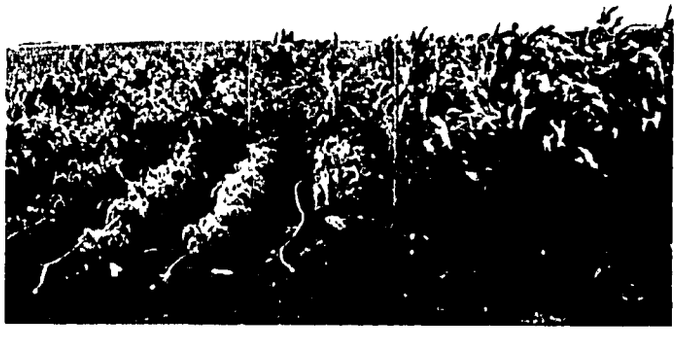
AID/ta-C-1108 Rec
Hawaii
PN-AAF-720

Contents

	Page
Narrative Summary of Accomplishments and Utilization	5
General Background	6
Project Objectives	6
Continued Relevance of Objectives	7
Accomplishments to Date	7
Objectives	7
Establish the Network of Soils	7
Carry Out Transfer and Soil Management Experiments	12
Determine Relationship between Production and Land Capabilities for Benefit of Farmers and Planners	19
Other Accomplishments	22
Memorandum of Agreement with Puerto Rico	22
Project Design and Work Plan	23
First Annual Coordination Meeting	23
AID On-Site Review Team	24
Research Design	27
Soil Families	27
Transfer Experiments	27
Variety Experiments	28
Management Experiments	28
Training	28
Dissemination and Utilization	29
Involvement of Institution and Government of Philippines and Indonesia	29
Philippines	29
Indonesia	30
Dissemination of Project Information	30
ICRISAT Seminar	30
Fertilizer INPUTS Project	30
South Pacific Regional Meeting	31
Soil Taxonomy	31
Soil Survey Method	31
Benchmark Newsletter	32
Correspondence and Feedback	32
Visitors	33
Statement of Expenditures and Obligations	35
Work Plan and Budget Forecast	36
Anticipated Accomplishments by October 1977	36
Budget Forecast	37
Appendix A: A Seminar on Uses of Soil Survey and Classification in Planning and Implementing Agricultural Development in the Tropics	38
Appendix B: Project Publications	46
Appendix C: Drip Irrigation	47
Appendix D: Meteorological Instrumentation	49
Appendix E: Classification of the Agricultural Research Station Soils in U.S. Soil Taxonomy System	51

SIMILAR SOILS...

Philippine Union College, Bicol, Philippines



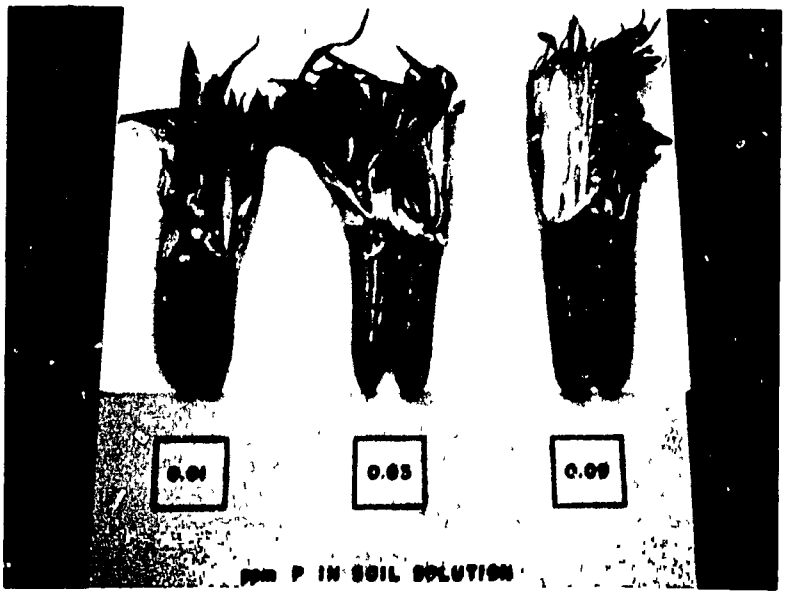
Kukaiau, Island of Hawaii, Hawaii

ANNUAL REPORT, 1975-1976
BENCHMARK SOILS PROJECT
UNIVERSITY OF HAWAII
REPORT NO. 3

Crop Production and Land Capabilities of a Network of Tropical Soil Families

UH/AID Contract No. ta-C-1108

...SIMILAR RESPONSE



on Hydric Dystrandepts in the Philippines and in Hawaii

Annual Report Summary Sheet

Crop Production and Land Capabilities of a Network of Tropical Soil Families
(The Benchmark Soils Project)
ta - C - 1108

Project Title and Contract Number

L. D. Swindale/J. A. Silva, University of Hawaii

Principal Investigators and Contractor

Department of Agronomy and Soil Science, Honolulu, Hawaii 96822

Contractor's Address

May 31, 1974 - May 30, 1977 Contract Period (as amended) From-To	July 1, 1975 - September 30, 1976 Reporting Period From-To
Total Expenditures and Obligations Through Previous Contract Year	$404,410
Total Expenditures and Obligations For Current Contract Year	$945,553

Narrative Summary of Accomplishments and Utilization

In the first two years, the University of Hawaii has established a network of soils belonging to the thixotropic, isothermic family of Hydric Dystrandepts in Hawaii, the Philippines, and Indonesia. Preliminary soil survey studies have indicated that the same or similar families may occur in Rwanda and Cameroon.

Two sites on the clayey, kaolinitic, isohyperthermic family of Tropeptic Eutrustox have been located in Hawaii. This family is similar to the Coto series in Puerto Rico and serves as the link with the parallel project at the University of Puerto Rico.

An on-site review of the project by an AID panel was held during June 1976. It commended the program design, the project accomplishments, and the forward planning toward achieving the project objectives. It suggested that the scope of the project be broadened to include additional soil families, training components for the soil family concept in the cooperating countries, and dissemination of information worldwide.

A detailed work plan for the life of the project was developed by using activity schedules and associated milestone events with assistance from R. Kitchell. J. A. Silva participated in developing a similar work plan for Puerto Rico. A memorandum of agreement between the University of Hawaii and the University of Puerto Rico was signed. It covers cooperative activities of both projects.

Soil exploration is being carried out to locate a suitable family of either Tropohumults or Tropudults of the order Ultisols. This additonal group of soils was included at the request of participating countries (the Philippines and Indonesia) where these are considered "problem" soils and at the recommendation of the AID Review Team. Arrangements for field survey in African are being negotiated with both the International Institute of Tropical Agriculture (IITA) and the Kenya Soil Survey to coordinate activities in locating suitable Ultisols/Oxisols sites.

Crop response data has only just begun to be generated. Initial results from Hawaii and the Philippines, though very preliminary, seem to reflect very positively on the transfer hypothesis. Transfer experiments on maize and soybeans have been installed, and crops were harvested at three sites. Results from these experiments in Hawaii and the Philippines show that the thixotropic, isothermic family of Hydric Dystrandepts requires large applications of phosphorus and little, if any, lime for acceptable maize yields.

The project has already had an impact on land use planning in the Philippines and Indonesia as evidenced by the high priorities set by their governments in this field. Other countries have shown great interest in a tie to the Benchmark Soils Project. A major activity toward information dissemination and utilization was completed during January 1976. An international seminar entitled "Uses of Soil Survey and Classification in the Planning and Implementing Agricultural Development in the Tropics" was held at ICRISAT, India. Eighty soil scientists and planners from 25 Asian and African countries participated in the seminar. As a result of the seminar, a network of Tropical Agricultural Experiment Stations is being established by the University of Hawaii by including the soil classification and the agronomic information in its "Soil Data Bank." LDCs will have an access to the information from this Bank.

General Background

In May 1974 a contract was signed between the U.S. Agency for International Development (AID) and the University of Hawaii (UH) to initiate a project entitled "Crop Production and Land Capabilities of a Network of Tropical Soil Families." The project is more briefly and popularly known as Benchmark Soils Project. The purpose of the project is to test an innovative methodology, a concept, for LDC use that will help them obtain agrotechnology for utilizing their land resources for increased food production and better nutrition. It will also bypass three key constraints faced by LDCs: lack of trained personnel, lack of capital, and, above all, lack of time to catch up with their needs. The poor farmers in LDCs do not have the luxury to wait for decades for an evolutionary process of trickling down of agricultural technology.

The concept in question is: can agrotechnology be transferred from one tropical region to another tropical region on the basis of Soil Taxonomy at the soil family level of classification? The concept, if proven correct, will have far greater effect on food production and its tempo than may seem possible at first glance. Its effect may well be profound. First, millions of dollars worth of research information produced by thousands of man-year efforts will be available for immediate tapping. Second, costs of site-specific trials all over the world -- which reach millions of dollars yearly -- will be saved, and the waste of precious human and other resources will be alleviated. Third, the overall process will be the formation of a worldwide network of expertise and a Soil Data Bank(s) to expedite and provide the needed information and communication for development. Fourth, the concept of agrotechnology transfer will be all-encompassing: it will include transfer of information on soil management practices and all that goes with it -- information on crops and cropping systems, water management practices, erosion control measures, suitability to new crops, economics of crop production, use and problems of irrigation, regional and national planning and priorities, and so on.

Project Objectives

The objectives of the project are to correlate food crop yields on a network of benchmark tropical soils and to determine scientifically the transferability of agroproduction technology among tropical countries.

Transfer (soil fertility), variety, and soil management experiments are being carried out on carefully selected benchmark soils in the same soil families-- in the Philippines, Indonesia, and Hawaii -- and will be carried out in one country in Africa.

Within the first three years of this project the contractor will accomplish the following:

1. Establish the network of soils;
2. Carry out transfer and soil management experiments;
3. Determine relationship between production and land capabilities for benefit of farmers and government planners in participating countries.

Continued Relevance of Objectives

The objectives continue to be relevant.

Accomplishments to Date

Objectives

1. Establish the Network of Soils

a. Findings

Sites. Two kinds of experimental sites are used in the soils network and are designated either as primary or secondarv. A primary site is 5 to 10 hectares in area and can accommodate transfer, variety and management experiments simultaneously. A secondary site is usually one hectare in size and accommodates only the transfer experiment. Hence, transfer experiments have been and will be installed at all sites. A minimum of eight transfer sites is required to complete a soil family network.

All experimental sites included in the soil family network of Hydric Dystrandepts and Tropeptic Eutrustox to date are listed in Table 1. The level of development of each site in the Philippines, Indonesia and Hawaii is indicated by the milestone achieved.

b. Status Prior to Reporting Year

At the end of the last reporting period, basic soil survey and site selection on the thixotropic, isothermic family of Hydric Dystrandepts in Hawaii were nearly complete. Similar reconnaissance work in the Philippines and Indonesia revealed probable sites of the same family in the Bicol Region on the island of Luzon in the Republic of the Philippines and in central Java in Indonesia. Soil survey investigations in tropical West and East Africa were being planned.

Preliminary desk study and soil survey were initiated to locate a site or sites on the clayey, kaolinitic, isohyperthermic family of Tropeptic Eutrustox in Hawaii. The Coto series of Puerto Rico belongs to this family which would be the link in the soil network between the University of Hawaii (UH) and the University of Puerto Rico (UPR). The Lihue and Wahiawa series in Hawaii are prime possibilities to match up with the Coto.

Families of either Tropohumults or Tropudults were given consideration as additional soils because of extreme interest expressed in Indonesia and Philippines.

c. Progress to Date

Hydric Dystrandepts

Philippines. The memorandum of agreement between the Philippine Council for Agriculture and Resources Research (PCARR) and the University

Table 1. Soil Family Network of Experimental Sites

SOIL FAMILY	COUNTRY	LOCATION	SITE	MILESTONE ACHIEVED
Thixotropic, isothermic Hydric Dystrandepts	Philippines	Philippine Union College Panicuason, Naga City	Primary	4
		Palestina, Pili Camarines Sur	Secondary	3
		Burabod, Calabanga Camarines Sur	Secondary	3
	Indonesia	ITKA Cisarua, Java	Primary	3
		PLP Lembang, Java	Secondary	3
		Segunung Cipanas, Java	Secondary	3
	Hawaii	Niulii - Iole North Kohala, Hawaii	Primary	3
		Niulii - Halawa North Kohala, Hawaii	Secondary	4
		Kukaiau Hamakua, Hawaii	Secondary	4
Clayey, kaolinitic, isohyperthermic Tropeptic Eutrustox	Hawaii	Maunaloa, Molokai	Primary	1

Milestones:
1. Soil survey completed
2. Agreements signed
3. Site prepared and staffed
4. Experiments underway
5. Experiments completed

of Hawaii was formally effected in February 1976. This agreement, which required nearly a year of negotiation, covers all activities to be carried out by the Benchmark Soils Project.

Initial implementation of the project was dependent on the availability of vehicles, personnel, and storage space from the Bureau of Soils. The project was initially headquartered at the Bureau of Soils Regional Office in Naga City before moving to the Zenith Apartments.

The project also relied on funds advanced by PCARR while awaiting bank clearance on the transfer of funds from Hawaii to the Philippine National Bank in Naga City. PCARR also provided personnel support to obtain release of project equipment from the Bureau of Customs in Manila.

After preliminary inquiry on the availability of land in the Bicol area by W. H. Hudnall, lease arrangements were made by PCARR with the Philippine Union College (PUC) for 5 hectares initially with additional areas available for expansion and with Isarog Farms, Inc. for a hectare each at Palestina and Burabod.

Sugar cane is the principal crop under or intended for cultivation at all three sites. Previous attempts at growing corn on a large scale (10-100 ha) in the area proved futile.

A water reservoir, which can impound at least 50,000 gallons of spring water, was constructed for irrigation at the primary site (PUC). This became operational toward the end of August. Pipelines for the other sites were installed and ready for use for the next cropping season.

A building with floor area of 1100 sq. ft. was constructed at PUC to provide space for field supplies, a field office, and a working shed. The latter is used as a staging area for experimental field materials and for threshing, drying, and weighing of harvested plants and grains. It has wooden floors and sidings with nipa roofing. Smaller and cheaper versions of this type of facility were also constructed at each secondary site. These were necessary support facilities for project operations considering the general lack of transportation and inaccessibility of roads during inclement weather conditions.

Dr. Frank Sheppard, Assistant Director for Agricultural Development, AID Manila, was instrumental in facilitating banking arrangements of project funds in accordance with AID guidelines. Dollar and peso accounts were established at the Philippine National Bank. He was also responsible for providing two surplus vehicles for project use. This task was assigned to Mr. Romie H. Santiago, who spent much time with Drs. B. G. Cagauan, Jr. and A. A. Briones, project and co-project leader, in locating these vehicles and visiting AID-contracted service shops to rehabilitate both vehicles. During the latter part of July and until the first week of August, a rented passenger jeepney was used as the project vehicle. Mr. Santiago also arranged for the delivery of excess property materials, such as cabinets, mattresses for our field workers, and a 10-KVA generator, for use at our Naga site.

Indonesia. Soil and agronomic activities of the project are covered by the Implementation Agreement between the Soil Research Institute (SRI), Ministry of Agriculture and the University of Hawaii which was signed

in April 1976. This UH/SRI agreement was signed under the USAID Project Assistance to Agriculture, Project No. 497-11-110-189.

Selection of primary and secondary sites was based on the recommendation made by W. H. Hudnall.

The primary site at the Institute Theologia and Keguruan Advent (ITKA) was chosen because of its location on land owned by an institution rather than private individual and the possible availability of sufficient area (up to 15 hectares). Coincidentally, both ITKA and PUC in the Philippines are Seventh-Day Adventist schools. Power, water, labor, and tractors are available. Choices for secondary sites were narrowed to PLP, Segunung and Malabar Tea Estate. Upon selection of sites, SRI agreed to enter into negotiations with the landowners to arrange a long-term lease.

A. R. Hurdus, with assistance from Mr. I P. Gedjer Widjaja-Adhi of SRI, laid out initial plots for transfer experiments at ITKA, PLP, and Segunung. Soil samples were collected from each plot of the 3 sites and shipped to Hawaii for analyses of phosphorus, KCl-extractable aluminum and pH.

Office space and administrative and other support services are to be provided by SRI in Bogor. The SRI office will be project headquarters until a UH project leader is employed.

Hawaii. Lease agreements for both secondary sites were secured in 1975/76 with Kohala Corporation and Honokaa Sugar Company, respectively. Lease arrangement for 12 hectares of land for the primary site was finalized with Kohala Corporation this year. The primary site was fenced, runoff ditches were constructed, and 1.5 hectares were prepared for the winter planting of both transfer and variety experiments. All three sites were previously under sugar cane cultivation. The Kukaiau site is surrounded by sugar cane of a viable company, while the Niulii sites are surrounded by "volunteer" cane fields and pasture. Hog and cattle wire fences were installed to keep grazing cattle and mountain pigs out of the experiments at both Niulii sites.

County water lines are being used as water source for irrigation at the Niulii primary site and the Kukaiau site. The water source for the Niulii secondary site is a reservoir adjacent to the field. A natural spring will also be tapped as an additional water source at the Niulii primary site. Installation and operation of the drip irrigation system has proceeded without any major problems. Plugging of the orifices on the drip tube has been minimal.

Both secondary sites are equipped with meteorological instrumentation to measure and record solar radiation, rainfall, relative humidity, and temperature. Wind speed and direction are also measured and recorded at Kukaiau.

The Benchmark Soils Project continued to use the Mealani Experiment Farm of the Hawaii Agricultural Experiment Station (HAES) in Kamuela as the primary staging area for Kukaiau and Niulii sites. Personnel from HAES were made available from time to time in accordance with plot allocations submitted by the project and approved by HAES.

Tropeptic Eutrustox

Hawaii. Soil survey investigations for suitable and leasable sites on a Tropeptic Eutrustox in Hawaii were completed. Characterization data of the Lihue, Wahiawa, and Lahaina taxajunct on Kauai, Oahu and Molokai, respectively, were compared to the Coto series of Puerto Rico before selecting a probable site. Soils belonging to this family of Tropeptic Eutrustox in Hawaii are difficult to lease because they are intensively used for sugar and pineapple production. Lands that can be leased are those being phased out of agriculture because of high costs and urbanization.

Arrangements are being made to lease land either on Waipio, Oahu, from Gentry-Pacific Ltd. or Maunaloa, Molokai, from Molokai Ranch. The former lessor is a developer and the latter is a cattle ranch. Both sites were formerly under pineapple cultivation by Dole Corporation.

On the Island of Molokai, there are no HAES personnel or stations to assist the project. A field office and warehouse will need to be rented at a location near the field site. On Oahu, the HAES stations are not conveniently located to serve a site at Waipio. Additional agricultural technicians will be required.

Tropohumults or Tropudults

Soil survey investigation for a suitable soil family of Tropohumults or Tropudults was initiated by the hiring of a soil survey consultant in A. R. Grunewald. After preliminary desk and field studies in Hawaii and the Philippines, Grunewald and associates from the Bureau of Soils focused the initial survey in the Bicol region and other locations on Luzon. Additional locations would be looked at on Mindanao and Negros. This phase of the investigation will be completed in mid-November.

A similar soil survey for a suitable soil family of either Tropohumults or Tropudults that is common to either the Philippines or Hawaii, or both, was set to begin in October with L. D. Swindale as team leader. Preliminary investigations by G. Uehara and W. H. Hudnall in 1974 and 1975, respectively, on Sumatra and desk information from the FAO were examined by Swindale prior to his travel in October and will be reported later.

Information on location and classification of various soil families of Orthoxic or Humoxic Tropohumults in Hawaii is readily available to project personnel.

Soil Family in Africa

Preliminary on-site soil survey investigations were conducted over a 7 week period. Institution and government contacts were established in Nigeria, Ghana, Cameroon, Kenya, Tanzania, and Rwanda. Numerous sites were visited by H. Ikawa during a week's stay in each country and 7 different soils were collected showing some relationship to our project. In addition, two pedons were collected by Mr. G. W. van Barneveld, FAO Pedologist, in Cameroon, and four pedons were collected by Dr. H. Neel, Pedologist, in Rwanda, and forwarded to Hawaii for characterization by

Mrs. Ada Chu and Dr. S. P. Periaswamy for classification.

Based on the results of the completed laboratory work in Hawaii, the following soils were located in Africa (Table 2).

Table 2. Tentative Classification of Soils of Africa

Country	Location	Tentative Classification
Cameroon	Mbouda*	Orthoxic Palehumult or Tropohumult
	Tombel*	Udic Eutrandept
Kenya	Murinduko	Ustoxic Dystropept
	Njoro	Typic Eutrandept
	Molo	Oxic Dystrandept
Tanzania	Moshi	Rhodic Paleustalf
Rwanda	Kinigi	Typic Dystrandept

*sample collected by G. W. van Barneveld; others by H. Ikawa et al.

2. Carry Out Transfer and Soil Management Experiments

a. Findings

Results of transfer experiments in Hawaii and the Philippines indicate that the family of Hydric Dystrandepts requires large applications of P and little if any lime for acceptable maize yields. The management experiment in the Philippines showed that 100N - 100P - 50K produced yields similar to those of 2 tons of chicken manure, a local farmer recommendation.

b. Status Prior to Reporting Year

At the end of the last reporting period no experiments had been installed since sites in Hawaii were still being prepared and those in the Philippines were being selected.

c. Progress to Date

Transfer Experiments

The design of the experiment used to test the hypothesis of transferability of agroproduction technology was selected at the Workshop on Experimental Designs held in May 1974. It was a 5^2 partial factorial developed by Escobar which is described in the paper by Laird and Turrent presented at the workshop. Two variables which are related to characteristics of the soil family are selected, i.e., P and pH or P and K, and the same treatment combinations are used in all sites of the same family. However, the variables selected may differ among families. Five levels of the two variables are included in the transfer experiment and all other controllable variables, i.e., irrigation, other nutrients, plant protection, etc., are maintained near optimum levels

so that treatment effects will be clear. Three replicates in a randomized complete block design are installed.

Variables selected for the Hydric Dystrandepts are phosphorus and lime. Phosphorus levels are expressed as ppm P in the soil solution measured according to the method of Fox and Kamprath (1970)[1/] while lime levels are based on KCl extractable Al according to the method of Kamprath (1970)[2/]. There are 13 design treatments and two control treatments which are shown in Table 3. The complete control receives no fertilizer and serves to indicate the natural productivity of the soil while the partial control receives the "blanket" application of N, K, and micronutrients, but not the variables.

Table 3. Coded Values of Treatments Used in Transfer Experiments on Family of Hydric Dystrandepts

Treatment	Phosphorus	Lime
A	-0.85	-0.85
B	-0.85	+0.85
C	+0.85	-0.85
D	+0.85	+0.85
E	-0.40	-0.40
F	-0.40	+0.40
G	+0.40	-0.40
H	+0.40	+0.40
J	0	0
K	-0.85	0
L	+0.85	0
M	0	-0.85
N	0	+0.85
O	Complete Control*	
P	Partial Control*	

* O = no fertilizer
P = no P or lime but receives blanket application of N, K and micronutrients

Hawaii. Two transfer experiments with maize and one with soybeans have been installed on each of the two secondary sites on the Hydric Dystrandepts in Hawaii. To date, one transfer experiment with maize has been harvested and the data analyzed from each of the sites. One was a late summer planting (August) on the Kukaiau site and the other a fall planting (October) on the Halawa site. These crops had been planted as soon as the sites could be prepared so as to gain experience with the

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1/ Fox, R. L. and E. J. Kamprath. 1970. Phosphorus sorption isotherm for evaluating the phosphate requirements of soils. Soil Sci. Soc. Amer. Proc. 34:902-907.

2/ Kamprath, E. J. 1970. Exchangeable aluminum as a criterion for liming leached mineral soils. Soil Sci. Soc. Amer. Proc. 34:252-254.

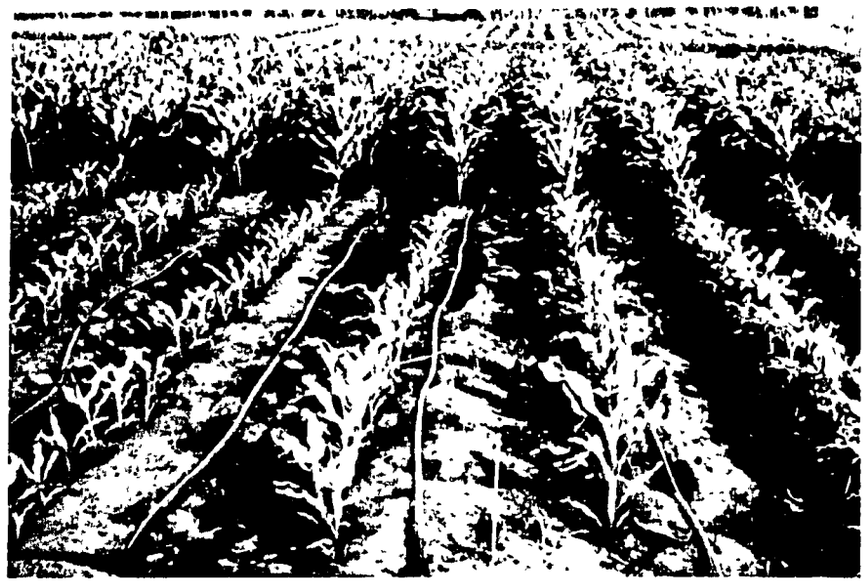

Figure 1 Maize transfer experiment on secondary site at Kukaiau, Hawaii.

experimental approach and the crops in Hawaii. Plantings are being made in May-June for the dry season crop and in December-January for the wet season crop now that the sites are fully established. The transfer experiments with maize and soybeans for the dry season crop on these sites are presently maturing and are scheduled for harvest in the fall. (Figure 1)

Maize grain yields for the Kukaiau site (Kukaiau series), which is at 1300 ft. (394 meters) elevation, are shown in Figure 2. There is a marked increase in yield with the first increment of P over the partial control treatment followed by a more gradual increase with subsequent levels of P. The largest increase in yield with P is at the lowest lime rate (90 kg/ha) and the smallest increase is at the highest lime rate (1110 kg/ha). Maximum yield with P was not attained at any of the rates of lime. The response to lime was relatively small and generally negative at the highest rate of lime. This site was a former sugar cane field that had received P and lime applications in the past. KCl-extractable Al values were generally low, about 0.2 meq/100 g, therefore a marked response to lime was not expected.

Grain yields for the Halawa site (Niulii series), which is at 1600 ft. (485 meters) elevation, also showed a marked response to P applications over the complete control and a smaller response to P over the partial control (Figure 3). Apparently there was residual P in the soil. Maximum yield with P was approached with the low and high rates of lime (105 and 1295 kg/ha), but not with the middle rate of lime. Response to lime was generally negative. KCl-extractable Al was 0.6 meq/100 g which was low. This site was a former sugar cane field and had received P and lime applications in the past. It is of interest that these two fields, which are at slightly different elevations, gave comparable yields of about 6000 kg/ha when both P and lime were applied.

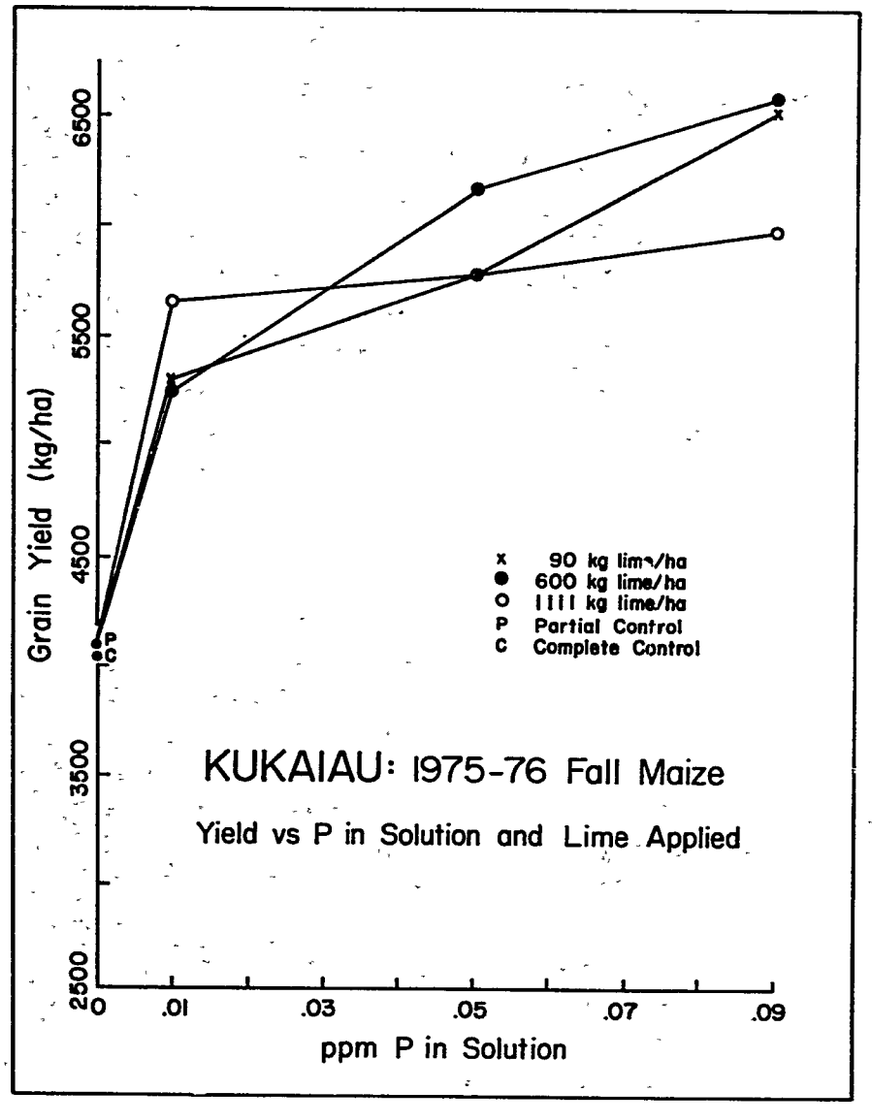

Figure 2. Grain yield versus P in solution and lime applied for secondary site at Kukaiau, Hawaii.

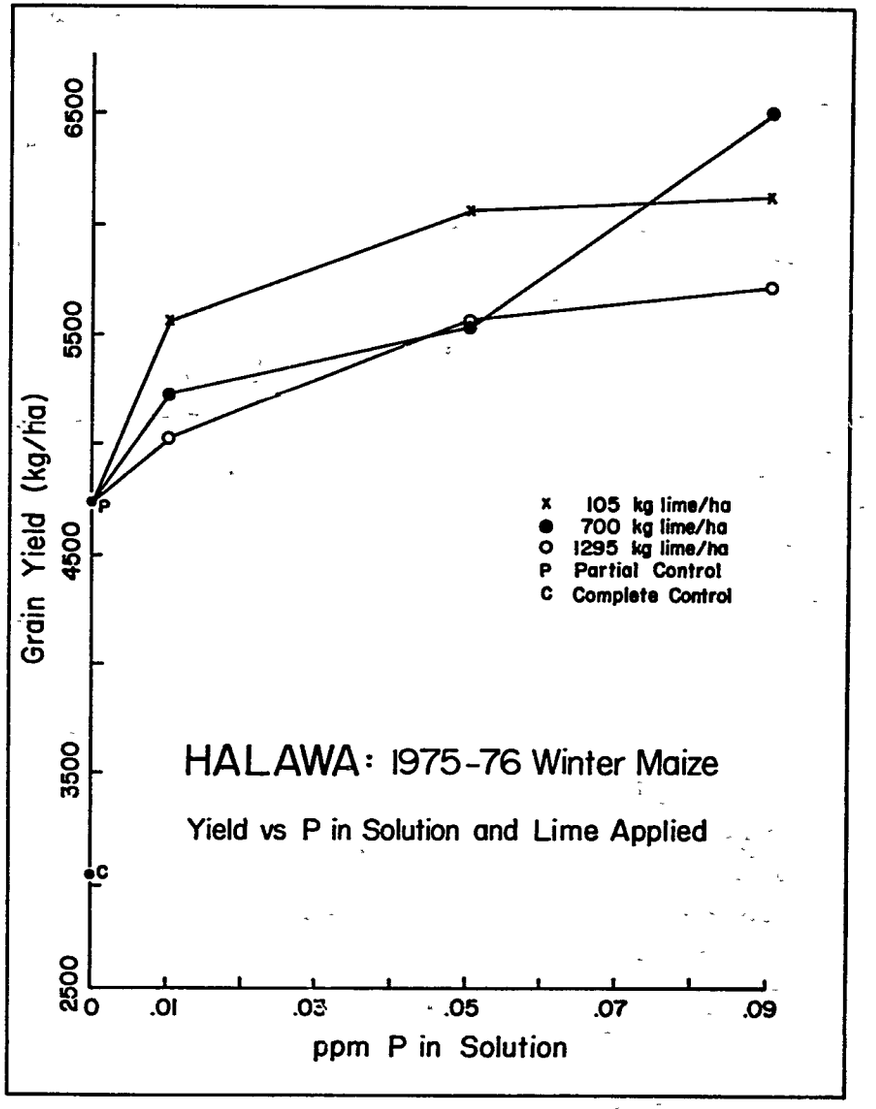

Figure 3. Grain yield versus P in solution and lime applied for secondary site at Niulii (Halawa), Hawaii.

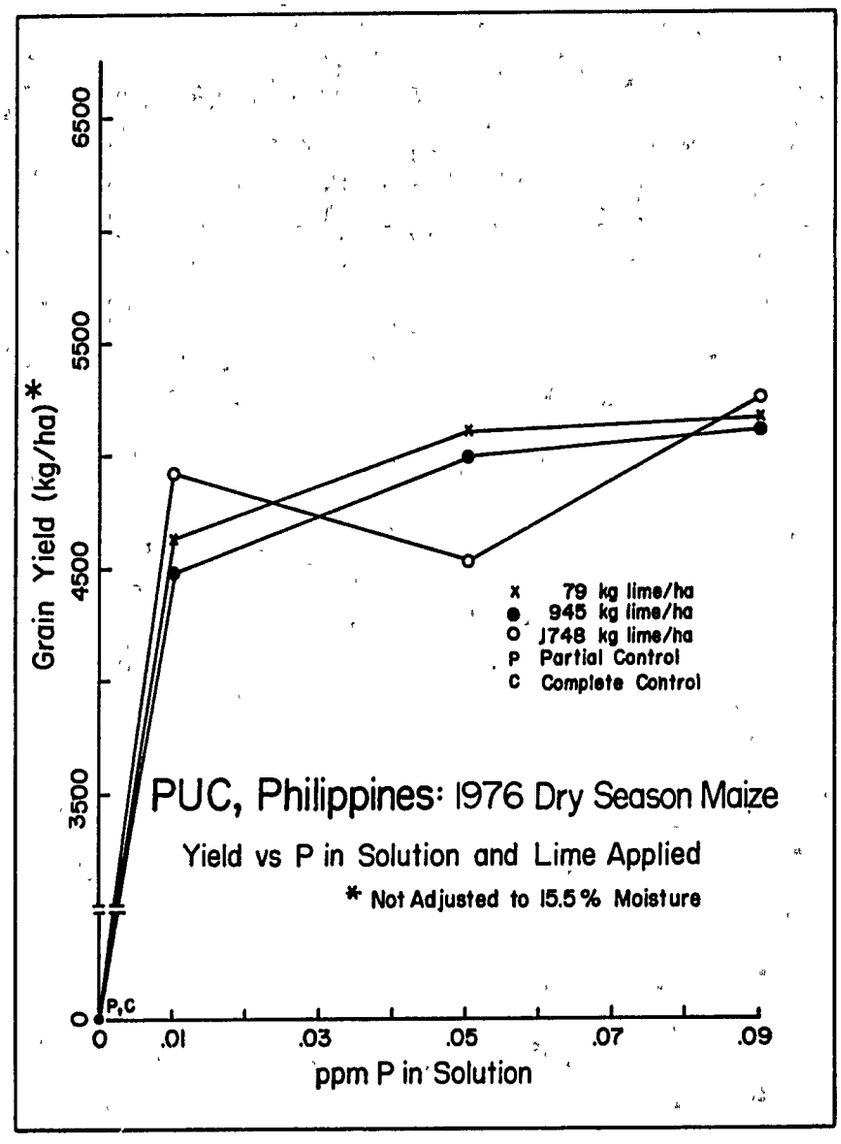

Figure 4. Grain yield versus P in solution and lime applied for primary site at Philippine Union College, Naga City, Philippines.

Philippines. One transfer experiment with maize and one with soybeans have been installed and harvested at the primary site, PUC site, in the Philippines. Response of maize to P was striking at this site since plants in the control plots which did not receive P died. Response to higher levels of P was also obtained, but was smaller. Maximum yield with P was approached at the low (79 kg/ha) and medium (945 kg/ha) levels of lime, while response to P at the highest rate of lime (1748 kg/ha) was erratic. Response to lime was relatively small and was negative in some cases. (Figure 4)

The transfer experiment with soybeans indicated a marked response to P over the control plots which was generally followed by continued response to higher levels of P, but at a lower rate of increase. Maximum yield with P applications was apparently being approached. (Figure 5)

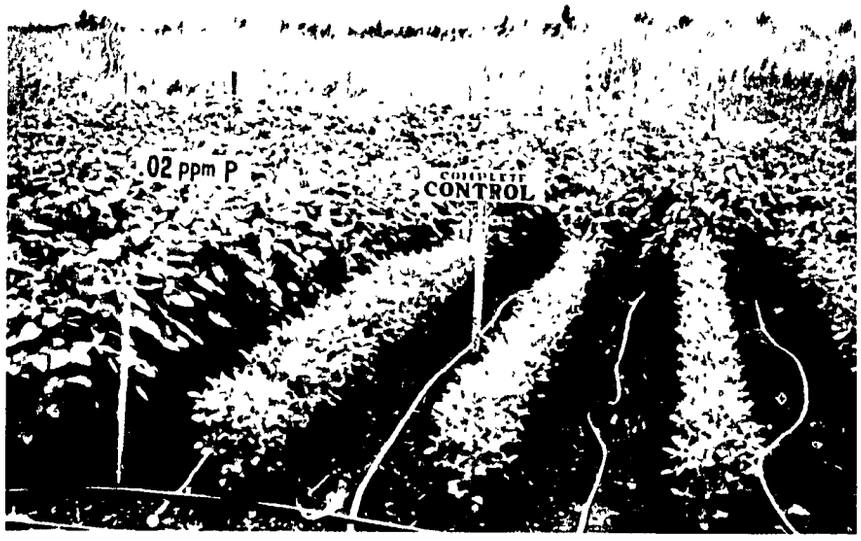

Figure 5. Soybeans transfer experiment on primary site, Philippine Union College, Naga City, Philippines.

Direct comparison of yield levels of maize in Hawaii and the Philippines is not appropriate because the crops were grown in different seasons and a different variety was used in the two locations. However, patterns of yield response were generally similar and indicated that the same family of Hydric Dystrandepts in Hawaii and the Philippines will not grow an acceptable crop (or any crop in the Philippines) without large applications of phosphorus. In addition, response to lime was small or negative in both locations. This tends to support the hypothesis of transferability in a general, practical way and suggests that this family of Hydric Dystrandepts requires P and little, if any, lime for acceptable maize yields.

Variety Experiments

Variety experiments were required by the recommendation of the Workshop on Experimental Designs that the "best adapted" local variety be used in the transfer experiments. This was suggested to avoid complete loss of the experiment by local insects and/or diseases to which foreign varieties may not be resistant or tolerant. Therefore, a variety experiment is installed at the Primary site each season transfer experiments are conducted. Varieties included in the experiment are the top two leading local varieties and varieties being grown in transfer experiments at other sites in the soil family network.

Hawaii. No standard variety experiments were installed in Hawaii this year because the Primary site had not been acquired or prepared at the time of planting the transfer experiment. However, a small observation planting of soybean varieties for adaptability and resistance to powdery mildew was carried out. Twenty-three varieties were grown and the following varieties gave good yields and also exhibited resistance to powdery mildew: Hill, Forest, Pomona, and Coulter 71. Davis also produced well but was less resistant to powdery mildew while Kahala yielded well, and was less resistant to powdery mildew than Davis.

Philippines. A standard maize variety trial (with 2 P x 2 lime treatments) was harvested at the primary site in the Philippines. The yields obtained are shown in Table 4 below.

Table 4. Variety Trial Yield Results—Primary Site, PUC, Philippines in 1976 Dry Season

Variety	Grain Yield (kg/ha)
DMR Phil Comp 1	5521
HPCA-1	6468
H-610	5722
DMR-1	5582
H 788	5725

Management Experiments

Management experiments on Maize were installed on the primary sites only. The objectives of these experiments are (1) to provide information to local governments on ways to increase production by improved availability and utilization of resources; and (2) to provide basic information to local farmers with limited resources to indicate how they can increase their yields.

Hawaii. Although no management experiments with maize or soybeans were installed this year, a cover crop of sorghum was planted on the maize transfer experiment site at Kukaiau. This was done to minimize soil erosion and to reduce nutrient levels in the soil. No additional fertilizer or irrigation was applied and no pest control measures were taken. The sorghum was harvested according to the plot layout of the transfer experiment and dry matter yields were expressed as kg/ha. A marked increase in yield was obtained with the first level of residual P over the control and yield increased at a slower rate with increasing levels of residual P. There was some response to the middle level of lime, especially at the higher P levels with no response to lime above the middle level. These results demonstrate the continued availability of the P and lime applied to the maize several months earlier. Thus return on the investment for P fertilizer and lime may continue to be realized on crops planted after the original crop to which they were applied. This information is of value to farmers contemplating application of large amounts of P and lime.

Philippines. A management experiment with maize was installed at the Primary site to investigate the response of maize to chicken manure, which is a recommended local practice, and to various levels of N, P, K and lime. Although local farmers have found they can grow a good crop if they apply about 2 tons of chicken manure, there is relatively little chicken manure available in the area. Therefore if the amount of inorganic fertilizer which can produce the same or greater yields than 2 tons of chicken manure can be identified, farmers could apply this since it is generally more readily available in the area. The experiment has been harvested and the data are presently being analyzed.

3. Determine Relationship between Production and Land Capabilities for Benefit of Farmers and Planners

a. Findings

A seminar entitled "Uses of Soil Survey and Classification in Planning and Implementing Agricultural Development in the Tropics" was organized by the Benchmark Soils Project of the Department of Agronomy and Soil Science at the University of Hawaii and the host, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), under the sponsorship of the United States Agency for International Development (AID). The seminar was held at the Ritz Hotel in Hyderabad, India on January 18-23, 1976.

Case studies and examples of uses of soil survey data in relation to land use planning and implementing agricultural development for food production were presented during the seminar. Initial emphasis was placed on the fundamentals of soil classification, especially the U.S. Soil Taxonomy. This established the communication ground work for the entire seminar proceedings.

The Seminar succeeded in increasing communication among agricultural scientists and between scientists and planners. Such communications can lead to accelerated agricultural development and technology transfer within national and international environmental constraints. Participants were able to visit an international tropical research institution in tropical Asia where work relevant to the theme of the Seminar is in progress. The visit also provided opportunities to observe the application of the principles discussed at the Seminar to agricultural development.

b. Status Prior to Reporting Year

Members of the executive committee of the Consortium on Soils of the Tropics (COST), T. S. Gill of TAB/AID, J. S. Kanwar of ICRISAT, L. D. Swindale and G. Y. Tsuji were designated as the Steering Committee for the seminar. Organization of the seminar program and correspondence to prospective participants and to AID Missions in tropical African and Asian countries were initiated.

c. Progress to Date

The seminar provided opportunities for program planners and soil scientists from tropical countries in Asia and Africa to report, discuss, and learn about the practical usefulness of soil classification, particularly the new United States Soil Taxonomy, in:

1) Inter-relating research studies on soil, water, and crop management to each other and to similar work in other tropical areas,

2) Land use planning and regulation, and

3) Planning and implementation of agricultural development for food production

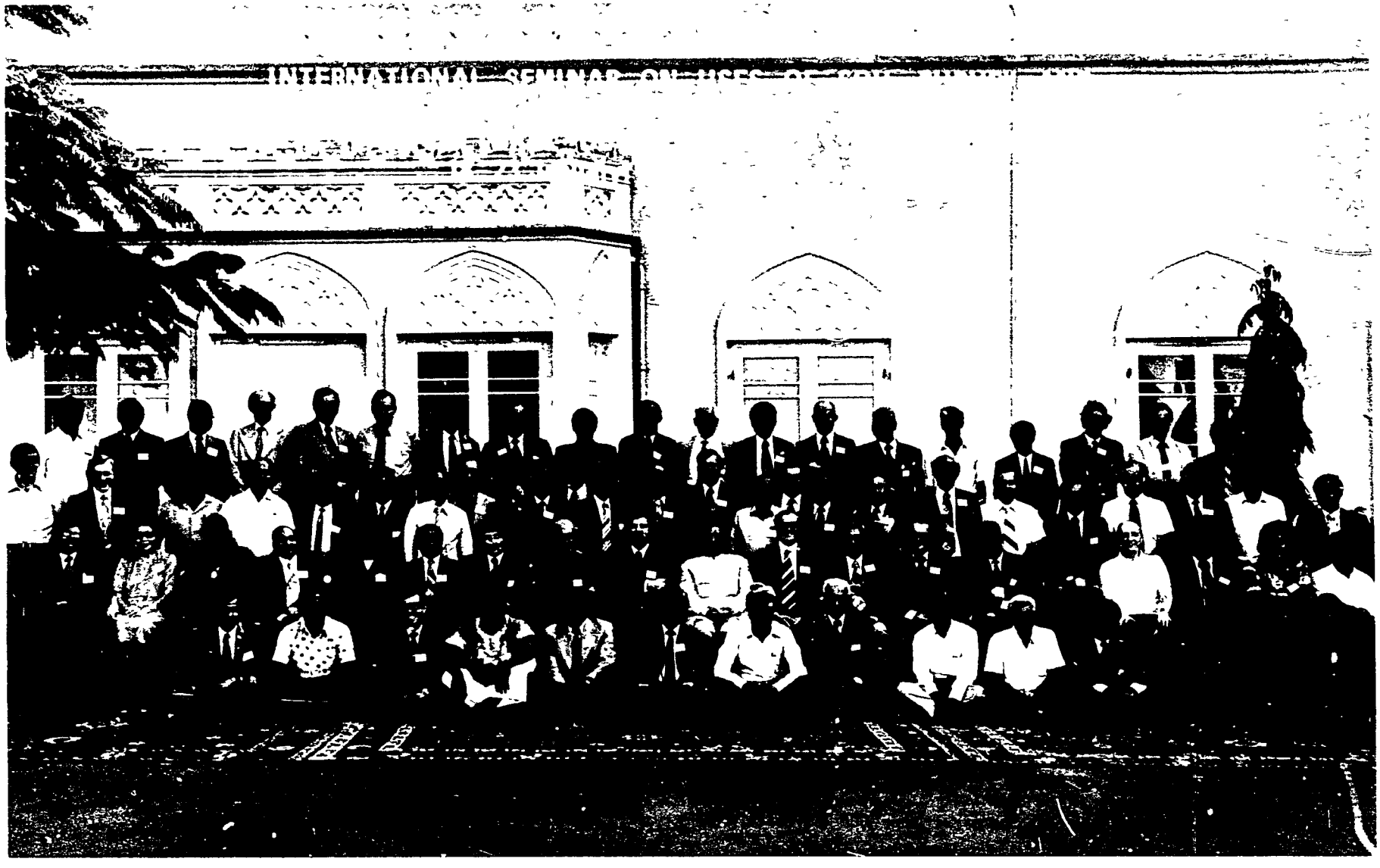

Figure 6. Participants at international seminar in Hyderabad, India

A number of papers dealt specifically with these topics. By combining research results on water and crop management, and on soil properties, with soil survey data, it was possible to make useful predictions about the uses of soils and of land and to relate these things to similar work in other tropical areas.

Eighty soil scientists and land use planners from Ghana, Ivory Coast, Nigeria, Kenya, Rwanda, Zaire, Malawi, Ethiopia, Central African Republic, Tanzania, Sudan, India, Nepal, Bangladesh, Sri Lanka, Philippines, Indonesia, Thailand, Malaysia, and Western Samoa attended the seminar. (Figure 6)

Soil scientists were able to share experiences in extending and providing information on the use of soil classification, soil survey and and soil data interpretation for land use planning. In providing such information, however, soil scientists were reminded that planners in LDC's must allocate scarce human and financial resources within national priorities. Those planners present at the seminar indicated that soil survey data would be valuable if the information would allow them to plan alternatives. Soils data which can be integrated with socio-economic data and with other forms of agricultural data should be presented. Interpretations with alternatives can be simple, and a statement by Kellogg (1962)[3/] "Planning good soil survey interpretations, like planning good research, depends first of all on a clear statement of the critical questions." should be appropriate to both soil scientists and planners.

In the discussions that followed each major session, the following recommendations were made: (1) Efficient organization of soil surveys was stressed in developing countries; (2) acceptance of the need for soil resource data by policy makers in the highest level of government would insure that planners make good use of soils data; (3) soil scientists should not be concerned about the amount of information that would be presented to planners as long as it is presented in proper and useful form and (4) quantitative data, data about the use of soils for specific purposes and alternatives, should be presented in a format that planners can absorb and use.

At national levels, land evaluations are needed -- broad-scale land evaluations that perhaps do not include specific crops information or specific input information and that do not give all the various alternatives. Land evaluations that require single factor interpretations and quantitative data should be developed at different levels of management. Examples of these are maps as integrating instruments or documents. Computer programs are also available to provide computer display maps that allow planners to make various alternative choices. Spatially oriented data would be extremely important in decision-making for planning.

Use of computers as soil data banks to store and retrieve soils and

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3/ Kellogg, Charles E. 1962. Interactions in Agricultural Development. In Science Technology and Development - U.S. Papers prepared for the UN Conference on the Application of Science and Technology for the Benefit of the Less-Developed Areas, Geneva, 1963. Vol. III, Agriculture, p. 12-24. U.S. Gov. Printing Office, Washington, D.C.

land use data was considered valuable. The Soil Conservation Service of the United States Department of Agriculture, the University of Hawaii, and other institutions have such soil data banks in use. These banks must carefully design the various data files on soil characteristics, soil use, and soil geographic distribution to ensure all files are compatible. As more information is gathered and placed into computers, data may get lost because the data files cannot be related to each other by the computer.

As a whole the Seminar participants all agreed that soil data are essential to resource planning, land use planning, agricultural and national development planning. Thus, soil scientists should certainly think of becoming involved with planning people. Discussions about the need for early involvement and suggestions of the best way to do this, resulted in the recommendation that soil scientists be included in planning organizations.

In order to close the communication gap between planners and soil scientists, it was the consensus of those in attendance that (1) annual conferences should be held where information needed for the next year or two is presented to a variety of resource data people as a means of communicating the needs of local and regional planning agencies, (2) familiarization sessions should be undertaken both for the soil scientist to learn from the planners and vice versa, and (3) agencies for bilateral and multilateral aid need to rectify problems of scale and information contained in soil surveys and the terminology used.

A great deal of interest was expressed in the Soil Taxonomy. Training sessions should be set up in various parts of the world to help people learn to use this taxonomy, learn to understand it, and teach others to use it. It was suggested that the University of Hawaii, the United States Agency for International Development and the Soil Conservation Service of the United States Department of Agriculture address themselves to this matter.

Finally, it was agreed that the soil network based on the soil family concept of the U.S. Soil Taxonomy would be useful in the transfer of agrotechnology. The classification of soils of agricultural research centers in the tropical world is a good way to start. The Benchmark Soils Project received soil characterization and classification data from participants of 12 different countries. The data would be used to classify their soils at the soil family level. Other soil data were to be sent to Hawaii by other interested parties. The host, ICRISAT, expressed interest in the possibility of using the technology transfer concept based on soil families to make their outreach program more meaningful and effective.

Other Accomplishments

1. Memorandum of Agreement with Puerto Rico

Cooperation between the Benchmark Soils Project of both the University of Puerto Rico at Mayaguez and the University of Hawaii was formalized with the signing of a memorandum of agreement between both institutions in January 1976. The agreement provides for joint soil survey investigations, wherever possible, and for analytical services of soil and plant materials to be provided by the University of Hawaii.

The Coto series of Puerto Rico and the Wahiawa series of Hawaii will serve to link both projects in the soil family network of clayey, kaolinitic, isohyperthermic Tropeptic Eutrustox.

2. Project Design and Work Plan

Several days were spent in Hawaii with Mr. Ray Kitchell, consultant for AID, in developing a detailed work plan for the project. All Hawaii project personnel participated in the development of the plan. The use of activity schedules and associated milestone events in the work plan brought out potential problem areas that need to be resolved for progression of the project. This was followed by a similar meeting with staff of the Puerto Rico project in Puerto Rico with Kitchell, and Dr. L. Frederick of AID and J. A. Silva, of the Hawaii Project, during which the Hawaii work plan was further improved. A final work plan was developed for both projects. This insured close coordination of the two projects and resulted in a better understanding of mutual problems encountered. This work plan is the basis of much of the project's activities.

3. First Annual Coordination Meeting

Two major recommendations for the Benchmark Soils Projects were accepted by the participants to the first annual coordination meeting of the Project at the University of Puerto Rico, Mayaguez on August 17 to 20. (Figure 7) These were:

(1) To increase the number of sites and the inclusion of more soil families in every participating country.

(2) To make the management experiments relevant to the host government and the small farmers.

In discussions on making the management experiments of the project relevant to the needs of the host country and the small farmers, Dr. L. D. Swindale stressed that the components of the management experiments should

Figure 7. Participants at annual coordination meeting at University of Puerto Rico, Mayaguez, August 17-20, 1976.

include soil survey interpretation that demonstrates how cooperating countries can:

(1) Transfer soils management information within and among countries.

(2) Provide planning agencies with more useable soils data.

(3) Improve soil survey interpretation of national soils institutions and stimulate research in this field.

(4) Establish better coordination of agricultural research through the classification of soils of agricultural research stations.

Target plans for the number of experiments to be implemented for the 1976-77 cropping year were made by those present at the meeting. Those affecting Hawaii are listed below in Table 5.

Table 5. Tentative Number of Experiments for Crop Year 1976-77

Type of Experiment	INCEPTISOLS Hydric Dystrandept			ULTISOLS		OXISOLS Tropeptic Eutrustox		
	Phil	Hawaii	Indo	Phil	Indo	Hawaii	P. Rico	Brazil
Transfer, maize	6	6	6	2	-	2	4	6
Variety, maize	2	2	1	0	-	1	2	2
Management, maize	2	2	1	0	-	1	2	3
Transfer, soybean	2	4	3	1	-	1	4	4
Variety, soybean	1	1	1	0	-	0	0	2
Management, soybean	1	0	0	0	-	0	2	1
Total	14	15	12	3	-	5	14	18

At the conclusion of the meeting, the Philippines was selected as the site of the next annual meeting in July or August 1977.

4. AID On-Site Review Team

In May 1976 an AID Review team conducted an on-site review of the project. The team leader was William M. Johnson, Deputy Administrator of the Soil Conservation Service, USDA and the team members were Dr. Fletcher Riggs, Chief, Agricultural and Rural Development Division, ASIA/TD/RD/AID, and Mr. Harold Kugler, Senior Agricultural Management Sepcialist, AFR/DR/ARD/AID. Dr. Tejpal Gill, Senior Soil Scientist, TA/AGR, the Project Manager accompanied the review team. The team visited the sites and personnel in the Philippines on May 23-26 and sites and personnel in Hawaii on May 27-28.

The review team met in Manila on May 23, 1976 to discuss the objectives of and the plans for the review of the Philippines sites. The team traveled to Naga on May 24. (Figure 8)

Following a brief stop at the Bureau of Soils headquarters near Naga, the review team; project staff from Hawaii; Philippine Project Leader, Bernardino G. Cagauan, Jr.; Dr. Eduvigis Pantastico (Director, Crops

Figure 8. AID On-site Review Team with Principal Investigator, L. D. Swindale, at Naga City, Philippines.

Research Division, PCARR); and Mr. Godofredo Alcasid (Assistant Director, Bureau of Soils), proceeded to the primary experimental site on the property of Philippine Union College (PUC) near Naga City. Soil preparation and planting of corn were in progress. Plot layout and experimental design were reviewed. The remarkable resemblance of the soil exposed in a ditch to Hydric Dystrandepts in Hawaii was noted.

The review team and accompanying personnel next visited a secondary site on Isarog Farm, Trevino Plantation near Palestina, Camarines Sur. This is an apparently virgin site, covered with fairly dense vegetation of trees and tall shrubs. The clearing operation was underway and the soil profile was exposed in a nearby road cut. There was discussion of the research planned for this site and the other secondary site, also on Isarog Farm, but which the panel could not visit because of the shortage of time.

Next, the review panel and Messrs. Gill, Swindale, Silva, and Pantastico visited headquarters of the Philippine Council for Agriculture and Resources Research (PCARR) at headquarters on the campus of the University of the Philippines at Los Banos. The Deputy Director-General, Dr. Ramon Valmayor, met the group. He indicated PCARR's intense interest in the Benchmark Soils Project and the intention of PCARR to support the project.

Finally, the review team and accompanying Univeristy of Hawaii and PCARR staff visited headquarters of the Bureau of Soils in Manila. All of the principal supervisory staff were present, headed by Dr. Juan Mariano,

Director; and Dr. Godofredo Alcasid, Deputy Director. There followed a discussion of the expansion of the experimental sites to include red upland soils, aprticularly the extensive Ultisols in the Philippines. Dr. Alcasid provided the review panel with a statement concerning the Bureau's research project proposal on soil management and technology transfer research based on the design of the Benchmark Soils Project.

The review team, accompanied by T. S. Gill, L. D. Swindale, J. A. Silva, A. R. Hurdus, and G. Y. Tsuji, visited the primary site and two secondary sites on the Island of Hawaii (Figure 9).

The primary site on Niulii soils had jsut been obtained and fenced and preparations for cropping were about to commence. The team was able to examine a profile of the typical soil in a shallow cut.

Secondary sites on Niulii and Kukaiau soils had gone through one cropping cycle. The review team examined growing crops, weather instruments, and the irrigation system. Downy mildew infection of soybeans is an obvious problem.

A seminar was held at the University of Hawaii Hilo campus, led by Silva, Hurdus and Tsuji. A slide presentation reviewed the project design and gave an analysis of the first season's harvest results from the secondary sites.

The last day of the review was devoted to presentation of key aspects of project design, operation and application. Dr. G. Uehara discussed the principles and practices of technology transfer and Dr. H. Ikawa discussed problems of site selection related to soil classification and soil geography. Dr. J. A. Silva discussed design of the project and some of the theoretical problems and L. D. Swindale discussed use of project results in land-use planning, soil management, and land development for agricultural production.

Figure 9. First established site of Benchmark Soils Project on Kukaiau series, Honokaa, Hawaii. (L. D. Swindale and T. S. Gill, TAB/AID/W.)

The presentations were followed by a general discussion of several subjects. Some of the principal points were related to putting project results into use, training, laboratory analyses of soils, broadening the scope of the project, establishing sites at additional locations, need for administrative services, funding and formation of the advisory council.

The Team made several recommendations to TA/AGR Management for future action. These are the following.

(1) UH should correct inadequacies in administrative services and space.
(2) UH should develop a clearer job description of project workers.
(3) Project should add more soil types, and UH should review crops for the transfer experiments and the purpose and design of the management experiments.
(4) Project should develop a training component in the areas of soil classification, soil interpretation, and field plot experimentation.
(5) AID should extend the project for 3 years.
(6) UH should follow up the ICRISAT Seminar, and AID should support this endeavor.

Research Design

Several changes in the research approach have been made during the year based on experience in the project, recommendations of the AID Review team, and interest of the cooperating countries.

1. Soil Families

The governments of the Philippines and Indonesia expressed the desire that the project establish additional sites on soils which are more extensive and of importance in agricultural development. The AID On-site Review Team also recognized this need and recommended that the project include additional sites to represent more extensive soils of the host countries. These sites may be on Ultisols or Oxisols in the Philippines, Indonesia, and Africa. Therefore, the project has initiated soil survey investigations for a suitable soil family of Tropohumults or Tropudults in the Philippines by hiring a soil survey consultant who is presently in the Philippines. Also soil survey investigations for a soil family of the Tropohumults or Tropudults in Indonesia are scheduled to begin in October. Preliminary on-site soil survey investigations were conducted and government contacts established in Kenya, Cameroon, Tanzania and Rwanda.

It was decided at the annual meeting held in Puerto Rico that the minimum number of sites required to test the hypothesis of transferability for a soil family is eight. This was recommended by the statistical consultants for the University of Hawaii and University of Puerto Rico projects, Dr. F. B. Cady and Dr. L. Nelson, respectively.

2. Transfer Experiments

The matter of priority of crops grown in the transfer experiments was discussed at the Annual Meeting and it was decided that maize will continue

to be the primary test crop as recommended by the Workshop on Experimental Designs. Because of the interest in soybeans in some of the countries cooperating in the project, soybeans will be the crop of second priority in the transfer experiments. The third crop which had been considered was a root crop, but it was decided to drop this crop for the time being to prevent the possibility of its reducing the time and resources devoted to the maize and soybean crops and thus result in less complete data collection.

It was also decided to have two plantings of the transfer experiment at each site to assess a wider range of climatic conditions. One planting would be in the dry season and the other in the wet season.

3. Variety Experiments

Variety experiments will be installed at the primary site each season a transfer experiment is conducted. It was decided that the varieties included would be the top two leading local varieties and varieties being grown in transfer experiment at other sites in the soil family network. The variety experiment was modified to include a 2x2 factorial combination of the two variables being studied in the transfer experiment to screen varieties for their responsiveness to these variables. This should prevent the inclusion of a non-responsive variety in the transfer experiment. The levels of the two variables would be the -.85 and 0 (optimum) coded levels of these variables.

4. Management Experiments

Management experiments have been modified from the recommendation of the Workshop on Experimental Designs in the light of experience in cooperating countries and on the recommendation of the On-site Review Team. The original management experiments were to evaluate possible limiting factors, i.e., lime, irrigation, weed control, pest control, N, P, and K at two levels, with and without, to determine which of these required correction to achieve full productivity of the soil. It was felt that some of these factors would be obviously limiting from soil and climatic information of the area, while others could be assessed readily with chemical methods. Therefore, it was decided at the annual coordination meeting in Puerto Rico in August 1976, that management experiments will be used to obtain data on crop and soil management practices for the specific soils used. Particular attention will be given to costly inputs or high energy-using cultural practices as well as important farmer practices. The purpose will be to provide information on economic and efficient practices which local farmers might utilize and information for subsequent soil interpretation and land classification.

5. Training

The AID On-site Review Team recommended that a training component be implemented before the termination of the first three years to meet cooperating country needs for implementing a benchmark soils program of their own. The project was asked to expand and strengthen training in three particular areas: (1) intensive training in the use of the Soil Taxonomy; (2) training in use of soil resource data for soil interpretation and technology transfer and (3) training in field plot experimentation. The recommendation stressed that training be project-oriented and be carried out in the cooperating country to the greatest degree feasible.

Dissemination and Utilization

Involvement of Institution and Government of Philippines and Indonesia

1. Philippines

The Government of the Philippines through the Philippine Council for Agriculture and Resources Research (PCARR) formally agreed to cooperate with the Benchmark Soils Project with the signing of a memorandum of agreement covering activities of the project in the Philippines. Assistance in the form of personnel, facilities and funds was made available to Dr. B. G. Cagauan, Jr. Dr. A. A. Briones of UPLB was appointed as PCARR's representative and co-project leader.

The Bureau of Soils in Naga City, through agreements with PCARR, provided office and laboratory space until the project located its own office at the Zenith Apartments. Vehicles were also provided by the Bureau of Soils and Mr. Feliciano Garcia, regional director, at no cost to the project. Lease arrangements for land were made by PCARR with the Philippine Union College for the primary site and Isarog Farms, Inc. for both secondary sites.

PCARR released its full counterpart funds for the year and deposited them in a local bank in Naga City. The funds were administered by the co-project leader and were used to provide cash advances to pay wages of laborers while awaiting bank clearances of UH funds. PCARR was also instrumental in preparing the necessary documents needed to release project equipment and supplies from the customs and shipping of the same to Naga. Funds have been arranged for PCARR to purchase supplies that cannot be bought in Naga. PCARR made initial negotiations with AID Manila for a vehicle to be used in the project after consultation with Hawaii. USAID/Manila provided two vehicles that required some rehabilitation for project use.

The Bureau of Soils and PCARR provided transportation and helped prepare the itinerary of the UH and AID "teams" visit to the project in May.

Seeds that were used in the project were given by the Bureau of Plant Industry, Naga; the International Rice Research Institute, Multiple Cropping Divisions, UPLB's Department of Agronomy. The soybean inoculum was obtained from UPLB's Department of Soils.

The Bureau of Soils provided two key personnel in Mr. A. Dayot and Mr. S. Ballesteros to accompany Mr. A. Grunewald, UH soil survey consultant, in his field survey investigations for a suitable family of either Tropohumults or Tropudults. To date, six profile samples have been collected from 4 sites in Luzon and Mindanao. Results of that investigation will be submitted in the semi-annual report and annual report next year. Motor vehicles were provided through the courtesy of Mr. John Derting UNDP/FAO in Manila. It should be pointed out that the UNDP provided similar assistance to Mr. W. Hudnall during the initial soil survey in 1975.

Messers Dayot and Ballesteros received valuable experience and training in assisting Mr. Grunewald, a recent retiree from the SCS, USDA. A copy of Soil Taxonomy and various SCS publications on soil survey interpretation and land use planning were presented to the Bureau of Soils.

Involvement of PCARR with the project also resulted in the first graduate assistant, Mr. C. R. Escano. Mr. Escano, Senior Program Specialist at PCARR, will receive academic training toward a PhD degree in soil science. Emphasis of his study will be related to objective 3 of the contract in terms of soil classification and land use in LDC's.

2. Indonesia

The Soil Research Institute (SRI) of the Ministry of Agriculture, Government of Indonesia, expressed an early interest in the concept of the project in 1974 and has since agreed to cooperate. A formal Implementation Agreement was signed in April 1976 and is covered under the USAID Project Assistance to Agriculture Project No. 497-11-110-189. In it, personnel, facilities and funds were made available to assist in the establishment of the project.

Prior to the signing of the agreement, SRI did provide logistical support to allow Mr. W. H. Hudnall to complete the soil survey investigation of Hydric Dystrandepts and initiate investigations of Ultisols on Sumatra in August 1975. In April 1976, Mr. I P. G. Widjaja-Adhi of SRI was appointed as project coordinator in accordance to the Implementation Agreement. He accompanied Mr. A. R. Hurdus to the ITKA, PLP, Segunung, and Malabar sites and assisted in site establishment at the first three locations.

Mr. W. Tappan of USAID/Jakarta was extremely helpful in providing advice and guidance in carrying out project activities in Indonesia. He will also assist in obtaining customs clearance for us to ship equipment and supplies into Indonesia.

Dissemination of Project Information

1. ICRISAT Seminar

Proceedings of the ICRISAT Seminar will be published as a book and be made available to those in attendance and to others upon request. The book will be of considerable value in fields of soil science and land use planning in developing countries. The Keynote address, made by Dr. W. P. Panton of the International Bank for Reconstruction and Development, cited the use of national inventory of soils, or any other natural resource for facilitating the transfer of information and technology. Titles of 27 manuscripts to be included in the proceedings are listed in Appendix A.

Technical editor of the proceedings is Dr. L. D. Swindale. Ms. Wake Fujioka has been employed to do the copy editing. The proceedings will be published by the Publications and Information Office of the College of Tropical Agriculture, University of Hawaii. Publication costs are provided for under a special amendment to the 211-d grant No. AID/csd-2833 in the Department of Agronomy and Soil Science.

2. Fertilizer INPUTS Project

The Benchmark Soils Project through L. D. Swindale was invited to participate in the "Review Meeting of the Fertilizer INPUTS Project" sponsored by the East West Center (EWC) in Honolulu. Participants representing Africa, Asia, and Pacific basin countries agreed that the soil family concept would be an appropriate means of extending information

from their project to other locations as well as among cooperators within their project. Adoption of this concept would provide a basis for future comparison of results.

Several participants provided soil characterization and classification data for use in classifying their soils at the family category of Soil Taxonomy (Appendix E). The information provided will be combined with those obtained from participants of the ICRISAT seminar and placed in the University of Hawaii Soil Data Bank for storage, retrieval and dissemination.

3. South Pacific Regional Meeting

At the request of AID, L. D. Swindale participated in the Regional Technical Meeting on Soil Science and Land Use in Suva, Fiji. The conference commenced auspiciously when the Minister of Land and Mineral Industries, the Honorable S. N. Waqanivavalagi, in his welcoming address made special mention of his government's interest in the UH Benchmark Soil Project.

Throughout the meeting this same interest was shown by delegates from all countries and territories represented. The following recommendation was adopted by the meeting:

(a) Governments with important soils in the soil families covered by the Benchmark Soils Project should consider taking part in the program and thereby can draw on the wide range of knowledge of these soils now becoming available from other parts of the world;

(b) the concept of a regional Benchmark Soils Project on soils important to the region using crops should be accepted as the basis for a follow-up soils and land use program. This program should follow the soil classification and correlation phase, but initial planning could be started now in some countries. Governments should be requested to support this work.

4. Soil Taxonomy

Agriculture Handbook No. 436 entitled "Soil Taxonomy" was released for public distribution in 1976. Soil Taxonomy, a basic system of soil classification for making and interpreting soil surveys, is the key document upon which the Benchmark Soil Project's hypothesis for agrotechnology transfer rests. The project issued copies of Soil Taxonomy to key developing country scientists. All cooperating countries of the Benchmark project will be adequately supplied with copies of Soil Taxonomy and encouraged to use this document for soil resource inventory and agricultural planning for development.

Soil Taxonomy combines more than 30 years of research in soil science in a single document. It is a condensed statement of the state-of-the-art in soil science written in taxonomic language. The objective is to facilitate agricultural development through technology transfer by means of an internation system of Soil Classification.

5. Soil Survey Method

The classification of soils according to criteria set forth in Soil Taxonomy requires laboratory characterization of soil samples by standard procedures. These procedures are outlined in Soil Survey Investigations

Report No. 1, prepared by the Soil Conservation Service of the U.S. Department of Agriculture. Fifty copies of the report were obtained from the Soil Conservation Service and distributed to requesting developing country scientists. The Benchmark project will continue to inform potential users of new developments in soil resource inventory and if necessary, provide them with revisions or new issues as they are released.

6. Benchmark Newsletter

Publication of a monthly Philippine Benchmark newsletter was initiated in July 1976. The purpose of the Newsletter is to inform Philippine and U.S. agencies about project objectives and progress. The newsletter makes liberal use of photographs illustrating problems, breakthroughs, people and project sponsored events. It is too early to evaluate public response to the letter, but project personnel feel that publication of a newsletter in each cooperating country is essential. It is hoped that cooperating countries will pattern and develop their own projects along the lines of the Benchmark Soils Project for the purpose of accelerating agricultural development. As the agrotechnology transfer hypothesis comes closer to reality, the in-country newsletter will become the most effective means to inform decision makers of alternatives in country development.

Correspondence and Feedback

The following is a list of people and organizations who have corresponded with project personnel.

Name/Organization	Country	Purpose/Result
1. F. Iyamuremye	Rwanda	Provided with (1) HAES Achievement Analysis - 1975 (2) Papaya, passion fruit, and guava seeds for trial plantings
2. National Assn. of State Universities and Land Grant Colleges	U.S.	Provided with information on Benchmark Soils Project
3. C. Changprai	Thailand	Provided with copy of Soil Taxonomy
4. N. Yaibuathes	Thailand	Requested and provided with (1) U.S. Soil Taxonomy (2) Guide for Interpreting Engineering Uses of Soils, SCS
5. R. Uchida (AMFAC)	U.S.	Provided with P isotherm analysis for Pioneer Sugar (Maui)
6. J. Menyonga G. W. van Barnewald	Cameroon	Requested assistance in soil survey to locate possible Ultisols and Inceptisols sites
7. W. K. Gamble F. R. Moorman	Nigeria	Requested assistance to carry out field survey in West Africa on project behalf

Name/Organization	Country	Purpose/Result
8. N. N. Nyandat	Kenya	Requested possible assistance in carrying out field survey in East Africa
9. J. K. Gitau	Kenya	Provided with information on macadamia nuts
10. P. Rankin	New Zealand/ Fiji	Provided with soil and plant analysis to assist in calibrating their instrumental analysis
11. R. L. Beacher	USAID/Seoul	Provided with organic carbon and phosphorus data on soil samples sent to Hawaii
12. D. R. Mitchell	USAID/Manila	Provided with analytical soil chemical data for Iloilo project
13. F. R. Schwenke	USAID/Haiti	Provided with soil and water analysis for rice seed project

Appendix A lists the ICRISAT seminar participants and speakers with whom communication linkages were established.

Visitors

Visitors to project headquarters in Hawaii and to both experimental sites in Hawaii and the Philippines are listed in Tables 6 and 7.

Table 6. Hawaii Visitors

Name	Country	Date	Purpose of Visit	Result
C. Ladenheim USAID/TAB Program Planning and Utilization Office	U.S.	01/76	Discuss concepts and goals of Benchmark Soils Project	Visit with project personnel
J. B'dillo C. Seubert University of Puerto Rico	U.S. U.S.	02/76	Obtain on-site experience of site establishment and coordinate management practices to be employed	Establish firm linkage with UPR's and Brazil PR operations
Godofredo Alcasid Director Bureau of Soils, Philippines	Philippines	03/76	Inspect Benchmark sites on Hawaii Island; Meet with Project personnel to discuss Philippines operations; Meet with Soil Conservation Service on administration of that organization and its goals	Extension of Benchmark soils concept to establishment of experiment stations in Philippines
T. S. Gill W. M. Johnson H. Kugler F. Riggs AID On Site Review Team	U.S.	05/76	Inspect and review project operations in Hawaii	Recommendation to extend project to 1980

--continued

Table 6. Hawaii Visitors (Continued)

Name	Country	Date	Purpose of Visit	Result
INPUTS group East West Center	Various	06/76	Attend "Increasing Productivity Under Tight Supplies" (INPUTS) conference at EWC where L. D. Swindale informed group of project progress	Visit to experimental site; Assistance in classifying soils at family level for information transfer within INPUTS group and to Benchmark Project
L. Frederick Microbiologist AID, TAB/AG	U.S.	08/76	Inspect Benchmark site and observe soybean, forage production	Field trip to Kukaiau and Halawa site; visit to Mealani and Kohala
Djoko Santoso Justina Sri Gedjer Widjaja-Adhi USAID fellows	Indonesia	08/76	AID sponsored training program; Discuss concepts of project and plans to implement Indonesia operation. Widjaja-Adhi previously appointed as Project Coordinator from the Soil Research Institute	Visit experiment sites to observe corn and soybean plots; Laboratory methods to determine fertilizer inputs
G. Amadee Cal Poly San Luis Obispo	U.S.	09/76	Collection of soil monoliths for instruction; Meet Project personnel to discuss project concept.	Visit to Benchmark sites; Observe and assist in harvest operations
Joseph Madamba Director General Philippine Council for Agriculture and Resources Research (PCARR)	Philippines	09/76	Consult with project personnel and coordinate project efforts in Philippines	Invitation to attend 2nd National Research Conference; Develop course content of Agrotechnology Transfer course

Table 7. Philippines Visitors

Name	Country	Date	Purpose of Visit	Result
A. R. Hurdus	U.S.	04/76	Inspect primary site at PUC	Orientation of Philippine operations
L. D. Swindale J. A. Silva UH/BSP Hawaii	U.S.	05/76	Prepare for AID on-site review; Inspect sites with Review team	Commendation and continuation of project activities
T. S. Gill H. F. Kugler W. M. Johnson F. Riggs USAID/TAB/W On-Site Review Team	U.S.	05/76	Inspect and review project operations in the Philippines	Recommendation to extend contract to 1980
G. Alcasid F. Garcia Bureau of Soils E. Pantastico PCARR	Philippines	05/76	Inspect project sites and operations	Assistance in implementing project objectives
Regional Research Staff Bureau of Soils, Bicol	Philippines	06/76	Provide orientation on project methodologies and objectives	Involvement of various staff to assist project
Domingo Tabbal and class Camarines Sur Agricultural College	Philippines	08/76	Provide orientation of project	Dissemination of project information

Statement of Expenditures and Obligations

The following are the line item expenditures and obligations incurred by the project from July 1, 1975, to September 30, 1976.

Line Item	Expenditures/Obligations
Salaries and Wages	$114,902
Fringe Benefits	14,268
Consultants	-0-
Equipment, Supplies and Services	123,335
Vehicles	-0-
Freight	5,693
Travel and Subsistence	71,657
Publications	950
Indirect Costs	51,887
Philippines*	21,718

(*Funds for use in the Philippines)

Line item designated for travel and subsistence is one that was underestimated for the life of the contract. As of September 30, 1976, expenditures for travel the first 2 years and 4 months have exceeded the total budgeted by $5,000. Underestimates were due to the following:

(1) U.S. Domestic Travel

(a) Inter-island travel between islands in Hawaii State was much greater than anticipated primarily because the initial soil family selected is located on the Island of Hawaii. The employment of an agricultural field technician and casual labor on the Island of Hawaii should reduce both the number of trips and personnel required from Honolulu.

(b) Annual on-site coordination meeting with Puerto Rico involving project personnel as well as 3 principal investigators resulted in added costs to fly the Project Associate, Hawaii agronomist, Philippines Project and Co-Project leader, and Indonesian Project Coordinator to Puerto Rico.

(2) International Travel

(a) Additional funds not previously budgeted were used to bring the Project Leader and Co-Project Leader from the Philippines for two and one month training, respectively.

(b) Funds were also required for travel to complete negotiations to finalize country agreements in Indonesia and the Philippines which were not readily forseen in the original contract proposal.

Funds for various equipment have not been expended thus far pending clearance from the Contract Management Office/TAB to purchase or lease. This is also true for vehicles.

Salaries and wages, especially for foreign sites, will be expended with the hiring of a Project Leader for Indonesia.

It should be noted that the expenses incurred thus far do not include operational expenses for Africa.

Field operations in Africa have been delayed in order that project resources and personnel can effectively implement site establishment in the Philippines and Indonesia. Added logistical and personnel support for soil survey investigations and site establishment will be required.

Work Plan and Budget Forecast

A network of benchmark soil families will have been established in Hawaii, Indonesia, the Philippines and one country in Africa during the period October 1, 1976 to September 30, 1977. Two different soil families will have been included in each country. Collection of data to test the various hypotheses of the project will continue and analysis of results will have been made. The project will also continue to assist tropical countries in classifying, storing and disseminating soils and land use data. Through seminars, conferences, and courses, linkages already established will be strengthened and new ones established.

Anticipated Accomplishments by October 1977

a. Publish proceedings of Workshop on Experimental Design

b. Publish proceedings of seminar on "Uses of Soil Survey and Classification in Planning and Implementing Agricultural Development in the Tropics" held in Hyderabad, India 1976.

c. Install nine each of wet and dry season transfer experiments in Hawaii, the Philippines and Indonesia on thixotropic, isothermic family of Hydric Dystrandepts.

d. Install 3 each of wet and dry season variety experiments at primary sites in Hawaii, Indonesia and Philippines on Hydric Dystrandepts.

e. Install one set of management experiments at the primary sites in Hawaii, Philippines, and Indonesia on Hydric Dystrandepts.

f. Conduct soil survey investigation for soil family of either Tropohumults or Tropudults in Indonesia and Philippines.

g. Conduct course in "Utilization of Agrotechnology Transfer for Country Development" at Los Banos, Philippines; Publish course material.

h. Analyze experimental data and program modifications in design if necessary for presentation at annual coordination meeting between UH and UPR to be held in the Philippines.

i. Select Project Leader for Indonesia and Africa.

j. Select second graduate fellow from the Philippines.

k. Select first graduate fellow from Indonesia.

l. Continue establishment of research network of benchmark soils throughout the tropics, and advise cooperating countries on types and designs of experiments.

m. Sign agreements and establish sites on Tropeptic Eutrustox in Hawaii.

n. Establish 6 to 8 sites on Tropohumults or Tropudults in Philippines, Indonesia and/or Hawaii.

o. Arrange agreement with IITA to conduct preliminary soil survey investigations in West Africa.

Budget Forecast

The budget forecast for the period October 1, 1976 to September 30, 1977 is listed below. The present contract expires on May 31, 1977. A request to extend the contract period to September 30, 1977 with the indicated request for additional funds has been submitted to AID/W for approval and funding.

Budget for the Period from October 1, 1976 to September 30, 1977.

Item	Balance Remaining	Request for Additional Funds	Projected for 10/01/76-09/30/77
Salaries	$229,632	$ 85,746	$315,378
Fringe Benefits	11,972	14,358	26,330
Consultants	23,800	1,200	25,000
Equipment, Supplies & Services	255,874	67,560	323,434
Vehicles	35,500	0	35,500
Freight	23,282	6,000	29,282
Travel and Subsistence	14,602	47,220	61,822
Publications and Subscriptions	27,696	0	27,696
Indirect Costs	88,480	12,631	101,111
TOTAL	$710,838	$234,715	$945,553

Appendix A: A Seminar on Uses of Soil Survey and Classification in Planning and Implementing Agricultural Development in the Tropics

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List of Papers

"Keynote Address", William Panton, International Bank for Reconstruction and Development, Washington, D.C., U.S.A.

"Modern Soil Classification Fundamentals", W. M. Johnson, Soil Conservation Service, USDA, Washington, D.C., U.S.A.

"Some Fundamentals of Soil Classification - U.S. Soil Taxonomy", F. H. Beinroth, University of Puerto Rico, Mayaguez, Puerto Rico, U.S.A.

"The Occurrence and Significance of Climatic Parameters in the U.S. Soil Taxonomy", H. Ikawa, University of Hawaii, Honolulu, Hawaii, U.S.A.

"Agro-technology Transfer and the Soil Family", G. Uehara, University of Hawaii, Honolulu, Hawaii, U.S.A.

"The Contribution of Soil Survey Interpretation in Land Appraisal", A. J. Smyth, Ministry of Overseas Development, Surbiton, Surrey, United Kingdom.

"Soil Survey, Classification, and the Transfer of Agricultural Information", A. W. Moore, Cunningham Laboratories, CSIRO, Brisbane, Australia.

"Developments in Soil Surveys for Improved Rubber Production in Peninsular Malaysia", Chan Heun Yin, Rubber Research Institute, Kuala Lumpur, Malaysia.

"Land Evaluation for Agricultural Land Use Planning", J. Bennema, University of Agriculture, Wageningen, Netherlands.

"Use of Soil Data in Land Use Planning - Techniques for Displaying Soil Data to Planners and Decision Makers", G. A. Nielsen, Montana State University, Bozeman, Montana, U.S.A.

"Uses of Soil Resources Data in Land Use Planning", M. Vakilian, Soil Institute of Iran, Teheran, Iran.

"Use of Soils Data in Land Use Planning - A Case Study from Karnataka (India)", R. S. Murthy, All India Soil and Land Use Survey, New Delhi, India.

"Use of Soils Data in Regional and National Development", M. L. Dewan, Regional Bureau for Asia and Far East, F.A.O., Rome, Italy.

"Use of Soils Data in National and Regional Agricultural Development in Ghana", H. Obeng, Soil Research Institute, Kwadaso-Kumasi, Ghana.

"Use of Soil Data in Regional and National Development - A Case Study of Tropical Alfisols from Sri Lanka", C. R. Panabokke, Central Agricultural Reaearch Institute, Peradeniya, Sri Lanka.

"Use of Soil Survey Data for Agricultural Development in Korea: Land Selection for the Introduction of Newly-Bred High Yielding Rice Variety, "Tongil", Yong Hwa Shin, Institute of Agricultural Science, Suweon, Korea.

"Interpretation of Small and Large Scale Maps for Land Use Planning in Semi-Arid and Arid North Indian Plains", H. S. Shankaranarayan, Indian Agricultural Research Institute, New Delhi, India.

"A Need for an International Research and Technology Network in Tropical Soils", G. B. Baird, United States Agency for International Development, Washington, D.C., U.S.A.

"A Soil Research Network Through Tropical Soil Families", L. D. Swindale, University of Hawaii, Honolulu, Hawaii, U.S.A.

"Soil and Water Management in the Semi-Arid Tropics", B. A. Krantz and Associates, ICRISAT, Hyderabad, India.

"Soil and Water Management in Rain-Fed Agriculture", Dr. Ch. Krishnamoorthy, All India Coordinated Research Project for Dryland Agriculture, Hyderabad, India.

"Use of Soils Information for Planning Agricultural Development in the Semi-Arid Tropics", B. A. Krantz and Associates, ICRISAT, Hyderabad, India.

"Soil Taxonomy - Indian Style", T. R. Srinivasan, Indian Photo-interpretation Institute, Dehra Dun, India.

"Translocation of Clay in Soils of NW India and Implications Involved in Using This Criterion for Classifying Soils", J. L. Sehgal, Punjab Agricultural University, Ludhiana, India.

"Soil Survey Interpretations for Watershed Development Programs", Y. P. Bali & Associate, All India Soil and Land Use Survey, Department of Agriculture, New Delhi, India.

"A New Approach in the Study of Vertisol Morphology", J. C. Bhattacharjee & Associates, Directorate of All India Soil and Land Use Survey Regional Centre, Nagpur, India.

"Agricultural Land Utilization and Land Quality", F. R. Moormann, International Institute for Tropical Agriculture, Ibadan, Nigeria.

Appendix B: Project Publications

A Soil Research Network Through Tropical Soil Families
L. D. Swindale

A proposal is made to establish a soil research network throughout the tropics based upon the soil family classification of the U.S. Soil Taxonomy. The network would be voluntary; dependent upon the free association and contributions of co-operating institutions. The University of Hawaii would be able to support the establishment and operation of the network through its Benchmark Soils Projects and its Bibliographic Information Retrieval Service for Tropical Agriculture. The University of Puerto Rico through its Benchmark Soils Project may also provide support.

The network will improve communication, stimulate co-operative research and training. Its usefulness to any country will depend in large part on the contributions that country makes, and the extent to which it tries to use the network to service its own needs. Mutual aid is the orientation and underlying philosophy.

Paper presented at South Pacific Commission Regional Technical Meeting on Soil Science and Land Use, Suva, Fiji, July 20-26, 1976, and at the seminar on "Uses of Soil Survey and Classification in Planning and Implementing Agricultural Development in the Tropics," Hyderabad, India, January 18-22, 1976.

Agrotechnology Transfer and the Soil Family
G. Uehara

Agricultural research and experience which are transferred to widely separated parts of the world have a better chance of succeeding if the transfer is made to similar soils. Soils which belong to the same phase of a soil family according to criteria set forth in the U.S. Soil Taxonomy are considered to be sufficiently similar to enable planners to transfer agrotechnology from one region to another. To achieve this goal, a national soil survey based on a comprehensive soil classification system is necessary. The soil survey can (1) be used to assess land use potential and (2) serve as a basis for accelerated, low cost national development through transferred technology.

Paper presented at seminar on "Uses of Soil Survey and Classification in Planning and Implementing Agricultural Development in the Tropics," Hyderabad, India, January 18-22, 1976.

The Occurrence and Significance of Climatic Parameters in the U.S. Soil Taxonomy
H. Ikawa

Climatic parameters such as soil moisture and soil temperature influence the properties of soils and ultimately the utilization of soils. They are expressed at the various categorical levels above the series level, especially from the suborder down to the family. At the suborder category, the climatic parameters can be used to prepare a small scale map to obtain the distribution of soils for general interpretation. At the family category, the soil temperature regime in particular can be used to relate to plant growth. Thus, climatic parameters are important features of Soil Taxonomy and together with other properties contribute to a system of soil classification that can be used for technology transfer and land use planning and development.

Paper presented at seminar on "Uses of Soil Survey and Classification in Planning and Implementing Agricultural Development in the Tropics," Hyderabad, India, January 18-22, 1976.

Appendix C: Drip Irrigation—Parts List for a Transfer Experiment

A. Main Line

For a rectangularly-shaped, 250' x 400' size 1 hectare transfer experimental site, a minimum of 1,500 feet of PVC pipe is required for the main line. This does not include the running footage for the conveyance system required to transport water from a source to the site. The size of pipe will need to be determined a priori from the slope and grade of the site.

Supply List:

1. Coupling, SxS, PVC Sch. 40
2. 90° Elbows, Sxs, Sch 40
3. Tee, SxSxS, Sch 40
4. Male adapters, Sch 40
5. Female adapters, Sch 40
6. Gate Valves, brass
7. Cap, T, Sch 40

B. Main to Sub-Main

The following parts list represents the couplings and accessories necessary to connect the main line to sub-main for the drip irrigation system for a transfer experiment.

Supply List:

		Minimum required
1.	Pressure gauge, 1/4 NPT, 0-30 psi	3
2.	1/2" Gate Valve, plastic, female threaded	3
3.	1/2" Male Adapters, Sch. 40	9
4.	1/2" x 1/4" Bushing, SxT, Sch 40	3
5.	1/2" Drain Valve	3
6.	1/2" Tee, TxTxT, Sch 40	3
7.	1/2" Tee, SxSxT, Sch 40	3
8.	1/2" Nipple, 2"	3
9.	1/2" 90° Elbow, SxS, Sch 40	3
10.	1/2" Female Adapter, Sch 40	3
11.	1/2" Insert Male Adapters	3
12.	Tee 1" x 1" x 1/2", SxSxS, Sch 40	3
13.	2" Y-Filter, reduced to 1", SxS fitting	3

For a complete system for a 1 hectare site, the minimum number of parts is obtained by multiplying by 6.

14. Other Supplies

a. PVC Cement
b. PVC Primer
c. De-burrer
d. 2-10" Pipe Wrenches
e. 1-12" Adjustable Wrench
f. 1-10" Adjustable Wrench
g. 1-Hacksaw
h. Teflon Tape
i. 1" Pressure Regulator

C. Laterals

The polyethylene pipes with orifices for emitting water currently in use by the project is known commercially as the 1/2" Anjac Biwall Tubing, Type B. The spacing of the outer orifices ranges from 12, 18 or 24 inches with water supply orifices within the larger tube spaced at 60", 72" or 84".

Because of supply shortages, the 12 x 60 Anjac Biwall is in use on our Hawaii sites. The 18 x 72 was preferred and recommended by the Agricultural Engineers. Emitter or orifice spacing should be chosen as a function of planting density and water distribution characteristics of the soil.

Parts List:

1. 1,200 feet of laterals for one plot - or 7,200 feet for 6 plots with 3 replicates each.
2. 1,250 feet of 1/2" thin walled (1/16") polyethylene tube to be used with #3 and #4.
3. 1/2" Lok-sleeve - Tee 348
4. 1/2" Lok-sleeve - Elbows 12
5. 1/2" Lok-sleeve - Male Adapter
6. 1/2" Cap, Threaded PVC

Laterals were placed at intervals equivalent to row spacing to insure an adequate supply of water during the early growing stages of transfer crops. (Fig. 1) This is especially true until the crop canopy is fully developed. On the Hydric Dystrandepts, irrigation time per crop was approximately 4 to 6 hours initially. Once the wetting envelope developed, irrigation time was shortened to an hour. Each orifice or emitter of the Anjac Biwall tubing delivered approximately 0.06 gpm at 10-15 psi. Laterals were normally installed normal to the greatest slope to prevent an uneven distribution of pressure and water emission along the length of the lateral.

A filtration system would be required at sites where natural or man-made reservoir water is used in order to prevent or reduce plugging of the drip orifice. A fine screen filter (200 mesh) that can be back-flushed for removal of coarse materials has been adequate at our secondary site in Kohala (Halawa). The filter was installed in the main line before the sub-main. Water filters (Wye filters) with screens are also normally installed as a general practice between the main line and sub-main. To minimize clogging problems due to algal or fungal growth, the laterals are flushed frequently by opening the flush valves connected at the end of each lateral after irrigation is completed.

Appendix D: Meteorological Instrumentation

In the test of our hypothesis of the transferability of agrotechnology, the Experimental Design Workshop (1974) recommended a monitoring of the following climatic variables:

1. air temperature
2. rainfall
3. relative humidity
4. solar radiation
5. wind speed
6. wind direction
7. soil temperature

There will be no distinction between primary and secondary sites in terms of meteorological instrumentation. This is a decision reached at the annual coordination meeting with Puerto Rico and is a change from what was recommended at the 1974 workshop. All of the instruments to be installed are battery-operated. The following is a list of instruments that have been purchased for installation at all sites and are shown in Figures 10 and 11.

Instrument	Climatic Variables
1. Mechanical weather station (Model 755W - Weathermeasure Corp., Sacramento, Calif.)	temperature, relative humidity, rainfall, wind speed and wind direction

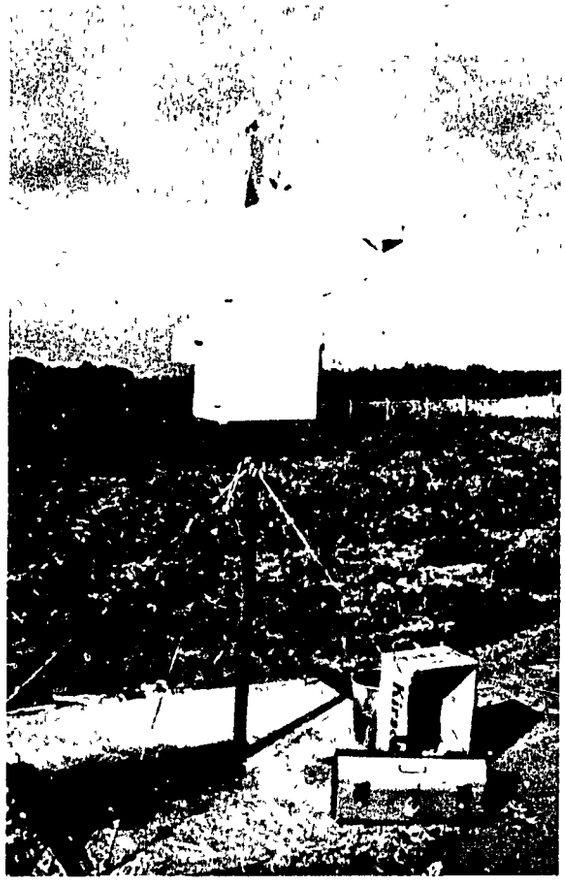


Figure 10. Mechanical weather station, Kukaiau, Hawaii.

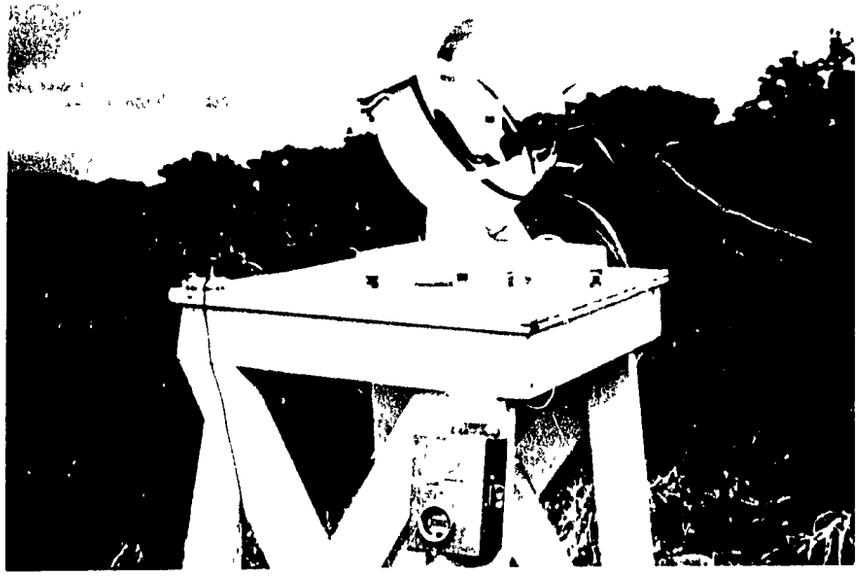


Figure 11. Wig-wag radiometer and Lambda pyranometer sensor and integrator to measure incoming solar radiation, Niulii, Hawaii.

2. Pyranometer Sensor and Integrator (Models LI-200S and LI-500, Lambda Instruments, Lincoln, Nebraska) — solar radiation

3. Tele-Thermometer and Thermistor (YSI-Model 44, Yellow Springs Instruments, Yellow Springs, Ohio) — soil temperature

Hygrothermographs and rain gauges will be used as back-up instruments, if needed.

Solar radiation was initially measured and recorded by a wig-wag radiometer (exclusive patent rights to the Hawaiian Sugar Planters' Association). However, the increased cost per unit and the minimum order required to manufacture the wig-wag were not favorable. Furthermore, the necessity of having to ship such a large and fragile instrument for annual servicing detracted its value for project use.

Pyranometer sensors and integrators were purchased from Lambda Instruments for testing in Hawaii. Accuracy of nearly 1 to 1 ratio with Eppley pyroheliometers, cost and ease of shipment and installation were advantages in procuring such a sensor over others.

Soil temperature measurements have not been made to date. Thermistors will be set at all sites at selected depths recommended by the World Meteorological Organization (WMO) at a meeting on "Meteorology and the Maize Crop" attended by Tsuji. Although the role of soil temperature may not be as exaggerated as in temperate regions, it should provide information on temperature effects during germination and during the various stages of crop development. Furthermore, soil temperature measurements at the 50 cm depth will be used to substantiate the temperature regimes--isohyperthermic, isothermic, or isomesic--of soil families.

Appendix E: Classification of the Agricultural Research Station Soils in U.S. Soil Taxonomy System

THAILAND

Research Station	Tentative Classification	Comments
Rice Research Station Bangkhem, Bangkok	Typic Tropaquept very fine, mixed, hyperthermic	
Rice Research Station Chai Nat Province	Aeric Tropaquept fine, mixed, hyperthermic	
Rice Research Station Khon Kaen Province	Typic Paleaquult fine-loamy, mixed, hyperthermic	
Rice Research Station Sakon Province	Typic Paleaquult fine-loamy, mixed, hyperthermic	
Rice Research Station Phan, Chiang Rai Province	Typic Tropaqualf fine, kaolinitic, hyperthermic	
Rice Research Station Phan Chiang Rai Province	Typic Paleaquult very fine, kaolinitic, hyperthermic	
Rice Research Station Phimai, Nakhon Ratchasima	Vertic Tropaquept very fine, montmorillonitic, hyperthermic	
Rice Research Station San Pa Tong, Chiang Mai Province	Typic Tropaqualf fine, kaolinitic, hyperthermic	
Upland Crops Research Station Chai Nat	Typic Ustifluvent fine-loamy, mixed hyperthermic	
Upland Crops Research Station Chai Nat	Aeric Tropaquept fine, mixed, hyperthermic	
Upland Crops Research Station Tha Khli, Nakhon Sawan Province	Typic Pellustert fine, montmorillonitic, isohyperthermic	
Upland Crops Research Station Tha Khli, Nakhon Sawan Province	Typic Calciustoll fine, montmorillonitic, isohyperthermic	
Upland Crops Research Station Khon Kaen Province	Typic Paleustult fine-loamy, mixed, isohyperthermic	
Upland Crops Research Station Khon Kaen Province	Typic Haplustox fine-loamy, mixed (oxidic), isohyperthermic	The mineralogy of the control section needs to be confirmed.
Upland Crops Research Station Loei Province	Typic Paleustult fine, kaolinitic, isohyperthermic	
Upland Crops Research Station Mae Jo, Chiang Mai Province	Ustoxic Dystropept coarse-loamy, silicious, isohyperthermic	
Upland Crops Research Station Mae Jo, Chiang Mai Province	Typic Paleustult fine-loamy, mixed, isohyperthermic	
Upland Crops Research Station SRI Samrong, Sukhothai Province	Udic Haplustalf fine-loamy, mixed, isohyperthermic	
Upland Crops Research Station Huai Pong, Rayong Province	Typic Paleudult fine, kaolinitic, isohyperthermic	
Upland Crops Research Station Huai Pong, Rayong Province	Typic Quartzipsamment sandy, isohyperthermic	
Fruit Trees Research Station Thon Buri, Bangkok	Typic Tropaquept very fine, mixed, hyperthermic	
Fruit Trees Research Station Sawi, Chumphon Province	Typic Paleudult loamy-skeletal, mixed, isohyperthermic	
Fruit Trees Research Station Prieu, Chanthaburi Province	Typic Paleudult fine (fine-loamy), kaolinitic, isohyperthermic	The texture of the control section needs to be confirmed.

THAILAND Research Station	Tentative Classification	Comments
Rubber Research Station Kohong Songkhla Province	Typic Paleudult fine-loamy, mixed, isohyperthermic	
Rubber Research Station Krabi Province	Rhodic Paleudult very fine, kaolinitic, isohyperthermic	
Rubber Research Station The Lang, Phuket Province	Typic Paleudult fine, kaolinitic, isohyperthermic	
Rubber Research Station Tha Kanthuri Surat Thani Province	Typic Paleudult fine-loamy, mixed, isohyperthermic	
Soil Conservation Center Chanthaburi Province	Typic Paleudult loamy-skeletal, mixed, isohyperthermic	
Soil Conservation Center Chiang Mai Province	Ustoxic Dystropept coarse-loamy, silicious, isohyperthermic	
Soil Conservation Center Chiang Mai Province	Plinthic Paleaquult fine-loamy, mixed, isohyperthermic	
Soil Conservation Center Khon Kaen Province	Typic Haplustox fine loamy, mixed, isohyperthermic	
Soil Conservation Center Khon Kaen Province	Typic Paleustult fine-loamy, mixed, isohyperthermic	
Soil Conservation Center Nan Province	Typic Haplustox fine-loamy, mixed, isohyperthermic	
Soil Conservation Center Nan Province	Typic Paleustult fine-loamy, mixed, isohyperthermic	
Soil Conservation Center Nan Province	Typic Paleustult loamy-skeletal, mixed, isohyperthermic	
Soil Conservation Center Pak Chong, Nakhon Ratchasima Province	Typic Paleustult very fine, kaolinitic, isohyperthermic	
Soil Conservation Center Samut Sakhon Province	Typic Tropaquept fine, mixed, hyperthermic	
Soil Conservation Center Samut Sakhon Province	Hydric Tropaquept fine, mixed, hyperthermic	

PAKISTAN Series	Tentative Classification	Comments
Lyallpur	Typic Camborthid loamy, --, hyperthermic	Mineralogy data required.

SUDAN Series	Tentative Classification	Comments
Gezzira	Entic Chromusterts fine, montmorillonitic, isohyperthermic	
Yambio		Insufficient data
Kenana	Typic Chromustert very-fine, montmorillonitic, isohyperthermic	
Hudeiba	Typic torrert fine, montmorillonitic, hyperthermic	

RWANDA Isar	Tentative Classification	Comments
Rubona Profile -- 1	Sombriustox, clayey, kaolinitic, isothermic	Oxic horizon and mineralogy need to be confirmed, mollic, oxic, sombric horizons.
Rubona Profile -- 2	Sombriustox clayey, kaolinitic, isothermic	Umbric, oxic, sombric horizons
Rubona Profile -- 3	Sombritropept clayey, --, isothermic	Mollic, sombric horizons umbric, oxic, sombric horizons.
Rubona Profile -- 4	Sombriustox clayey, --, isothermic	Umbric, oxic, sombric horizons.
Rubona Profile -- 5	Sombriustox, clayey, --, isothermic	Mollic, oxic, sombric horizons.
Rubona Profile -- 6	Sombriustox clayey, --, isothermic	Presence of oxic horizon needs to be confirmed, mollic, oxic, sombric horizons.
Karama Profile -- 1	Typic Eutrustox clayey, kaolinitic, isohyperthermic	Presence of Oxic horizon needs to be confirmed, mollic, oxic horizons.
Karama Profile -- 2	Udic Chromustert clayey, montmorillonitic, isohyperthermic	The cracks are assumed to remain open for 90 to 150 cumulative days.
Karama Profile -- 3	Udic Urgiustoll clayey, kaolinitic, isohyperthermic	Mollic, argillic horizons.
Rwerere Profile -- 1	Ustoxic Tropohumult clayey, kaolinitic, isothermic	Presence of argillic horizons need to be confirmed, umbric, argillic horizons.
Rwerere Profile -- 2	Ustoxic Tropohumult clayey, kaolinitic, isothermic	Weatherable minerals are assumed to be greater than 10%, mollic, argillic horizons.
Rwerere Profile -- 3	Ustoxic Tropohumult clayey, kaolinitic, isothermic	Presence of argillic horizon needs to be confirmed, mollic, argillic horizons.

Based on the data provided, the soils of the agricultural centers of Rwanda are classified up to the soil family level. The mineralogy of some soils have either to be determined or confirmed. The assumptions made, requirements of additional information and diagnostic horizons are indicated under the comments column.

KENYA Research Station	Tentative Classification	Comments
Gitumba Station Thika	Oxic Dystrandept Medial isothermic	This soil is assumed to have a bulk density value of 0.85 and/or dominated by pyroclastic materials (greater than 60%); umbric, cambic horizons.
Embu Station Embu	Udic Argiustoll clayey, kaolinitic, isohyperthermic	Mollic, argillic horizons
Murinduko Station Meru	Ustoxic Dystropept clayey, kaolinitic, isohyperthermic	Ochric, cambic horizons
Horticulture Station Thica & Kuriaha Substation	Typic Eutrustox clayey, kaolinitic, isothermic	Mollic, oxic horizons
Katumani Station Machakos	Ustollic Camborthid clayey, kaolinitic, isothermic	Mineralogy of the control section needs to be checked. Ochric, cambic horizons.

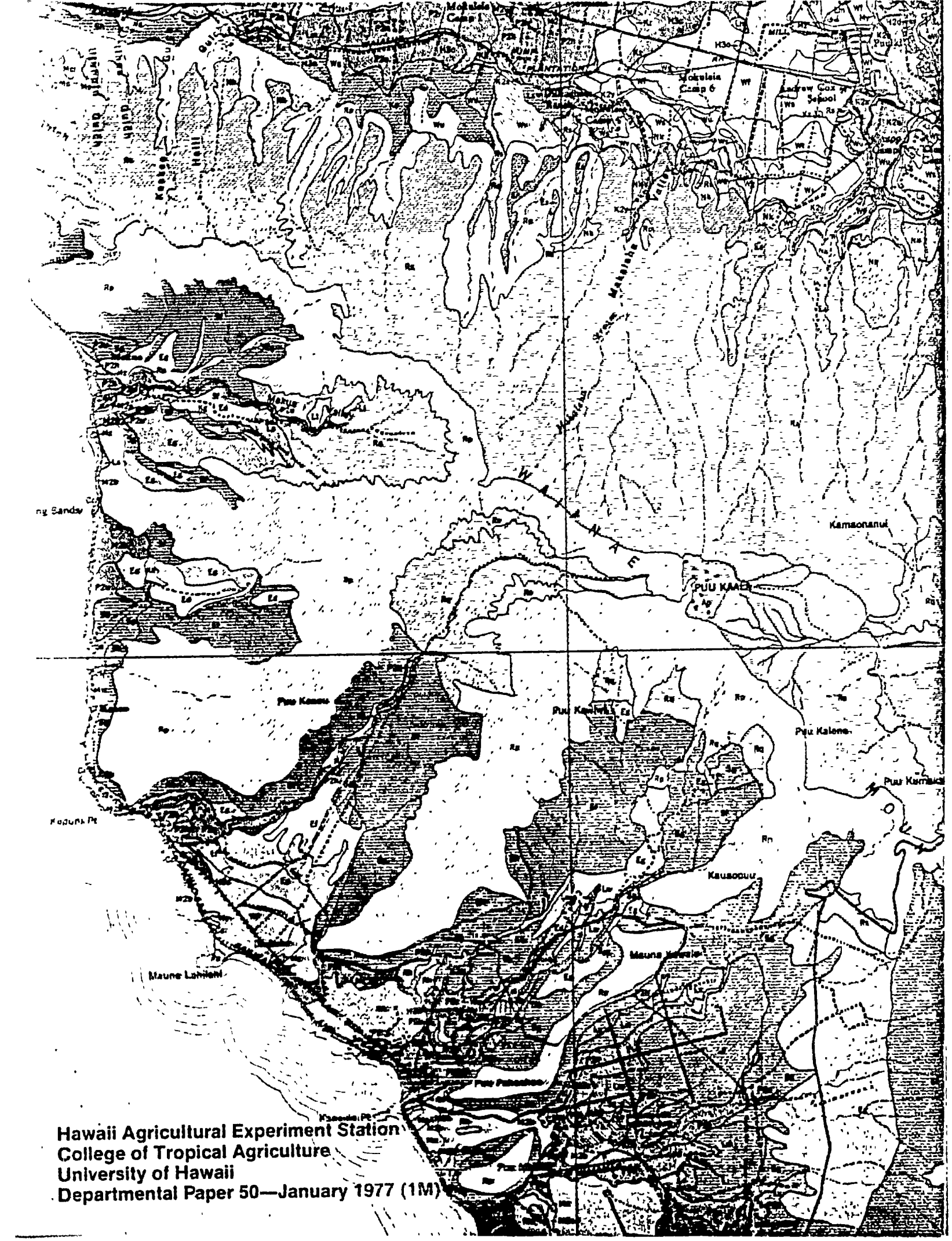
KENYA Research Station	Tentative Classification	Comments
National Agricultural Labs Nairobi	Ustollic Palehumult clayey, kaolinitic, isohyperthermic	Umbric, argillic horizons
Plant Breeding Station Njoro	Xeric Eutrandept Medial Isothermic	This soil is assumed to have a bulk density value of 0.85 or less and/or dominated by pyroclastic materials (more than 60%). Mollic, cambic horizons.
Pyrethrum Station Molo	Typic Eutrandept Medial, isomesic	This soil is assumed to have a bulk density value of 0.85 or less and/or dominated by pyroclastic materials (more than 60%). Mollic, cambic horizons.
Nyanza Agricultural Station Kisii	Typic Tropohumult clayey, kaolinitic, isothermic	Ochric, argillic horizons
Sugar Station Kibos	Typic Pellustert clayey, montmorillonitic, isohyperthermic	Mollic horizon
Western Agricultural Station Kakamega	Typic Paleustoll clayey, kaolinitic, isothermic	Mollic horizon
National Agricultural Station Kitale: Type - 1	Typic Haplustox clayey, kaolinitic, isothermic	Weatherable minerals are assumed to be less than 3%. Umbric, oxic horizons.
National Agricultural Station Kitale: Type - 2	Ustoxic Humitropept clayey, kaolinitic, isothermic	Umbric, cambic horizons

NIGERIA Series	Tentative Classification	Comments
Ondo	Grossarenic Plinthic Paleustalf sandy over clayey, mixed, isohyperthermic	Ochric, argillic horizons
Alagba	Oxic Paleustalf clayey, kaolinitic, isohyperthermic	Ochric, argillic horizons
Okpanam	Oxic Paleustult clayey, kaolinitic, isohyperthermic	Ochric, argillic horizons
Fagbo	Oxic Tropudalf clayey, mixed, isohyperthermic	Ochric, argillic horizons

The soil temperature regime and the presence of clay skins or cutans need to be confirmed. The data on soil physical, chemical and mineralogical properties as well as soil temperature and moisture regimes are needed to classify the soils of Araromi, Kulfo, Awode and Atan. The information on CEC, exchangeable bases, extractable aluminum, mineralogy, soil temperature and moisture data are required to classify the series Afomu-Ibadan, Gambari, Iwo, Majeroku and Egbeda.

ETHIOPIA Profile	Tentative Classification	Comments
2	Argiustoll	Clay skins or cutans are assumed to be present, mollic, argillic horizons.
P 13	Fluvent	
P 37	Typic Pellustert	
P 15	Fluvent	
P 16	Humult	Clay skins or cutans are assumed to be present.
P 27	Oxisol	
P 4	Typic Paleudoll	
P 44	Typic Paleudoll	Moist chroma is assumed to be less than 4. The moisture regime is assumed to be udic.
P 46	Typic Paleudoll	The moisture regime is assumed to be udic.
P 32	Fluvent	
P 35	Fluvent	
P 21	Typic Pellustert	
P 28	Typic Chromustert	
P 18	Typic Pellustert	
P 26	Entic Chromustert	
P 29	Typic Chromustert	
P 31	Entic Chromustert	

The data on soil mineralogy, soil moisture regime and soil temperature are required to classify these soils to the family level.



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