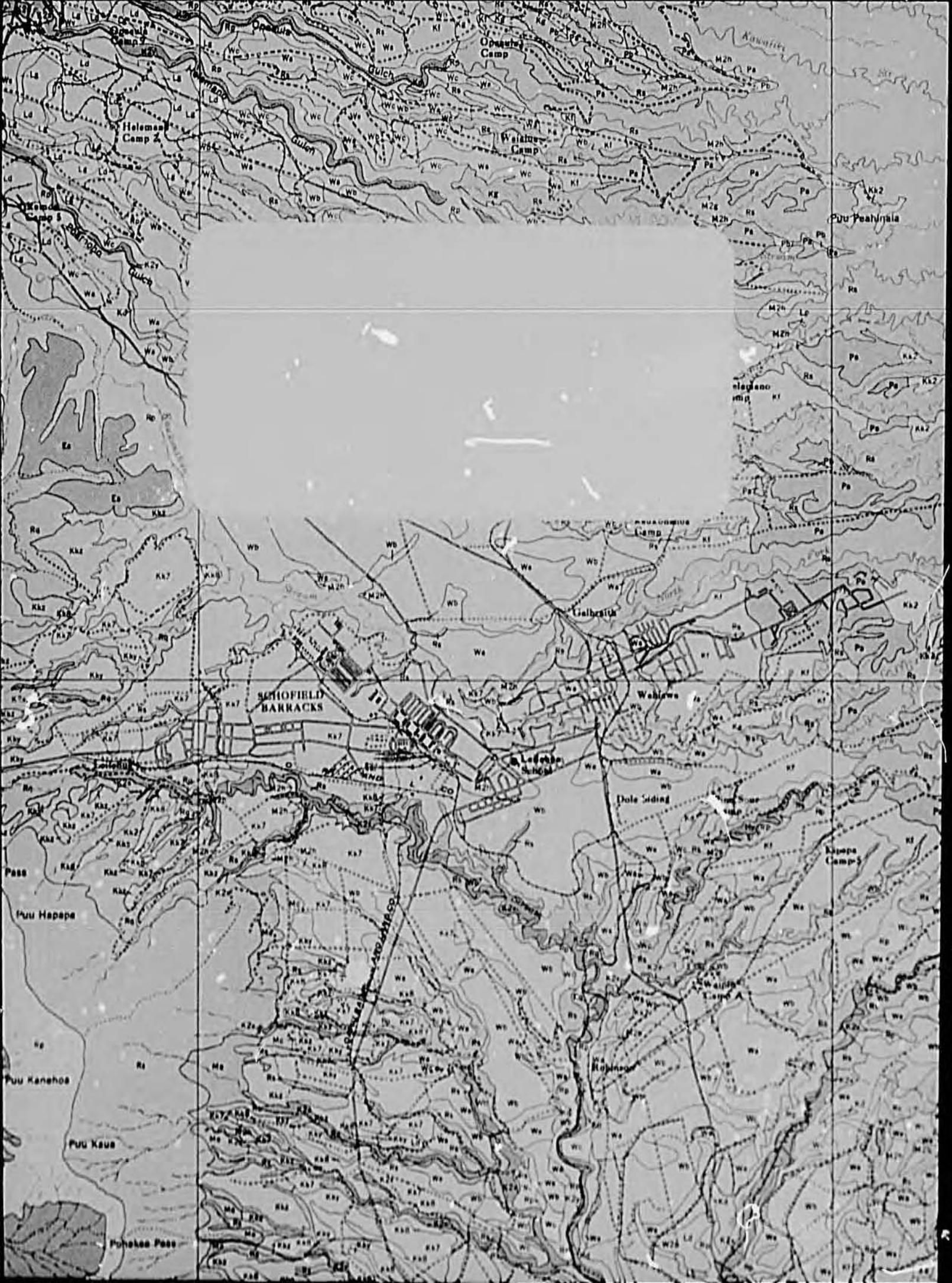
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Waialua Camp
Kawailoa
Puu Peahinala
Kaala Camp 5
Camp
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SCHOFIELD BARRACKS
Wahiawa
Leilehua School
Dole Siding
Kapapa Camp 5
Pass
Puu Hapapa
Waialua Camp 4
Robinson
Puu Kanehoa
Puu Kaua
Puhakea Pass

ANNUAL REPORT
Fiscal Year October 1, 1977–September 30, 1978
Benchmark Soils Project/Hawaii

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

Contract No. AID/ta-C-1108

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Summary Sheet

Project Title and Contract Number:
Crop Production and Land Capabilities of a Network of Tropical Soil Families (The Benchmark Soils Project)
AID/ta-C-1108

Principal Investigator and Contractor:
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Contractor's Address:
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3190 Maile Way/Honolulu, Hawaii 96822

Contract Period (as amended):
May 31, 1974 - May 30, 1980

Reporting Period:
October 1, 1977 - September 30, 1978

Total AID Funding to Date: $2,105,782

Total Expenditures and Obligations through Previous Fiscal Year: $1,393,318

Total Expenditures and Obligations for Current Year: $901,181

Estimated Expenditures for Next Fiscal Year: $1,115,532

Narrative Summary of Accomplishments and Utilization

Early results of a statistical test of the transfer hypothesis using maize grain yield data obtained on the thixotropic, isothermic Hydric Dystrandepts indicate that agrotechnology transfer from one location to another based on the soil family is likely to be verified. These first approximation results are expected to be confirmed by the second approximation in 1979. A number of crop production and soil management experiments are now underway to produce data for the second statistical test. Two soil family networks, the Hydric Dystrandepts and the clayey, kaolinitic, isohyperthermic Tropeptic Eutrustox, are complete and operational. (The Tropeptic Eutrustox network links the Hawaii Benchmark Soils Project with the parallel Puerto Rico Benchmark Soils Project.) The third soil family network, the clayey, kaolinitic, isohyperthermic Typic Paleudults, is expected to be completed in 1979; negotiations with the cooperating agency in Cameroon for site establishment are now in process. The first transfer experiments were installed on this family in two of three sites in Indonesia and one site in the Philippines; two more sites will be selected in the Philippines and two are planned in Cameroon for 1979 staffing.

Crop responses to phosphorus and nitrogen in the transfer experiments in all three soil families continue to effectively demonstrate the crop requirements of each

The ultimate objective is developing a model of agrotechnology transfer based on soil interpretation and land classification.

family for both nutrients. Differences in yield levels between families are related, in part, to site variables such as climate and soil environment. With additional yield and site variable data, more conclusive tests of the transfer hypothesis will be made on the Hydric Dystrandepts and first tests will be performed on the Tropeptic Eutrustox and the Typic Paleudults.

Crop response to residual phosphorus fertilizer, placement of phosphorus fertilizer, phosphorus fertilizer source, and varying application rates of nitrogen, phosphorus, and potassium was monitored in management experiments on the Hydric Dystrandept network. Grain yields from residual phosphorus in transfer experiments were nearly equivalent to yields from the initial transfer experiments.

Local maize varieties generally were rated better than introduced varieties in the variety experiments that complement the transfer and management experiments. Currently, 'H610' is used in Hawaii, 'UPCA Var. 1' in the Philippines, and 'Harapan' in Indonesia. 'Pioneer hybrid X304C' has been successfully grown throughout the Tropeptic Eutrustox network. Various local and introduced varieties are being tested for the Typic Paleudults network.

Several technical and semitechnical publications were distributed to a worldwide mailing list of over 1000 throughout the year. The quarterly Benchmark Soils News keeps the international group of Project personnel informed of research progress at all sites and contributes to lay-reader understanding of Project goals. The computerized Soil Data Bank was expanded to accept soils data from other agricultural research stations. Project personnel participated in various workshops and seminars throughout the year and presented a number of papers. Training of in-country nationals on the concepts of soil classification and land-use planning, as well as agrotechnology transfer, was initiated in the Philippines and Indonesia, and a local Benchmark Soils Project was established in Indonesia to help solve particular country needs. Graduate students sponsored by the Project now number four.

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 Families." The Project is more briefly and popularly known as the Benchmark Soils Project (BSP). The purpose of the Project is to test an innovative approach to agrotechnology transfer designed to assist LDCs (less developed countries) in appropriately utilizing their land resources for increased and better quality food production by bypassing three major constraints: scarcity of qualified research personnel; insufficient capital; and, above all, time needed to close the widening gap between agroproduction and food requirements. The traditional approach to agricultural research is extremely time-consuming, and farmers urgently need the basic information conducive to higher outputs; they cannot wait for local research to regenerate information that is already available to them via transfer.

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, and economics of crop production.

Project Objectives

The thrust of the Benchmark Soils Project is the acceleration and reduction of cost of agricultural planning and development in the less developed countries (LDCs) through the process of agrotechnology transfer. This relates to AID's objective of expanding the information available on the management of tropical soils to increase food production in the tropics. The objectives are:

1. To determine scientifically the transferability of agroproduction technology among tropical and subtropical countries.
2. To assist tropical countries in assessing the potential of upland areas for intensive cropping and intensive soil management.
3. To demonstrate the value of soil and land classification in formulating agricultural development plans in selected areas.

There are five major activities through which these objectives are being met (see Appendix 1, Milestone Events).

Continued Relevance of Objectives

The contractual objectives of the Project continue to be relevant since accelerated agricultural development to increase food production to meet the growing demand is as urgent as ever. The research conducted to date does not indicate the need for modification of Project objectives at this time.

Highlights of Progress

For a list of the milestone events achieved to date, see Appendix 1.

Objective 1: To determine scientifically the transferability of agro-production technology among tropical and subtropical countries

Activity 1. Establish and complete the network of soils

Three soil families from upland areas that have the potential to be productive under appropriate management practices were selected to test the hypothesis of agro-technology transfer. They are the thixotropic, isothermic family of Hydric Dystrandepts; the clayey, kaolinitic, isohyperthermic family of Tropeptic Eutrustox; and the clayey, kaolinitic, isohyperthermic family of Typic Paleudults. Detailed soil surveys were conducted in 9 countries, and a network of 3 soil families has been established on experimental sites in Hawaii, Indonesia, and the Philippines. In fiscal 1977-78, the Project completed soil surveys and establishment of Typic Paleudult sites in the Philippines and Indonesia; Cameroon sites were surveyed and a memorandum of understanding is being negotiated with ONAREST (Office National de la Recherche Scientifique et Technique) for site establishment and implementation of Project experiments. The Project began operations and completed the first experiments on Tropeptic Eutrustox sites on Molokai and at Waipio, in Hawaii, which included signing of a letter of agreement with Maui County officials. Renewal of leases on Hydric Dystrandept sites in the Philippines was obtained by the BSP (Benchmark Soils Project) cooperating agency PCARR (Philippine Council for Agriculture and Resources Research).

Activity 2. Establish, install, complete, and analyze transfer experiments

First approximation results of the initial statistical test on the Hydric Dystrandepts were released in fiscal 1977-78, suggesting that the hypothesis of agrotechnology transfer from one location to another on the basis of the soil family will very likely not be rejected (be verified) and that crop response can be predicted. Further approximations will be released in 1979 according to milestone events for this activity (see Appendix 1).

Field operations were in progress on all sites of the Hydric Dystrandepts and the Tropeptic Eutrustox; it is expected that completion of site establishment and field operations on sites of the Typic Paleudults will occur in 1978-79.

A total of 31 transfer (soil fertility) experiments on 3 soil families was conducted in fiscal 1977-78 to generate data for a second statistical test of the transfer hypothesis.

The Project has demonstrated that phosphorus must be applied on Hydric Dystrandepts to achieve acceptable maize yields. Application of lime generally resulted in little or no increase in yield, while higher levels of lime generally decreased yield. Response to nitrogen in the new phosphorus X nitrogen experiments was generally marked throughout the Hydric Dystrandept network, especially at the highest phosphorus rates.

The first transfer experiment on the Tropeptic Eutrustox network produced the highest yields to date--11 metric tons per hectare.

Objective 2: To assist tropical countries in assessing the potential of upland areas for intensive cropping and intensive soil management

Activity 3. Establish, install, complete, and analyze crop (variety) and soil management experiments

Crop variety trials (a total of 5 experiments in fiscal 1977-78) to identify the maize varieties that are best adapted to a locality were installed and are underway on all sites of the Hydric Dystrandepts and on several sites of the Tropeptic Eutrustox. Results on the Hydric Dystrandept network to date indicate that a universal variety for all sites has not been found for a proper assessment of yield potential at all sites.

Management trials (a total of 8 experiments in fiscal 1977-78) to study crop performance associated with different levels of management based on the economics of farmer inputs were installed and are underway. Results of management experiments, when correlated to soil resources and classification, provide agricultural planners with alternatives in determining best land utilization for agricultural and food production.

Specific soil family constraints determine the suitability of a parcel of land for specific crops.

In the Hydric Dystrandept network, residual fertilizer experiments have effectively demonstrated that phosphorus and lime application are effective for several crops and thus the net cost of fertilizer per crop is reduced. Nitrogen and phosphorus were found to be the most limiting nutrients for maize, and phosphorus and potassium, as well as molybdenum, were limiting nutrients for soybeans. Addition of farmyard manure or corn stover with applied phosphorus produced higher yields than either organic material alone. Finally, initial results from placement studies show promise for developing simplified fertilizer application techniques to maximize return from small phosphorus applications on soils with high phosphorus fertilizer requirements.

Activity 4. Analyze information for soil interpretation and land classification

Benchmark Soils Project personnel classified soils according to Soil Taxonomy in areas where this classification was unknown or unused before the Project's inception. This means that a unified system of soil classification is becoming a reality and that worldwide acceptance of one international soil classification system is a real possibility. As a result of the Project, the Soil Research Institute (SRI) of Indonesia ordered 50 copies of Soil Taxonomy for distribution to scientists and planners and conducted a workshop to promote the system's use. The soils of 9 proposed and existing experimental sites on key soils of Sumatra are being classified according to the Soil Taxonomy system by SRI.

In fiscal 1977-78, the Project replaced the initial phosphorus-sorption technique with another method to determine phosphorus treatment levels. In a correlation of environmental factors to crop yields, it was found that weather decidedly affects yields within a soil family network. The computerized Soil Data Bank was expanded to accept soils data from agricultural research stations in the tropics.

Objective 3: To demonstrate the value of soil and land classification in formulating agricultural development plans in selected areas

Activity 5. Disseminate principles, concepts, and results

The Project has entered into cooperative agreements with 4 agencies or institutions and established linkages with 7 international agricultural research centers.

The problem of translating available agricultural technology into action to feed a hungry world can only be tackled by a number of participants cooperating and sharing information.

Awareness of Project goals has been disseminated through training programs, meetings, workshops, conferences, and publications. The Project has an important role in the growing network of communicating and cooperating research institutions focusing on the food problems of the tropical world. In fiscal 1977-78, the Project completed laboratory analyses of soils for AID-Djibouti, INPUTS (East-West Center, Inc.), and SCS-USDA, all at their request.

Publication of two brochures describing the Project, the first in English, French, and Spanish, and distribution to our international mailing list of approximately 1000 persons, preceded publication of the joint Puerto Rico and Hawaii Progress Report, which was well received. In addition, the hardcover book Soil-Resource Data for Agricultural Development was published by BSP through the Hawaii Agricultural Experiment Station, with funding by AID. Approximately 6 publications are in process for publication in the next fiscal year. A 6-page report, the Benchmark Soils News, is issued quarterly to over 1000 planners, decision-makers, scientists, and other personnel.

PCARR, the Philippines, and SRI, Indonesia, convened advisory committees this year to "provide guidance in the conduct of activities that could influence the course of regional programs pursued by the Project," and these committees will serve as a bridge between scientists and planners. SRI also established its own local Benchmark Soils Project on Ultisols in Sumatra to solve its particular needs.

Three in-country nationals (from the Philippines and Indonesia) were brought to Hawaii for graduate training, making a total of 4 graduate students sponsored by the BSP. A survey questionnaire of soil information display and delivery systems was prepared for distribution to agricultural planners in fiscal 1978-79. In addition, Project personnel participated in planning and organizing the international conference on the operational implications of agrotechnology transference research to be held at Hyderabad, India, by ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) in October 1978.

Accomplishments to Date

Establishment of a Network of Benchmark Soil Families

Three soil families from upland areas that have the potential to be productive under appropriate management practices were selected to test the hypothesis of agrotechnology transfer:

Classification of soils in the Benchmark Soils Project[a]

Soil Taxonomy taxa	Soil family A	Soil family B	Soil family C
Order	Inceptisols	Oxisols	Ultisols
Suborder	Andepts	Ustox	Udults
Great group	Dystrandepts	Eutrustox	Paleudults
Subgroup	Hydric Dystrandepts	Tropeptic Eutrustox	Typic Paleudults
Family	thixotropic, isothermic	clayey, kaolinitic, isohyperthermic	clayey, kaolinitic, isohyperthermic

[a]Based on Soil Taxonomy (Soil Survey Staff, 1975)

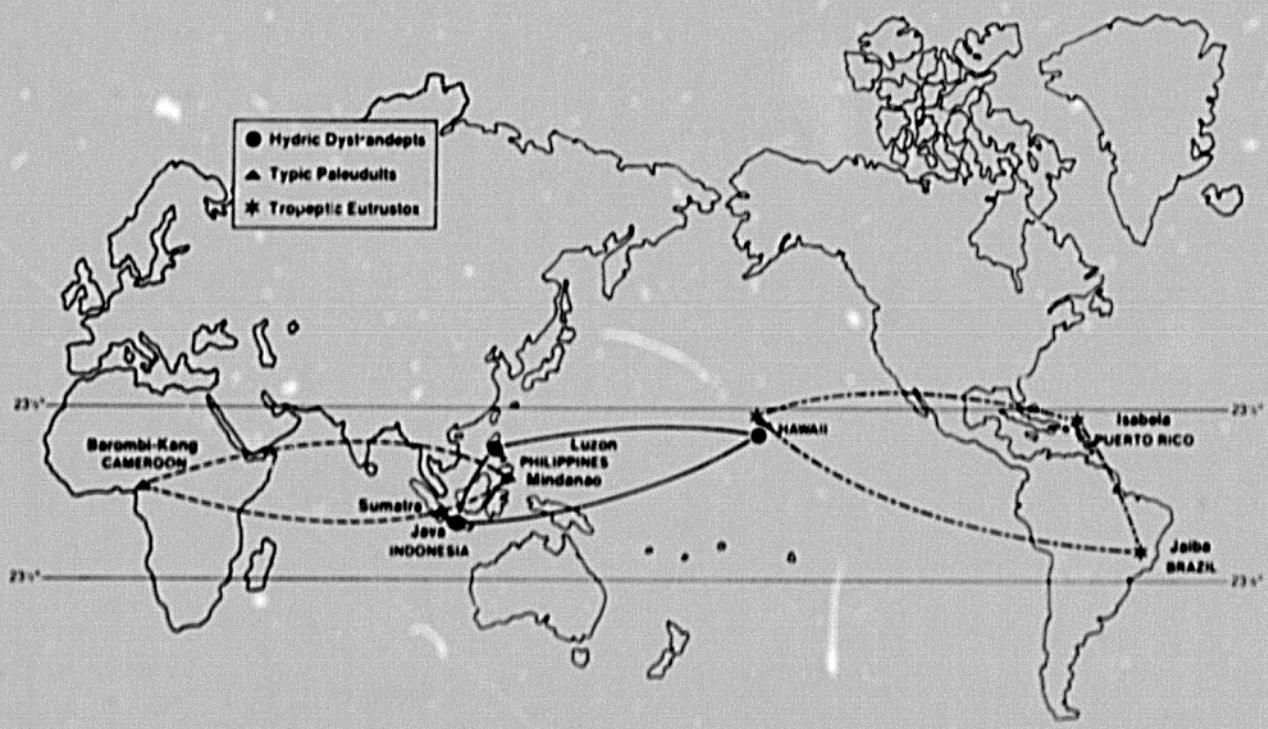


Fig. 1. Location of the three tropical soil families in the Benchmark Soils Project.

The locations of the soil network are shown in Fig. 1, and the linkage of the different countries is shown in Fig. 2.

The first family selected was the thixotropic, isothermic Hydric Dystrandepts because this soil is easy to locate and Project personnel had long experience with its management. The second family, clayey, kaolinitic, isohyperthermic Tropeptic Eutrustox, occurs in Puerto Rico and Hawaii and was selected to foster closer linkages between the Puerto Rico and Hawaii Benchmark projects. The third family, clayey, kaolinitic, isohyperthermic Typic Paleudults, was included at the request of the host countries because it is an important, underutilized soil in the tropics.

Site Selection for 2 out of 3 Soil Families Is Nearly Completed

Hydric Dystrandept Sites Fully Operational

Renewal of leases on Hydric Dystrandept sites in the Philippines was obtained by BSP cooperating agency PCARR (Philippine Council for Agriculture and Resources

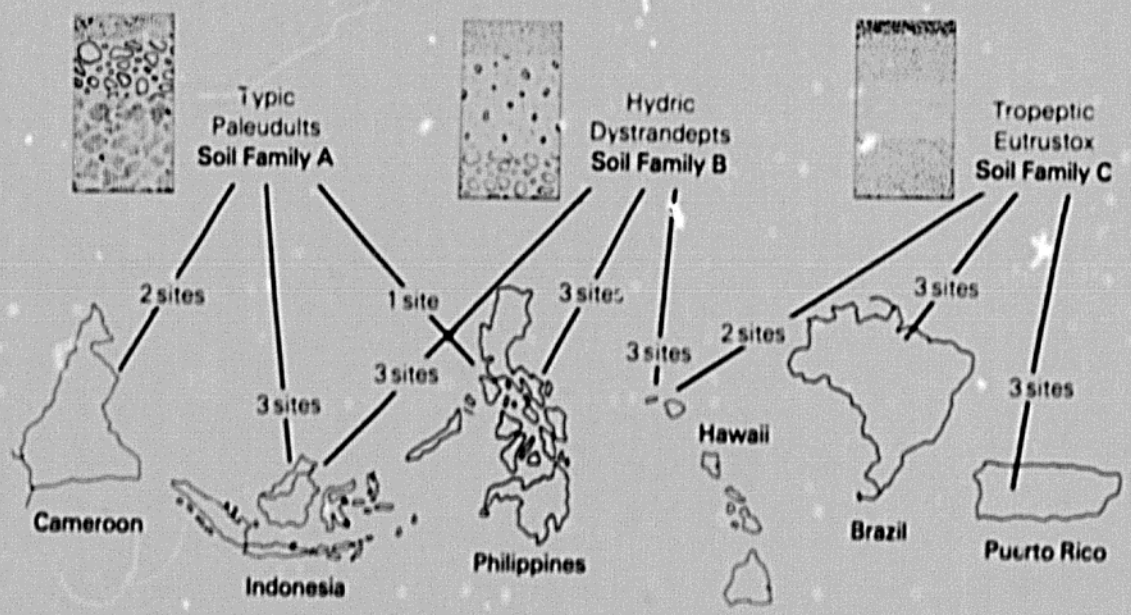


Fig. 2. Soil linkages among countries in the Benchmark Soils Project. As of October 1978, 15 sites are operational. The remaining 4 sites are expected to be operating by the end of 1978.

Agrotechnology transfer will not be confined to soil management; it will be shown to encompass all associated experience and knowledge.

Research). Similar extensions on lease agreements were negotiated in Indonesia by SRI (Soil Research Institute). Each of the 9 sites is adequately staffed and maintained by both Project-employed and SRI- or PCARR-employed personnel.

Tropeptic Eutrustox First Experiments Completed

The Project began operations and completed the first transfer experiments on Tropeptic Eutrustox sites on Molokai and at Waipio, in Hawaii. Letters of agreement were signed with Molokai Ranch, Maui County, and developer Gentry Pacific for experimental sites on the Islands of Molokai and Oahu, respectively. These agreements signify the completion of long negotiations for land and water rights.

Typic Paleudult Site Establishment Nearing Completion

In fiscal 1977-78, the Project completed soil survey investigations and establishment of experimental sites in Indonesia, established the primary site and completed the field survey for two additional sites in the Philippines, and completed the field survey for another two sites in Cameroon. A memorandum of understanding in the latter with ONAREST (Office National de la Recherche Scientifique et Technique) for site establishment and implementation of Project activities have not been finalized.

Three sites, two in Lampung, South Sumatra, Indonesia, and one at Bago Oshiro, Davao City, the Philippines, are operational. The third site in Sumatra is being cleared and prepared for planting in January 1979. Lease agreements and site establishment for two additional sites in Davao are scheduled to be initiated upon verification of mineralogy. The Typic Paleudults network is scheduled for completion in 1979.

General Characteristics of the 3 Families of Benchmark Soils Are Determined and Described

Profile descriptions and laboratory data for the soils at each site (13 soil profiles representing 17 sites of the Hawaii Project) were collected and compiled and are presented in Tech. Rep. 1 (Ikawa et al., in press), and the 19 sites of the Hawaii Project are summarized in Table 1 (Appendix 2, Tables). A summary of the

A common knowledge base is essential for effective communications and agrotechnology transfer.

general characteristics of the 3 soil families under study by the Benchmark Soils Project is also found in Table 2 (Appendix 2).

Within the same family of a soil, as in any population, there is a range in the general characteristics, but the range that was encountered by Project personnel, although acceptable within the family, was wider than expected. A summary of the ranges in characteristics of the three soil families was prepared in fiscal 1977-78 and is shown in Tables 3, 4, and 5 (Appendix 2). In transferring management practices from one site within a soil family to another, this range should be considered in evaluating the potential of crop production of the specific site. For this reason, it is essential to include site variables in the prediction equation (see the discussion on the statistical test of the transfer hypothesis).

Release of First Approximation Statistical Results of the Transfer Hypothesis on Hydric Dystrandepts

One of the major objectives of the Project is the development and application of a statistical test of the hypothesis of transferability. This is the means of showing scientifically that soils of the same family respond similarly to management.

One test of the hypothesis was made using regression techniques to predict the yield response to phosphorus and lime at the Benchmark sites included in this study. It was found that a generalized equation could predict the yield response for any of the sites, provided terms reflecting the different average yields at the sites were included. Thus, a combined agrotechnology model describing the response to phosphorus and lime is considered transferable among sites of the same soil family.

The combined estimated response surface equation is the following:

$$Y = b_0 + \underset{(71)}{492P} - \underset{(71)}{91.6L} - \underset{(141)}{167P^2} - \underset{(141)}{107L^2} - \underset{(107)}{53.8PL}$$

Figures in parentheses are standard errors for the regression coefficients. The intercepts (b_0) were 5007 (PUC-A), 5437 (PAL-C), 5980 (KUK-A), 9487 (KUK-C), and 8517 (HAL-B) (see Appendix 3).

Estimated response surfaces for the Philippine and Hawaii sites (Fig. 3) were calculated using this equation and the appropriate intercepts. A marked difference

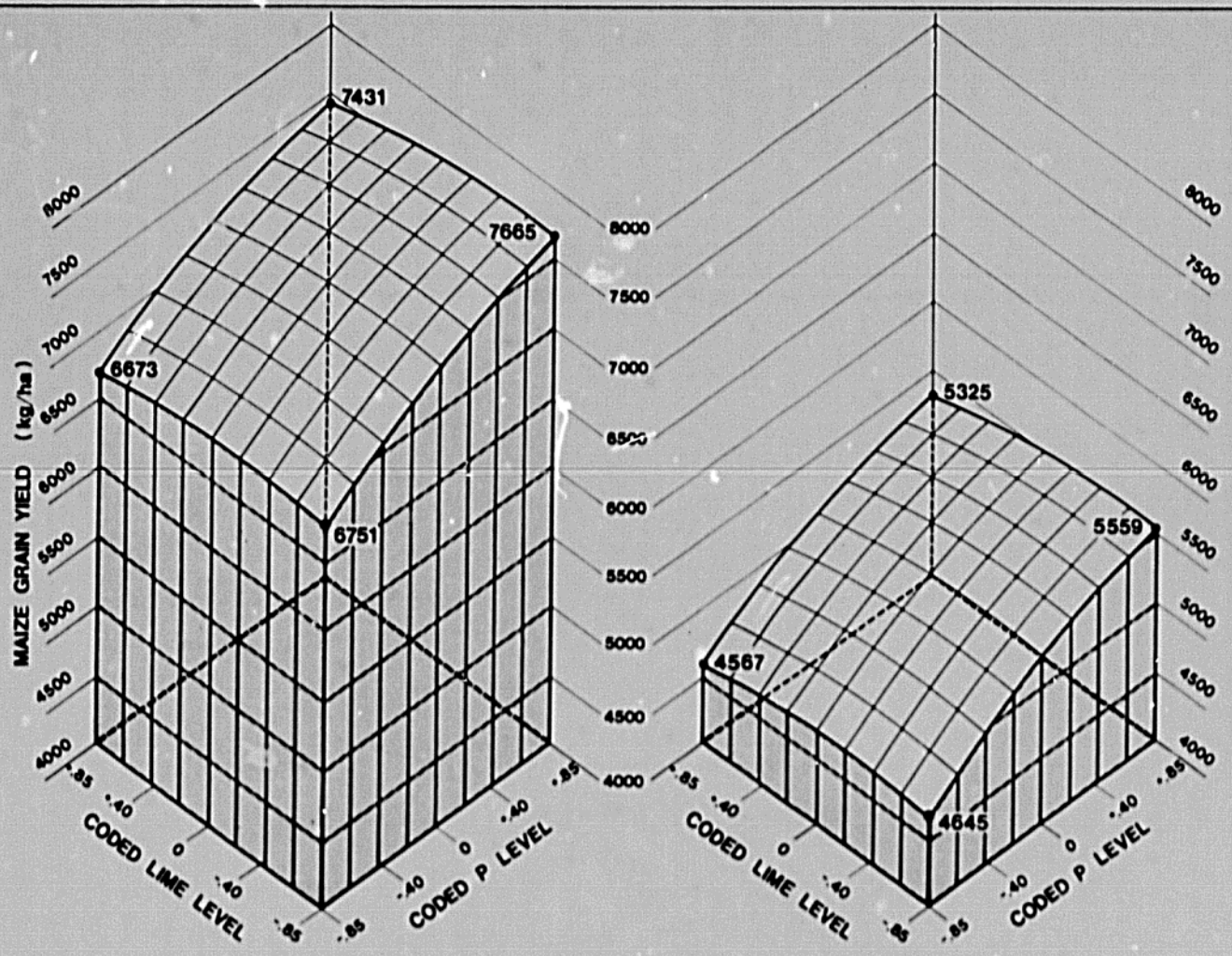


Fig. 3. Similar response surfaces of the Hydric Dystrandepts in Hawaii (left) and the Philippines (right).

in yield level between the two countries is evident, along with the fact that the highest yields were attained with the highest phosphorus and lowest lime treatment combination. There was a similar marked response to phosphorus and a lack of response to lime in both countries.

The difference in the height (yield) of the fitted surfaces of the two countries reflects the difference in the intercept. The intercept integrates the effects of site variables such as temperature, solar radiation, and so on. Some of the experiments included in this test were installed before weather instruments were completely operational, so that complete weather data were not available for use. A preliminary equation that included average maximum daily temperature near the time of tasseling did not do as well as the equation with the individual intercepts in predicting yields for the individual sites. These differences in yield potential between sites will be described and tested more precisely when more complete data on uncontrolled site variables are available in the equation.

Management practices depend on the limiting factors and can therefore be predicted for specific soils.

Another approach to testing the hypothesis involved the estimation of a transfer equation from several sites and using it to predict yields on a different site. This is ultimately what is desired--that is, to transfer information from one site to another of the same soil family. This second test gave limited evidence that agrotechnology could be transferred between soils of the same family, but a more conclusive test awaits more yield and site variable information.

A detailed discussion of the statistical test of the transfer hypothesis is presented in Appendix 3.

Correlation of Soil Properties with Management Practices

To date, the Project has verified through field experimentation and experience that accessory soil properties implied in the soil family taxonomic names are indeed inherent soil family characteristics, although the range of these characteristics varies from site to site within a family. In addition, the Project has successfully demonstrated that some of these soil family characteristics have specific inferences for management practices. The chart on page 17 details some inherent soil family characteristics in the 3 soil families as they relate to the taxonomic name and the management considerations.

In every soil family there are certain limiting factors affecting good crop yields. These factors were confirmed by Project experimentation to be the same within the same family and different between soil families. An example is shown in Fig. 4 by the relationship of maize grain yield for the three soil families with each respective soil family environment. The cool and warm environments are related to the isothermic and isohyperthermic temperature regimes, while the wet and dry environments refer to the udic and ustic moisture regimes. These relative yields from each soil family were expected from our knowledge of the taxonomic nomenclature in Soil Taxonomy. Management practices depend on the limiting factors and can therefore be predicted for specific soils. The recommended management interpretations on page 18 are results of Benchmark Soils Project field experimentations to date on the two soil families studied.

Soil family properties and their inferences for management practices

Taxonomic name	Inherent soil family characteristics	Management implications
thixotropic, isothermic Hydric Dystrandepts		
thixotropic	High surface activity of colloids.	High amounts of phosphorus must be added.
isothermic	Cool soil temperatures (15-22°C).	Crops must be suited to cool climate.
Hydric	Moist humid soils.	No irrigation or only supplemental irrigation required.
Dystr-	Low base saturation (<35%).	High fertilizer input required; lime application required in some cases.
-andepts	Low bulk density (<0.85 g/cm^3).	Low power requirement for tillage; good drainage and infiltration characteristics.
clayey, kaolinitic, isohyperthermic Tropeptic Eutrustox		
clayey	More than 35% clay in the subsoil.	Moderate power requirement for tillage; tendency for soil compaction.
kaolinitic	Dominated by low active clay.	Moderate P fixation requires moderate P application.
isohyperthermic	Warm soil temperatures throughout the year (mean >22°C); small difference between summer and winter temperatures (<5°C).	Crops must be suited to warm climate; potential for year-round crop production.
Tropeptic	Moderate structure; less than 125 cm deep; or both.	Good drainage and infiltration characteristics.
Eutr-	Moderately enriched with nutrients; medium to high base saturation (≥50%).	Moderate nutrient-supplying capacity; only moderate amounts of fertilizer needed.
-ust-	Pronounced dry season (dry for more than 90 cumulative days/year).	Irrigation required during the dry season.
-ox	Presence of oxides of iron and aluminum; low cation-exchange capacity.	Low nutrient retention; low available water capacity.
clayey, kaolinitic, isohyperthermic Typic Paleudults		
clayey	More than 35% clay in the subsoil.	Good subsoil water-holding capacity; subsoiling may be required.
kaolinitic	Dominated by low active clay.	More frequent applications of fertilizer required.
isohyperthermic	Warm soil temperatures throughout the year (mean >22°C); small difference between summer and winter temperatures (<5°C).	Crops must be suited to warm climate.
Typic	Typical or central concept.	Connotes standard management practices.
Pale-	Deep old soils with low nutrient supply.	Moderate to high fertilizer input generally required.
-ud-	Humid soils.	Only supplemental irrigation required.
-ults	Low base saturation (<35%).	Likelihood of soil acidity; lime probably required.

Interpretations of management practices

Unique soil property	Finding	Recommended management practice
Hydric Dystrandepts network		
Contain high amounts of amorphous materials that fix high amounts of phosphorus. Frequently deficient in phosphorus.	Yield responses to maize observed at the sites in Hawaii, the Philippines, and Indonesia showed a similar pattern: all responded to application of fertilizer phosphorus in varying degrees.	Much larger applications of phosphorus are necessary than on the Tropeptic Eutrustox.
Have relatively low percentage of aluminum saturation between pH 5.0 and 5.5.	Lime treatments generally had no effects on yield when the KCl-extractable Al was low and exchangeable Ca was present, even though the soil pH was lower than 5.5. In fact, some experiments even showed a decrease in yield with highest rates of lime application.	The existing expensive practice of liming acid tropical soils to obtain good crop response does not necessarily apply to Hydric Dystrandepts.
Have wet climate and low temperatures (uniformly cool and moist).	Only minor incidence of downy mildew (which requires warm, moist conditions) occurred in Indonesia and none occurred in the Philippines, even though downy mildew is a serious disease in these countries.	Downy-mildew-resistant varieties may not need to be used because the isothermic temperature regime may retard the development of this disease.
Tropeptic Eutrustox network[a]		
Contain iron and aluminum oxides, which fix phosphorus.	Maize and soybean responded to phosphorus application.	Phosphorus must be added, but in lower amounts than for the Hydric Dystrandepts.
Are enriched with bases.	Maize and soybeans did not respond to potassium application.	Adding potassium to these soils is not necessary for initial cropping seasons. However, continuous cropping without supplementary addition of potassium will eventually deplete the potassium reserves in these soils.
Have dry, warm climate with high solar radiation.	Registered the highest maize yield in the Benchmark network.	Irrigation is required for optimum yields.

[a]See Progress Report 1. This information provided by the Puerto Rico Project.

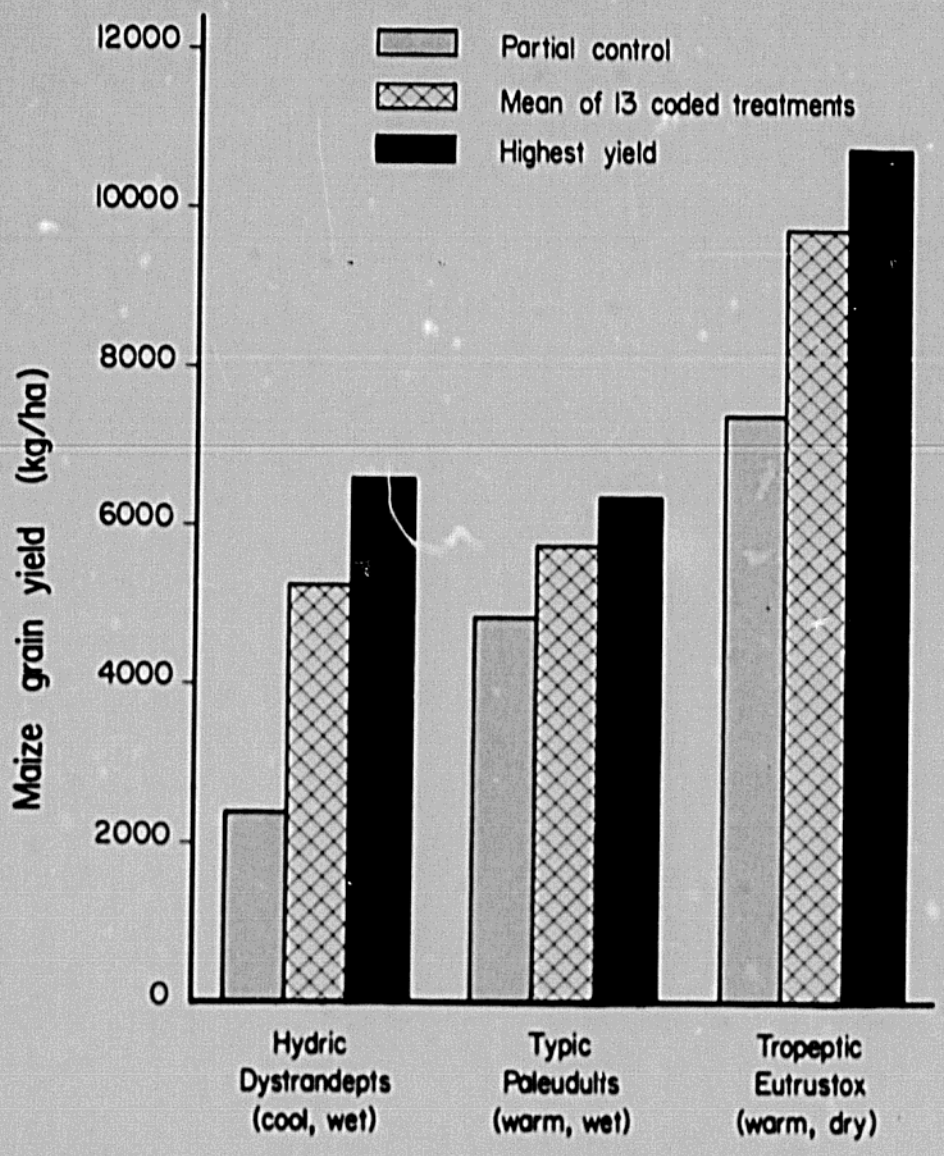


Fig. 4. Effect of soil family environment on maize grain yield.

Conduct of Experimental Field Work

The number of experiments completed in fiscal year 1977-78 break down as shown on page 20.

Transfer Experiments Show Differences between Families

A total of 27 maize transfer experiments were completed on 9 Dystrandept sites, while a total of 2 maize transfer experiments were completed on 2 Eutrustox sites. It is expected that the full complement of experiments (2 per year on each site) will be carried out in the latter soil family in the coming year when the network is completed. To date, 8 transfer experiments on the Paleudults have been installed in the Philippines and Indonesia and 2 were completed in fiscal 1977-78.

Hydric Dystrandept Network

The Project has effectively demonstrated through transfer experiments that phosphorus must be applied on Hydric Dystrandepts in order to achieve acceptable maize yields. Throughout the network a plateau in the response curve was reached at

Experiments completed in fiscal year 1977-78

Country	Crop	Transfer experiments	Variety experiments	Management experiments
Hydric Dystrandepts				
Hawaii	Maize	10	1	0
	Soybeans	2	0	0
Indonesia	Maize	9	2	2
	Soybeans	2	1	2
	Irish potatoes	0	0	2
Philippines	Maize	8	1	1
	Soybeans	0	0	0
	Sorghum	0	0	1
Totals	Maize	27	4	3
	Soybeans	4	1	2
	Irish potatoes	0	0	2
	Sorghum	0	0	1
Tropeptic Eutrustox				
Hawaii	Maize	2	0	0
Totals	Maize	2	0	0
Typic Paleudults				
Philippines	Maize	2	0	0
Indonesia	Maize	0	0	0
Totals	Maize	2	0	0

higher levels of phosphorus applied. This was attributed to using too high optimum phosphorus rates, established by the phosphorus-sorption isotherm method. Rates of phosphorus applied vary with the amount of native or residual phosphorus in the soil at a specific site. Alternative methods of analysis to establish the status of soil phosphorus are now being used (see section on Changes in Research Design).

Application of lime generally resulted in little or no increase in yield. In some cases, in fact, higher applications of lime often resulted in a decrease in grain yield. Soil pH ranged from 4.6 to 5.5, and KCl-extractable Al (aluminum) was generally 1.5 meq/100 g or less. Although these soils do not display the detrimental effects of acidity, they require calcium as a nutrient. These tropical soils are able to supply adequate amounts of calcium to crops, even though the pH is relatively low.

The effects of lime and phosphorus on maize grain yield are relative to the unique properties of the Hydric Dystrandepts and are predictable from taxonomic nomenclature of the soil family as previously discussed. The data collected verify the management considerations required for acceptable crop yields.

The following paragraphs are reports of experimental findings for the past fiscal year in the Hydric Dystrandept network.

All transfer experiments showed dramatic response to phosphorus application.

Hawaii. Both P (phosphorus) x lime and P x N (nitrogen) experiments were conducted during the year (Table 6, Appendix 2). The 5 P x lime experiments were residual experiments. All 5 P x N experiments showed significant grain yield increases with N, while significant yield increases with P were not found in the Iole experiment where soil P is relatively high from P application to sugarcane formerly grown in the area. Yield response to P and N for KUK-D is shown in Fig. 5.

Indonesia. Six P x lime experiments and 3 P x N experiments were harvested in Indonesia during the year (Table 7, Appendix 2). Three of the P x lime experiments were initial plantings, while three were second plantings utilizing residual P and lime. The general yield pattern for the P x lime experiments is illustrated in Fig. 6 for PLP-D. Yields generally increased as P increased and were variable as lime increased; that is, yields increased with lime in some experiments and decreased at the highest rates of lime in other experiments. In the few experiments in which lime increased yields at the highest lime rate, this increase occurred only at the highest P level. Yields of the residual P x lime experiments were lower than those from the initial planting although the yield patterns were similar to those of the initial planting; however, the residual experiments were planted in the wet season while the initial planting grew during the dry season. The lower solar radiation and temperature, as well as heavy rains at tasselling, probably accounted for some of the reduction in yields in the residual experiments. In the P x N experiments, yields increased to the optimum N level at the low and optimum P rates and to the highest N level at the high P rate (Fig. 7).

Some soils in the Indonesia sites have been used for vegetable production for many years and have had additions of animal manure in the past; therefore, P levels are not exceptionally low. Yields generally increased with P application, however, even though the increases were not as large as at other sites. Season had a marked effect on the level of yield attained. Crops grown in the dry season, with maximum solar radiation and temperature, had yields of 6 to 8 tons/hectare, while those grown during the wet season had yields of 2 to 6 tons. The lack of consistent response to lime was due to the properties of this soil family, as explained above.

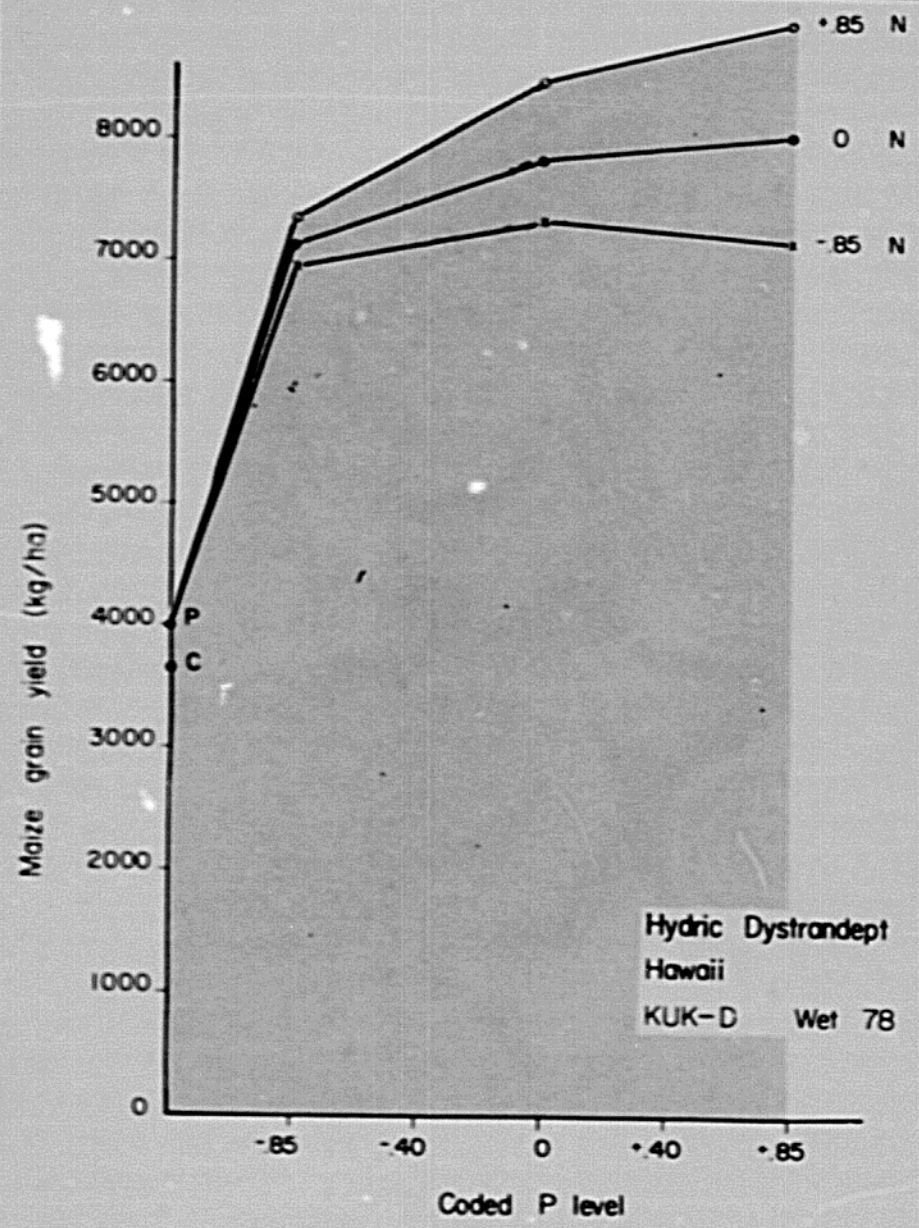


Fig. 5. Response of maize to coded levels of phosphorus and nitrogen, secondary site/Hawaii.

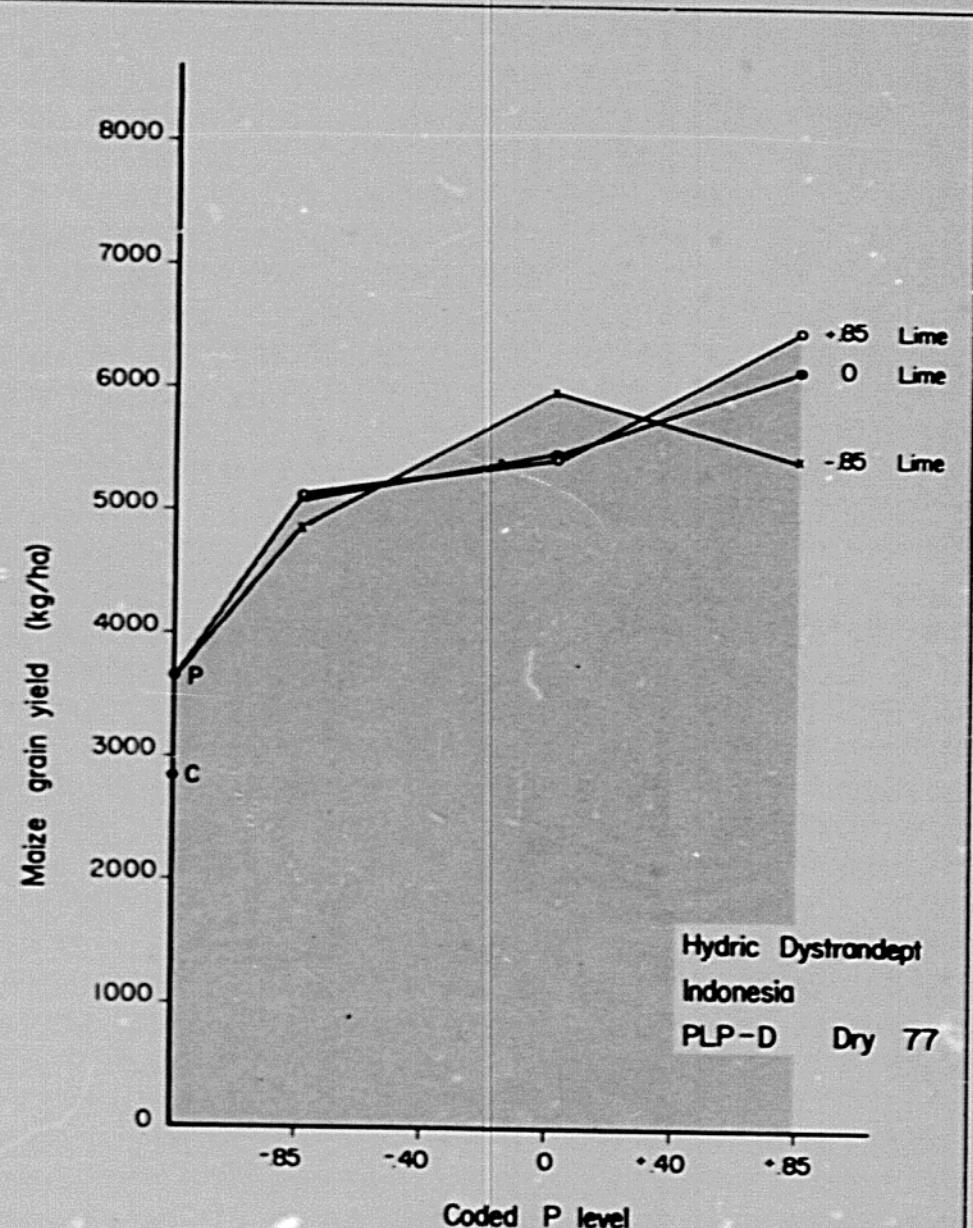


Fig. 6. Response of maize to coded levels of phosphorus and lime, secondary site/Indonesia.

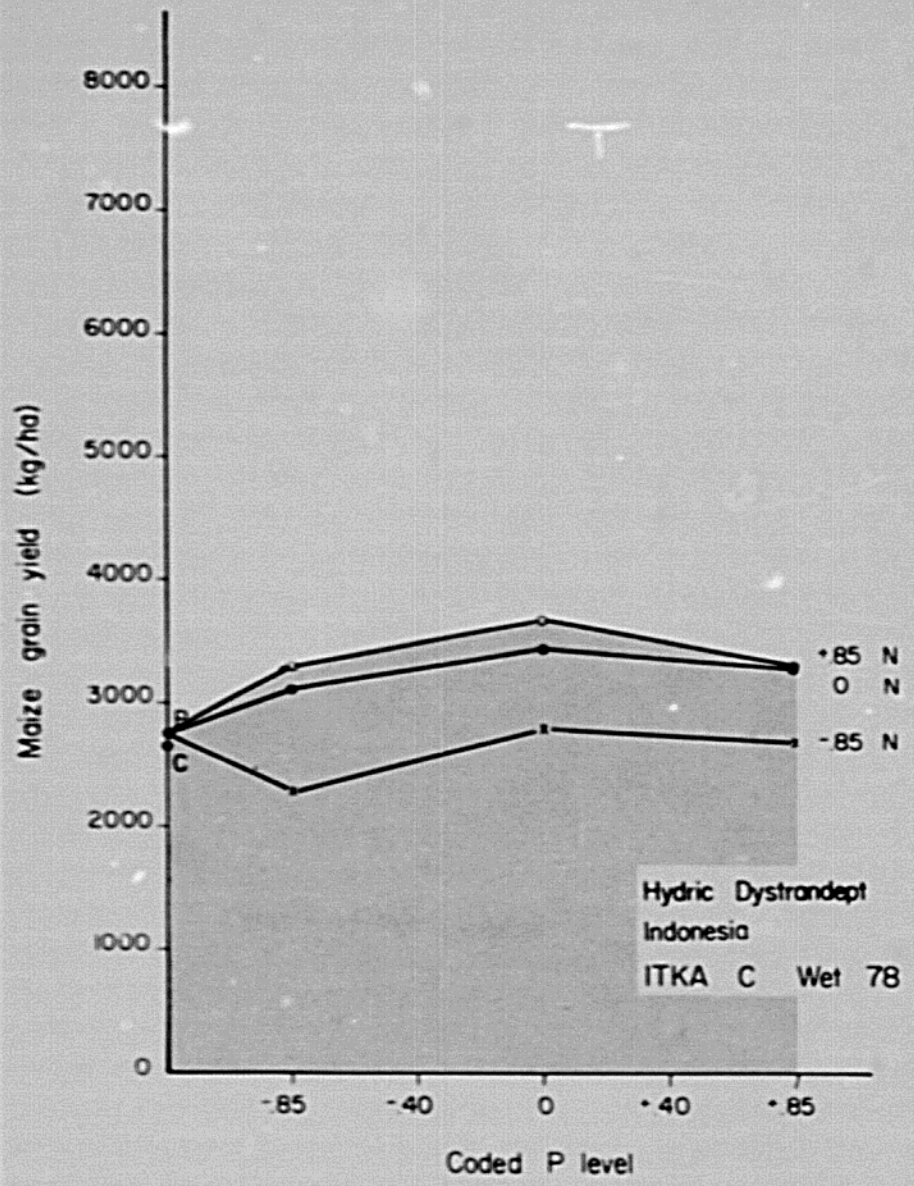


Fig. 7. Response of maize to coded levels of phosphorus and nitrogen, primary site/Indonesia.

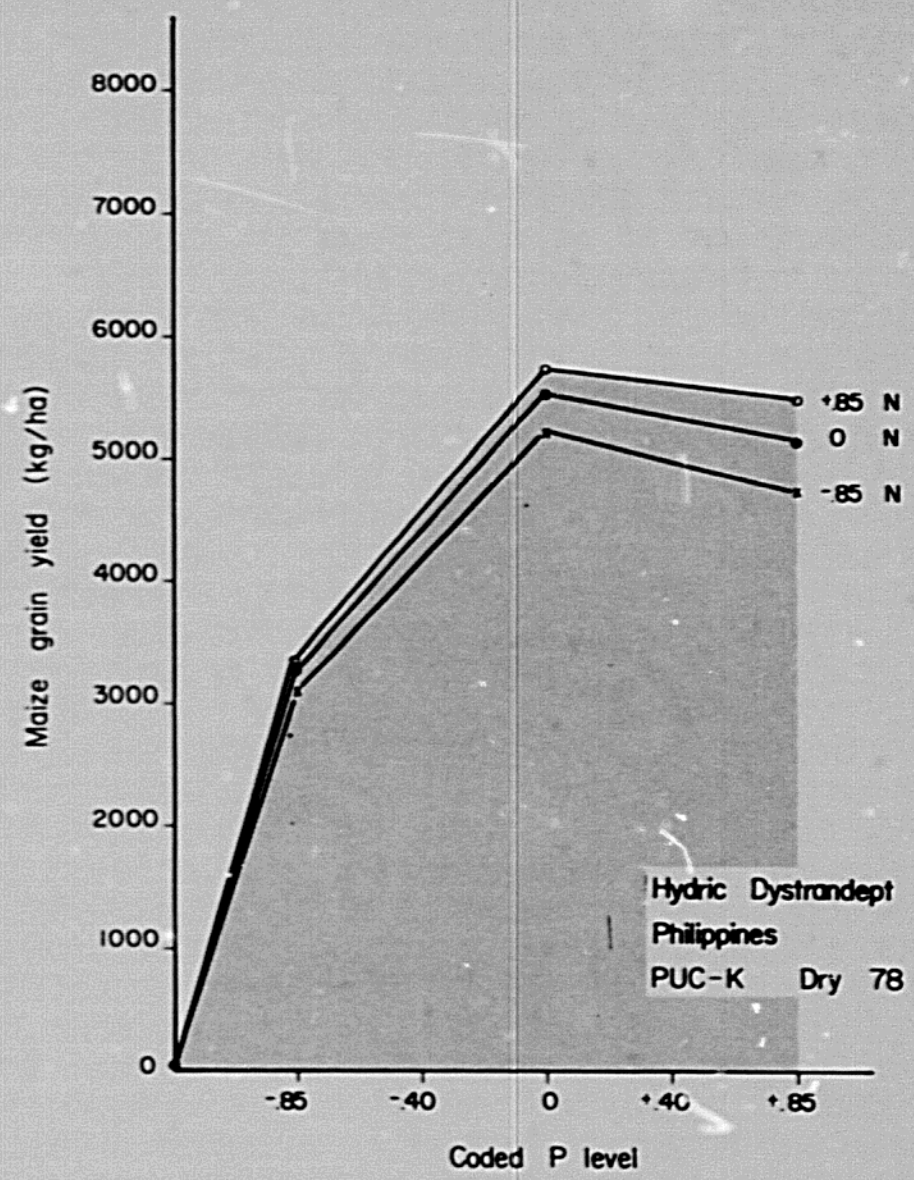


Fig. 8. Response of maize to coded levels of phosphorus and nitrogen, primary site/Philippines.

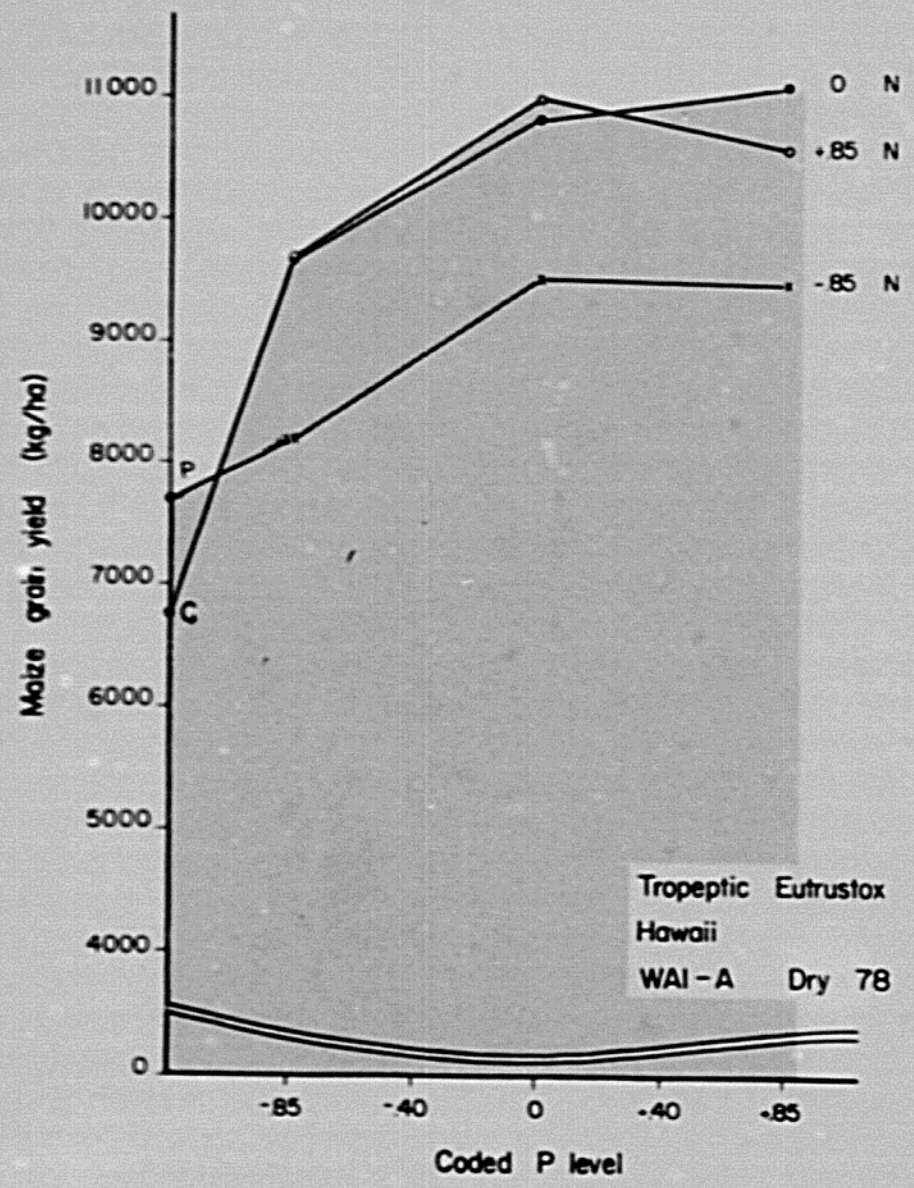


Fig. 9. Response of maize to coded levels of phosphorus and nitrogen, secondary site/Hawaii.

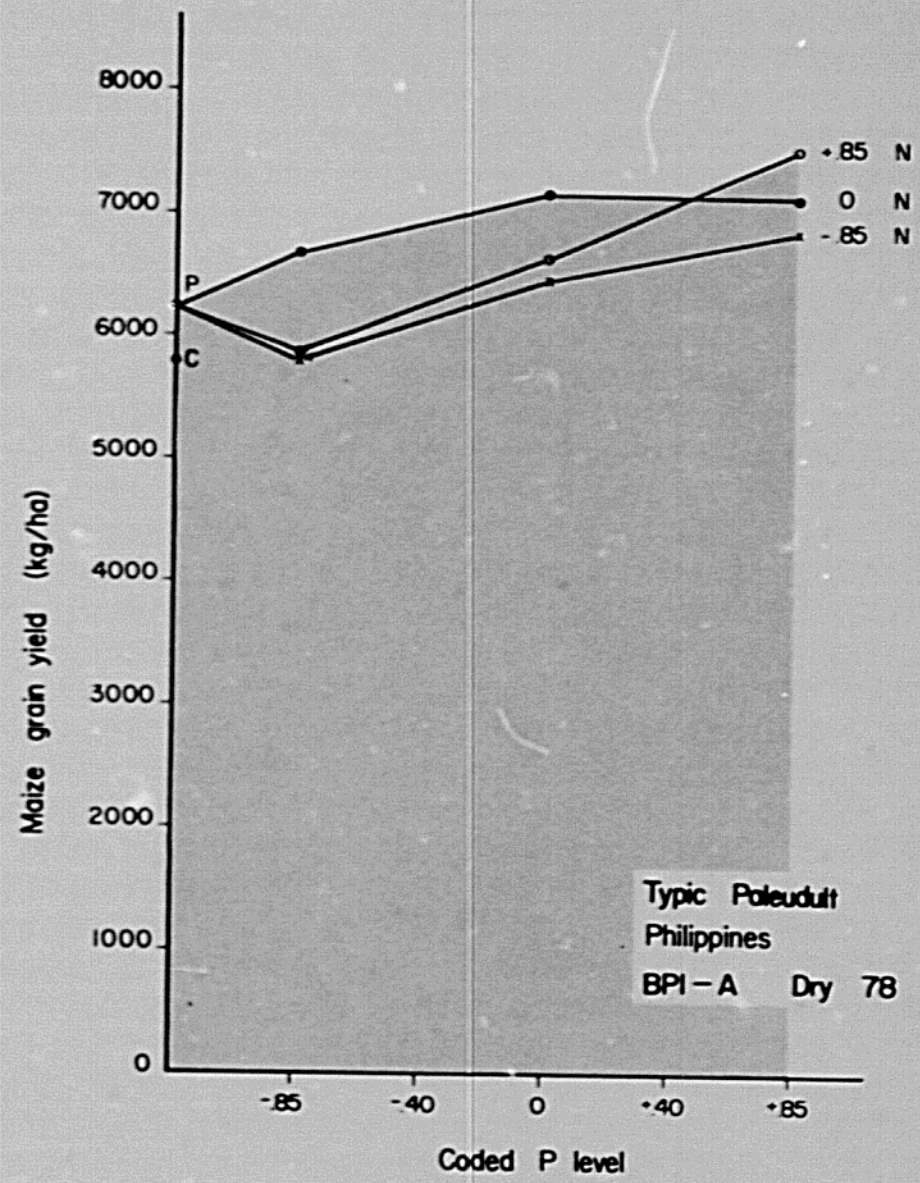


Fig. 10. Response of maize to coded levels of phosphorus and nitrogen, primary site/Philippines.

The theory is that the response of maize obtained in one country can be applied to sites on the same soil family in another country.

Philippines. Three residual P x lime transfer experiments were conducted during the dry season and all exhibited a large response to P application (Table 8, Appendix 2). There were occasional responses to lime, but the patterns were not consistent. Continued responses to P have occurred for 2 crops on some of these experiments, illustrating the continued availability of applied P. Five P x N transfer experiments were also carried out during the dry season. Yield responses were evident to the optimum P rate, and at higher P rates yields either remained constant or decreased. At the highest N rate, yields generally increased to the highest level of P (Fig. 8). Yields increased with increasing N to the optimum N level at the optimum P level in most experiments. At the highest level of P, yields generally increased to the highest N rate.

Hydric Dystrandept sites in the Philippines had been cultivated very little and thus had relatively low fertility. Yield responses were very striking for both P and N. Results of these transfer experiments illustrate why farmer practices of applying N fertilizer only did not produce satisfactory yields. Soil P levels were so low without added P that grain yields were zero or very low.

All three transfer experiments for the wet season 1978 were lost when Typhoon Weling struck the Bicol area and severely damaged the experiments. Therefore, no yield data are reported for this season.

Disease Incidence. Two varieties of maize known to be susceptible to downy mildew, a disease that is prevalent on maize throughout the tropics, were grown in the transfer experiments in Indonesia and the Philippines. Surprisingly, no incidence of downy mildew was found in the transfer experiments on 'UPCA Var. 1' in the Philippines, and less than 1 percent of the plants were infected in the transfer experiment using 'Harapan' in Indonesia. The Project believes the climatic environment of the isothermic regime of the Hydric Dystrandepts is unfavorable for the development of downy mildew; further tests are expected to confirm this.

Tropeptic Eutrustox Network

The first transfer experiments were harvested from the Waipio and Molokai sites in Hawaii (Table 9, Appendix 2). Marked response to both N and P occurred at all levels with maximum yields of 11 tons/hectare. The sites were former pineapple fields

and thus had relatively high native fertility. This was exhibited in the yields of the control plots, which were about 7 tons/hectare (Fig. 9). Yields on Molokai were about 1 ton lower than those at Waipio due to the average wind speed of 25 km/hour. This soil is situated in one of the best environments for high crop production in the State of Hawaii. It has high solar radiation and warm temperature, so that with adequate irrigation and fertilization, high yields are possible. These weather conditions are implied in the soil family name by the term "isohyperthermic," which refers to warm soil temperatures greater than 22°C, and to the term "ust," which implies that water must be supplied during the dry season. The need for irrigation during the dry season indicates there is little rain and thus abundant solar radiation during this season. This is in contrast to the Hydric Dystrandept sites, which occur in moist, overcast, cool environments and thus do not have the same yield potential possible as the Tropeptic Eutrustox (see Appendix 4, Weather Data, and Fig. 4).

Typic Paleudult Network

The first transfer experiments were harvested this year from the Typic Paleudult network (Table 10, Appendix 2). They were from the BPI site in Davao on Mindanao, the Philippines, which is the first site to become operational. A response to P was observed at all N levels, while response to N occurred to the optimum N level except at the highest rate of P where the maximum yield occurred with the highest rate of N (Fig. 10). The Typic Paleudult sites in Indonesia have recently become operational, and the first transfer experiment is scheduled to be harvested in late 1978.

Transfer Experiments with Soybean

Two soybean transfer experiments with P x lime variables were harvested at two sites each in Indonesia and Hawaii in the dry season 1977 (Table 11, Appendix 2). They were already planted when the decision was made at the annual meeting in August to change from P x lime to P x N and thus drop soybean as a test crop in the transfer experiments (see section on Changes in Research Design).

There was a general increase to P levels in all four experiments, and a mixed response to lime. Maximum yields of 2.9 to 3.5 metric tons were achieved at the

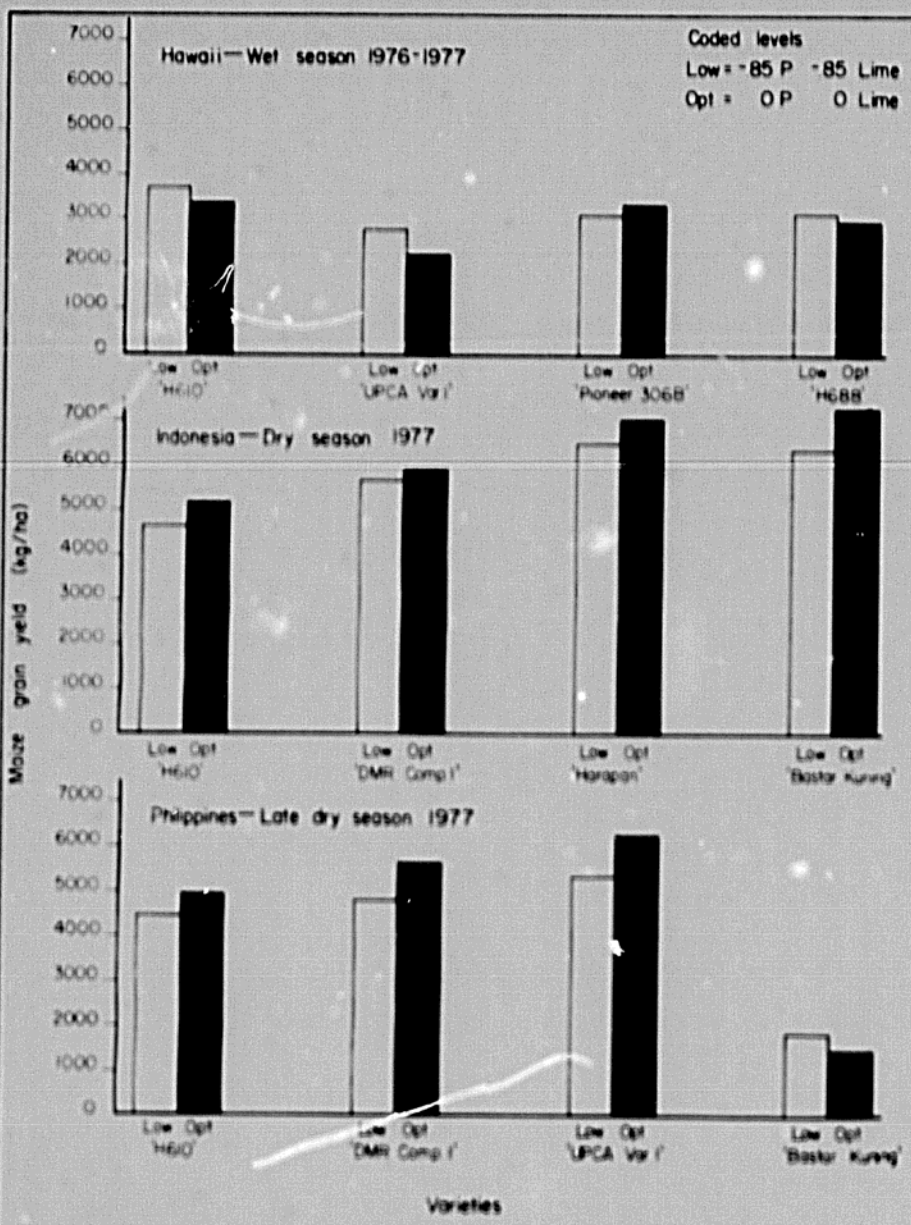


Fig. 11. Range of maize variety yields in 3 countries in the Hydric Dystrandept network.

four sites. Variety 'Orba', which had not been recommended for the isothermic upland soils of Indonesia previously had yields that were 75 percent over the soybean breeders' expectations at low elevations. The good agronomic management practices followed and the use of inoculum probably accounted for the good yields.

Variety Experiments Provide Performance Data

Whether or not the yield potential of a particular soil is realized also depends on the crop and the variety of that crop grown. In the transfer experiments in all 3 soil families, a variety of maize that is well adapted to the area is grown to avoid the complete loss of an experiment. Since we are conducting experiments over weather conditions ranging from a low-light intensity wet season to a high-light intensity dry season, we expect that one cultivar may not perform optimally during both seasons for each soil family. Another criterion used by the Project in selecting varieties for the transfer experiments is responsiveness to the variables being

In each country, the best adapted variety of maize is grown; these varieties are recommended by local research institutions.

tested, that is, phosphorus and nitrogen. Varieties are screened in experiments that have the appropriate fertilizer differentials.

Variety tests with maize confirmed the environmental adaptability of a given cultivar in a given network. Yield results to date indicate that a universal variety for all the sites is not presently available for a proper assessment of yield potential at all sites. A summary of varieties planted in the transfer experiments in all three soil families indicates the need to simultaneously plant both a variety experiment and a transfer experiment to identify a likely "best variety" for a given network. Fig. 11 shows the range of maize variety yields on the Hydric Dystrandept network. The following list summarizes the "best varieties" to date in each country in each family.

Soil family maize varieties

Country	Cultivar
Hydric Dystrandepts	
Hawaii	H610
Indonesia	Harapan
Philippines	UPCA Var. 1
Tropeptic Eutrustox	
Hawaii	Pioneer X304C
Puerto Rico[a]	Pioneer X304C
Brazil[a]	Pioneer X304C
Typic Paleudults	
Philippines	Tiniguib
Indonesia	H6

[a]Data provided by the Puerto Rico Project; see Progress Report 1.

Hydric Dystrandept Network

Hawaii. One variety experiment with P x N variables was conducted in Hawaii during the wet season (Table 12, Appendix 2). Several 'Pioneer' hybrids were included in the trial and generally outyielded the Hawaii varieties. Varieties 'Pioneer X304C, 816, 4817, and 5800' produced yields of 5 to 6 tons/hectare during the less than optimum season. It is interesting to note the 'Pioneer X304C' has also performed well in early growth at the Tropeptic Eutrustox sites in Hawaii and in final yields on the same family in Puerto Rico.

Indonesia. One variety experiment with P x lime variables and one with P x N variables were installed in the dry and wet seasons, respectively (Table 13, Appendix 2). Indonesia varieties 'Bastar Kuning' and 'Harapan' gave the highest yields of about 6 tons/hectare and about 3 tons/hectare in the dry and wet seasons, respectively. 'H610' from Hawaii and the Philippine varieties 'DMR Comp. 1' and 'UPCA Var. 1' produced less grain, but they still gave acceptable yields (see Fig. 11).

Philippines. One variety experiment with P x N variables for maize was conducted at the primary site during the dry season (Table 14, Appendix 2). The Hawaii varieties 'H610' and 'H688' gave the highest yields, which were not different from those of 'UPCA Var. 1' (Philippine variety) or 'Bima' and 'H6' (Indonesia varieties). 'UPCA Var. 1' has been used in transfer experiments in the Philippines in the Hydric Dystrandept family.

Tropeptic Eutrustox Network

No variety experiments have been completed to date because these sites were recently established; however, these experiments are already in the ground and results will be reported in the next fiscal year.

Typic Paleudult Network

No variety experiments have been completed to date because these sites were recently established; however, these experiments are already in the ground and results will be reported in the next fiscal year.

Variety Experiments with Soybean

A soybean variety trial with a P x lime fertility differential was conducted in Indonesia in late 1977 (Table 15, Appendix 2). Indonesia variety 'Orba' was the highest yielding variety, followed by variety 'Shakti', also from Indonesia. Soybean varieties from Hawaii and the Philippines gave significantly lower yields.

Disease Incidence

Although the yield potential of a particular soil is reflected in the soil family name to a great degree, the actual yields attained can be greatly influenced by diseases that can be devastating to crops. Therefore, the kind and severity of

The farmer receives technology tailored to his needs.

diseases are being recorded at all experimental sites.

On the Hydric Dystrandept sites, maize was affected by northern leaf spot (*Helminthosporium turcicum*), rust (*Puccinia sorghi*), and downy mildew (*Sclerospora maydis* Rac. Butler), and soybeans were affected by rust (*Phakospora pachyrhizi*), Cercospora leaf spot, and powdery mildew (*Oidium* Sp.). In some cases, the diseases were confined with proper sprays so that damage was small, but in others, damage was severe. Resistant varieties are being used wherever they are available.

An interesting observation that has been made on the Hydric Dystrandept sites in the Philippines and Indonesia is that although downy mildew is present in the area and susceptible varieties are being grown, no incidence of the disease has occurred in the Philippines and only minor incidence (less than 1 percent) has occurred in Indonesia. If this is substantiated in the future by additional data, this may imply that the isothermic temperature regime is not favorable for the development and growth of the disease, so that it is not a serious threat to maize. This would be transferable information based on the soil family.

Management Experiments Demonstrate Critical Soil Family Practices /Hydric Dystrandept Network

Management experiments are conducted to study agronomic problems to identify practices for local farmers with limited resources. The objectives of management experiments are (1) to provide information to local government agencies 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 improve crop yields at different levels of management. These tests should eventually lead to determination of the most economic and efficient agricultural practices for each country and information for subsequent soil interpretation and land capability classification.

Experiments carried out include tests to determine the limiting nutrients in a soil, the proper amounts of phosphorus to be applied at various band widths, the effects of organic manure, spacing of corn plants, residual effects of phosphorus and irrigation, weed control, insect and disease control, and other necessary management practices required.

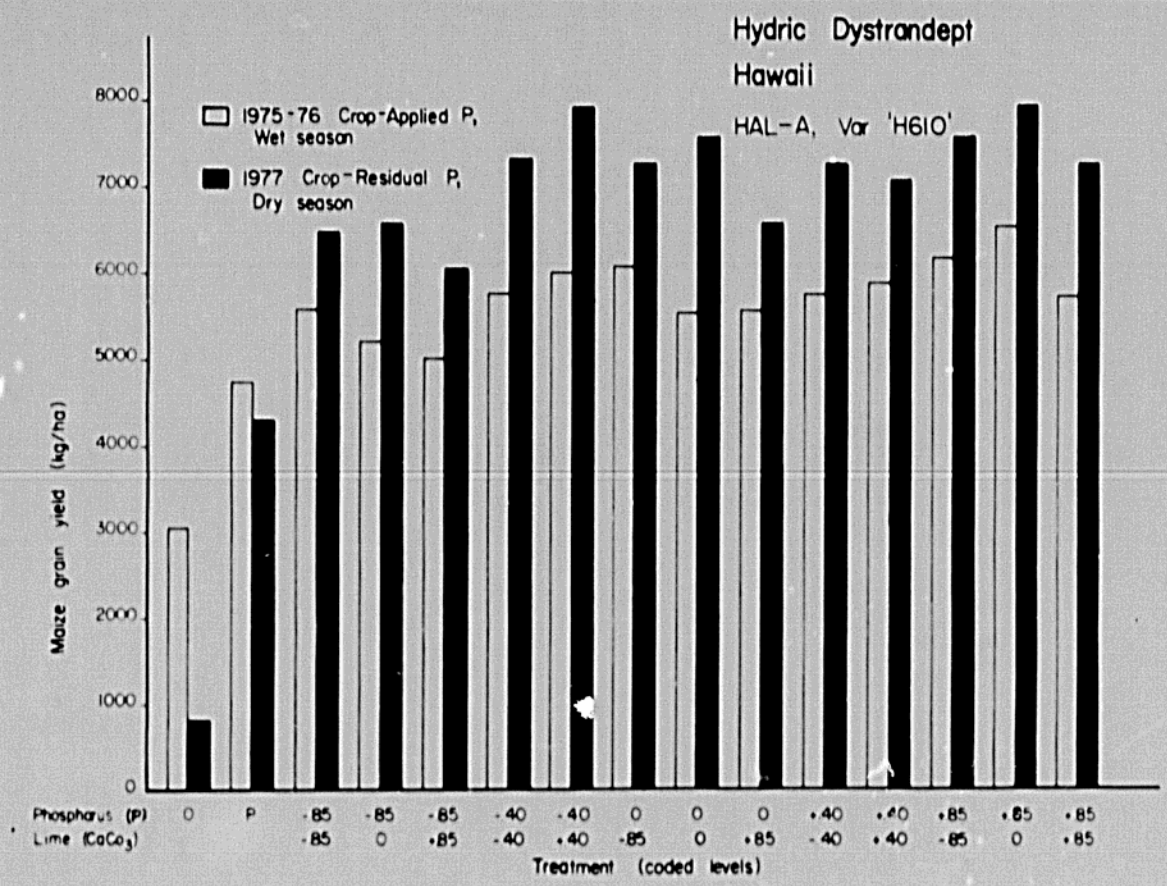


Fig. 12. Maize grain yield for initially applied and residual phosphorus x lime experiment.

Residual Fertilizer

Irish potatoes were planted on three former soybean transfer experiments in Indonesia. Only an additional 138 kg N and 120 kn K/hectare were added to the plots. The highest tuber yields achieved were 15 to 18 tons/hectare; maximum yields were obtained with the highest P and lime treatments. This indicates that the initial cost of P fertilizer and lime can be considered a capital investment that can be amortized over more than the first crop, thus reducing the net cost of fertilizer per crop.

Residual P and lime experiments with maize were conducted throughout the network to demonstrate this cost savings. Comparable, or in some cases greater, yields were obtained from the residual crop. A third crop of maize on HAL-A for the 1978 dry season had an average yield of 8046 kg/hectare, which is higher than both the 1975-76 wet season and 1977 dry season yields shown in Fig. 12.

Nutrient Requirements of Maize and Soybeans

An experiment was designed to determine the optimum N and P application rates for maize by installing an NPK experiment at ITKA, Indonesia. Nitrogen rates ranged from 0 to 160 kg/hectare, and phosphorus rates ranged from 0 to 120 kg/hectare.

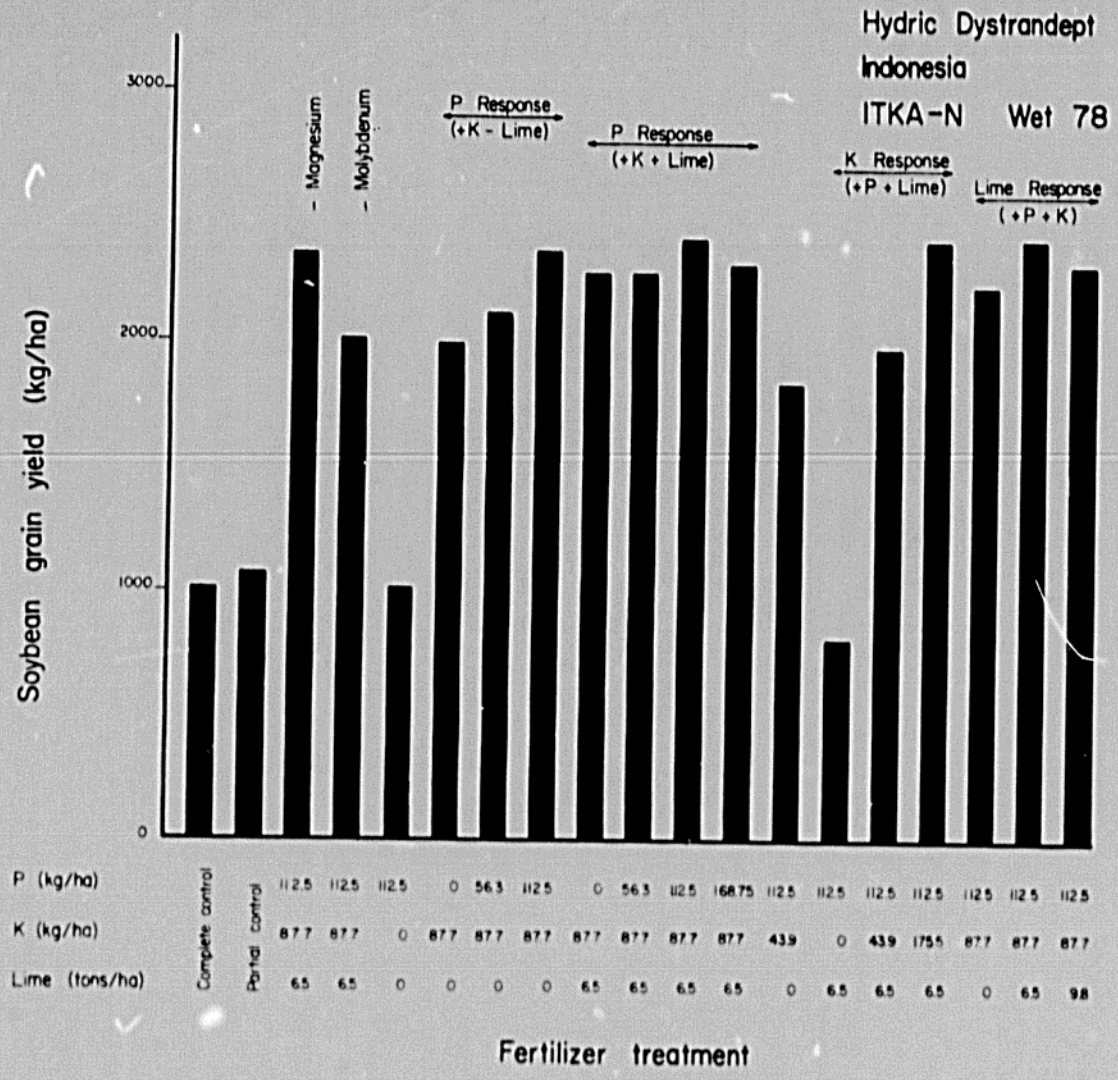


Fig. 13. Soybean response to phosphorus, potassium, and lime.

Highest yields were obtained with 120 kg P, 40 kg N, and 100 kg K/hectare; however, there was no significant yield difference between 0 and 100 kg K/hectare. Response to N at this site was quite erratic and was not shown to be significantly different. Addition of the "blanket" fertilizer treatment only, which consisted of 100 ppm Mg, 15 ppm Zn, and 2 ppm B, increased yields significantly over the control treatment, which received no fertilizer.

Two experiments were installed to determine the P, K, and lime requirements of soybean variety 'Orba' on the Hydric Dystrandept sites in Indonesia. Adequate amounts of nutrients appeared to be 113 kg P/hectare, 88 kg K/hectare, and 4.3 to 6.5 tons lime/hectare, depending on the site. At the ITKA site (Fig. 13), the minus Mg treatments reduced yields only slightly from the treatment with Mg, but leaving out Mo caused a yield decrease of about 400 kg/hectare. Experiments of this type indicate the kind and level of nutrients required by a crop in a particular soil family.

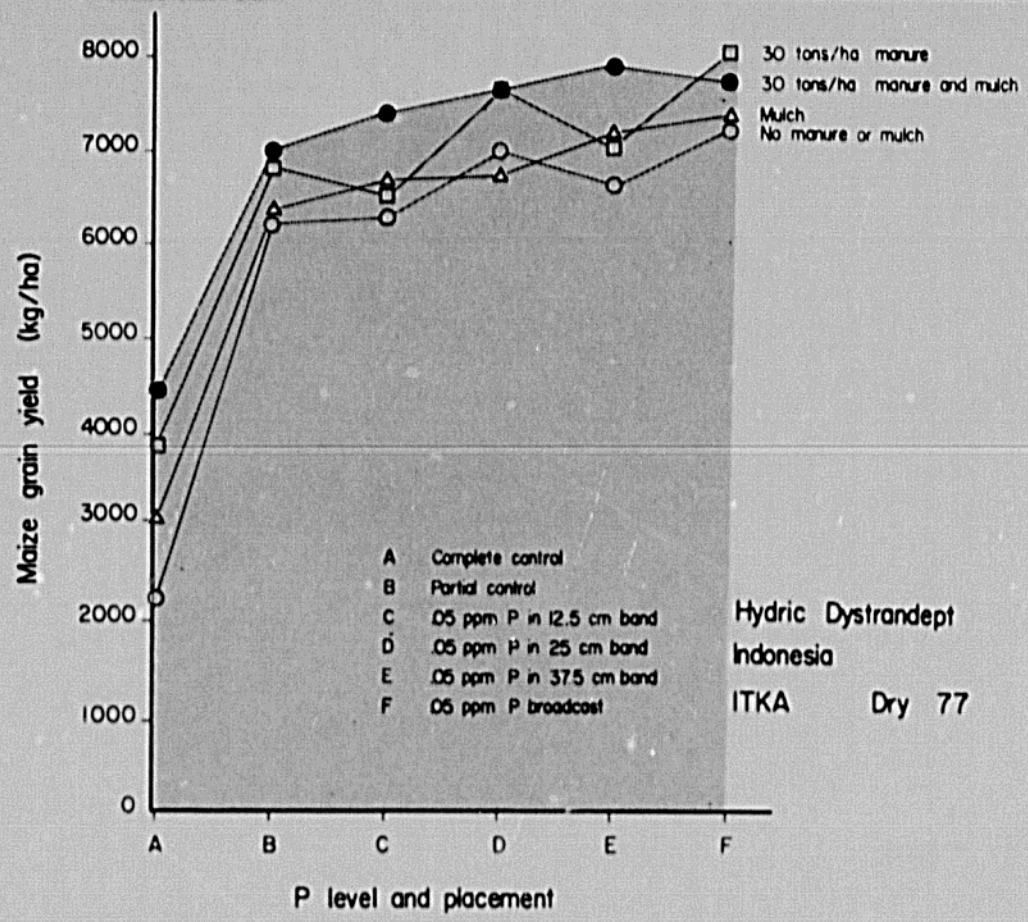


Fig. 14. Effect on maize grain yield of manure and mulch with phosphorus placement.

P Placement x Organic Manure on Maize

This experiment was installed in 1977 at the primary site (ITKA) in Indonesia on the Hydric Dystrandept soil. There are 4 P placement treatments: broadcast, 37.5-cm wide band, 25-cm band, and 12.5-cm band. The amount of P applied is to provide 0.05 ppm P in solution to the fertilized area. There is also a control plot that receives "blanket" application of fertilizer, consisting of Mg, Zn, and B and a complete control plot that receives no fertilizer at all. The organic manure treatments are farmyard manure (FYM) and maize stover mulch. These treatments are applied in factorial combination. Four crops will be planted in this experiment, and additional P will be added in the banded P treatments so that the same total amount of P will have been added to all P plots by the time the fourth crop is planted in early 1979. Maize variety 'Harapan' is being grown.

The broadcast P application with 30 tons/hectare of FYM and mulch gave the highest yields (Fig. 14). Addition of both FYM and mulch gave consistently higher yields over all P treatments than either organic manure alone. Results of this experiment indicate that local farmers may realize yield increases at low cost by the

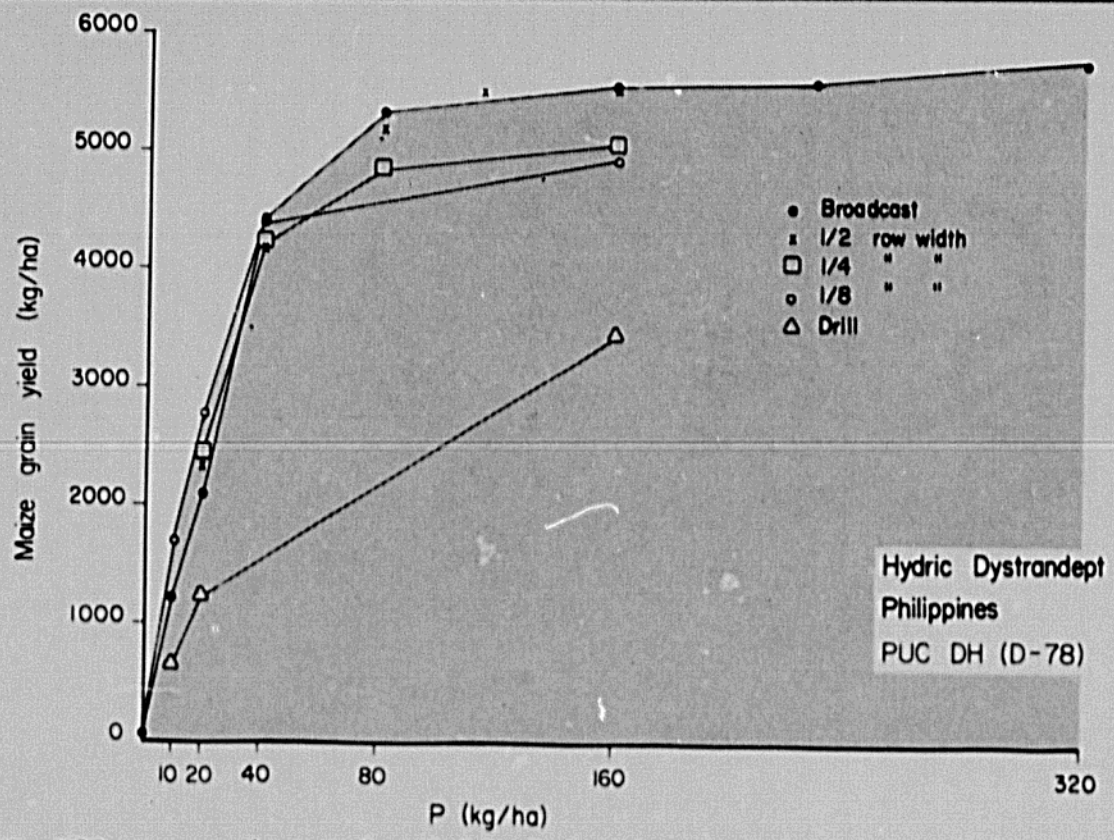


Fig. 15. Effect on maize grain yield of phosphorus placement using drill, banding, and broadcast methods.

addition of maize stover mulch or FYM, and also indicates whether the same yields can be obtained from one large application of P, which requires considerable capital for the first crop, as from 4 small applications of P, which requires less capital per crop.

Maximizing the Effect of Low P Inputs

Considering that Hydric Dystrandepts and similar soils require large amounts of P fertilizer, which is expensive for small farmers with limited capital, a P rate X placement management experiment was installed in March 1978 at the PUC site in the Philippines to determine the most efficient utilization of low rates of P fertilizer. Rate treatments ranged from 10 to 320 kg/hectare. Placements included broadcast application with incorporation (100% of tillage layer = 1) decreasing by steps to a band width of 9.8 cm (1/8 of the tillage layer fertilized), and finally a drill application in a small band to the side and below the seed row (see Table 16, Appendix 2, for complete list of treatments).

The yield results for the first maize crop (Fig. 15) indicate a negative effect from restricted placements at high rates of 80 kg/hectare or above, however, at the low rates of 10 and 20 kg/hectare, yields 39 and 32% higher than the broadcast treatments, respectively, were obtained from the 1/8-band width placement. Thus,

even for the first crop, placement increases the efficiency of the P fertilizer applied and the increased yield due to placement in these two cases is more than adequate to pay for the P fertilizer at these rates. Restricted placement is also expected to increase the residual effect of phosphorus and the experiment will be replanted in 1979 and 1980 to quantify this effect. These initial results show promise for developing fertilizer application methods that maximize returns from small P application on soils with high P fertilizer requirements.

Increase of Use of Soil Classification to Formulate Agricultural Development

The state-of-the-art on uses of soil classification for agricultural development in developing countries is presented in the book Soil-Resource Data for Agricultural Development, edited by L. D. Swindale and published by the Hawaii Agricultural Experiment Station and the Benchmark Soils Project. Portions of the book include case studies of agricultural planning using various national and international classification systems. Effective agroproduction technology transfer hinges on the international adoption of a standard soil classification system, based on uniform standards, to enable communication and exchange of information by means of a common taxonomic language. Soil Taxonomy, the system of soil classification developed by the Soil Conservation Service of the U.S Department of Agriculture, is the most comprehensive and widely accepted system today.

The system in Soil Taxonomy, however, requires further refinements in the classification of soils of the tropics where information is largely incomplete. The Benchmark Soils Project is assisting in gathering soils data and increasing information exchange within a network of tropical soils. Because of the Benchmark Soils Project approach, the value of soil classification and Soil Taxonomy is becoming increasingly evident to host-country cooperators, as shown in the sections below.

Indonesia to Adopt Soil Taxonomy

At the conclusion of the Soil Classification Workshop held in April 1978 at Cisarua, Indonesia, it was agreed that the National Classification of Indonesia should be related to Soil Taxonomy. Specific soil characteristics, as defined in

Soil Taxonomy, were the basis for discussions of soil classification at the conference. Copies of Soil Taxonomy were ordered through the Benchmark Soils Project by the Soils Research Institute (SRI), who hosted the 2-day working seminar, for distribution in Indonesia.

Soils in Sumatra Being Classified According to Soil Taxonomy

The SRI in Bogor, Indonesia, is currently carrying out soil surveys in Sumatra to identify extensive and important soils on which experiment stations will likely be established. This is a cooperative effort between the Ministry of Agriculture and USAID/Jakarta. The Central Resource Institute for Agriculture (CRIA) and SRI are the key government agencies. Soils are being classified in both the national soil classification system and Soil Taxonomy to minimize site-specific research and to establish a common base to receive and share information with others with similarly classified soils.

Areas common in West and South Sumatra are currently being surveyed. Early indications show that the predominant soils are Ultisols, particularly Tropudults and Paleudults.

Soil Taxonomy Focus of Conference in Malaysia and Thailand

Participants at the Second International Soil Classification Workshop held in Malaysia and Thailand in August-September 1978 critically examined the taxonomy of certain classes of tropical soils and formulated a series of recommendations for Soil Taxonomy and associated subjects that may well serve as the framework for future international activities in soil classification. Chaired by Fred Beinroth, Principal Investigator of the Benchmark Soils Project/Puerto Rico, the conference was attended by Hawaii scientists Goro Uehara and Haruyoshi "Ike" Ikawa. It was obvious at the workshop that Soil Taxonomy is emerging as the de facto language for international communication. For communication with each other, soil scientists are increasingly relying on Soil Taxonomy, which is thus becoming a unifying element of pedology and the basis for agrotechnology transfer.

Soil Data Bank Expanding

To extend the concept of transference of agrotechnology on the basis of the

The Soil Data Bank can serve as a focal point in establishing an effective network of research stations throughout the tropics.

soil family in Soil Taxonomy to other potential users, the Benchmark Soils Project, in association with the Consortium on Soils of the Tropics (CST) and the Hawaii Agricultural Experiment Station (HAES), has expanded their Soil Data Bank to include soils of experimental locations in the tropics.

The Benchmark Soil Data Bank is a computerized system of data storage and retrieval that can be used to perform standard statistical analysis for interpreting soils data for different uses. Soil descriptions are stored either as a text or in a coded form, and chemical and physical data are stored as numbers. These data, as well as derived or calculated data, can all be easily and quickly retrieved. The Project is also planning to develop a framework through which soil, crop, and weather information can be stored and combined to produce soil interpretation files.

One of the objectives of the Project is to be a "storage house" of soils and soil-related data of the important agricultural research stations of the tropics. The Project, it is hoped, will be able to furnish participants the soil classification names, according to Soil Taxonomy, of their soils. The data will be reproduced in a standard format similar to that in the Soil Survey Investigation Reports published by the Soil Conservation Service, USDA. Information on soil interpretation may become available as criteria for agricultural or nonagricultural land uses are established.

The Soil Data Bank can serve as a focal point in establishing an effective network of research stations throughout the tropics. For the first time, this allows participants--scientists and planners--to share and exchange data of mutual interest. Efforts toward this goal are now underway, but utilization of data bank information by participating countries is still in the future.

Other Accomplishments

Assistance to Agriculture Project, USAID/Jakarta

The Benchmark Soils Project participated in the annual project evaluation for Project 497-0189, Assistance to Agriculture of USAID/Jakarta. This Mission-funded project provided an "umbrella" for the Benchmark Soils Project to sign a cooperative memorandum of agreement with the Soil Research Institute and to facilitate receipt of

materials and equipment from Hawaii during the first 2 years of the Project.

Project 497-0189 was terminated in September 1978; however, umbrella coverage of the Project continued under the Agricultural Development Planning and Administration Project as per Project Agreement Revision Number 2. Such expressed cooperation from both the Ministry of Agriculture and the USAID Mission to the Benchmark Soils Project represents, in part, the enthusiasm and support of Project concepts and activities.

Expanded Housing and Staff Additions in Hawaii

Space needs on the University of Hawaii Manoa Campus have been alleviated by the relocation of the Benchmark Soils Project offices and laboratory to Krauss Hall, formerly the Pineapple Research Institute. Office area increased from 200 square feet to nearly 1500 square feet. The additional space finally allowed the Project to fill staff positions for an editor, a computer programmer/statistician, and a training coordinator to meet the expanded Project objectives of the first extension phase.

Provisions for additional space by the College of Tropical Agriculture are indications of support by the University of Hawaii for programs in international agriculture.

Changes in Research Design

Measurement of Soil Phosphorus

The phosphorus-sorption method of Fox and Kamprath (1970[a]) was initially used to determine the amount of P to be added to each plot to attain the differential P treatments. Several problems became evident. (1) The very low concentrations of P remaining in solution for samples to which no or little P had been added were below the level of detection on the spectrophotometer. Readings could be made, however, from the chart on a P autoanalyzer for these low samples. (2) Variability was quite high, especially on samples with low amounts of P in solution, even when determined

[a]R. L. Fox and E. J. Kamprath. 1970. Phosphate sorption isotherms for evaluating the phosphate requirements of soils. Soil Sci. Soc. Amer. Proc. 34:902-907.

Comparison of P isotherm and modified Truog methods for measuring P in solution with the same soil sample (Burabod B) (average of three replicates)

P added	P Isotherm P	P Isotherm CV	Modified Truog P	Modified Truog CV
µg/g soil	ppm	%	ppm	%
0	0.005	26.0	0.047	7.0
500	0.012	13.5	0.833	1.6
1000	0.031	5.8	2.22	2.4
1500	0.074	19.9	3.93	0.4

with the P autoanalyzer. (3) This variability was transmitted to the field since the amount of P added to an individual plot was based on the amount of P sorbed by a sample from that plot. This resulted in high coefficients of variation for yield. (4) The recommended level of P in solution for 95% of maximum yield was found to be too high for the families of Hydric Dystrandepts and Tropeptic Eutrustox being studied since there was little or no yield response above the lowest P level.

Because of these problems, a soil chemist, Dr. T. M. Lai, was hired as a consultant to try to improve the P-sorption method and also compare it with the Modified Truog, Modified Bray No. 1, and Olsen methods for soil P. The P-sorption method was found to have greater variability than the other methods, especially at low P levels, and required greater care in determination (see chart top of this page).

Since large numbers of soil samples must be analyzed in a short time, a method that was more suitable for routine analysis was sought. Evaluation of the methods indicated that P measured by the Modified Truog and Modified Bray No. 1 methods was more highly correlated with yield than was P measured by the P-sorption or Olsen methods. Therefore, the Modified Truog and Modified Bray No. 1 methods are being used to assess soil P, and calibrations are continuing with results of current experiments to establish the adequate level of soil P for maize. Indications are that the tentative levels established for these two methods are resulting in P levels that are giving good yield response curves with a yield plateau being reached at the higher P rates.

The techniques used to measure amounts of P remaining in the soil after cropping and the amount of P required to reestablish the original P level was modified also. The equilibration time for standard P solutions with soil samples was reduced from 6 days to 1 day, and the P extracted from the soil is now determined instead of the amount of P remaining in solution. The P-extraction method resulted in a higher concentration of P to be measured and, consequently, minimized variability due to instrumentation as indicated in the chart above. This departure from our early techniques retains the good qualities of both the sorption and extraction methods.

Plot Size

Plot size was increased from 3 x 6 meters to 3 x 8 meters to increase the amount of material harvested so that more stable yield data could be obtained. This change was suggested by the statistical consultant in the Project. Change in plot size was not possible at all sites, however, because some experiments had already been established and fertilizers applied. As new experiments are installed, the larger plot size is being used.

Additional Treatments

Two additional treatments were suggested by the Project's statistical consultant for inclusion wherever space permitted. These are no P with optimum N and optimum P with no N. These treatments provide information on the response to N alone and to P alone to indicate the relative importance of these two nutrients. In areas where several seasons of data on the unfertilized control have been obtained, the treatment is being dropped and one of the two treatments mentioned above is being included The new experiments also have 16 plots per replication rather than 15, wherever possible, so that the two treatments mentioned above can be included. These treatments are useful for agronomic interpretation but are not included in the analysis of the 13 design variables that are being used to test the transfer hypotnesis.

Dissemination and Utilization of Research Results

Awareness of Project goals has been disseminated through training programs, meetings, workshops, conferences, and publications. The Project has an important role in the growing network of communicating and cooperating research institutions focusing on the food problems of the tropical world, and linkages with international agricultural research centers are maintained through regular mailing of various publications and through correspondence and visitors.

Papers and Publications

Publication of two brochures describing the Project, the first in English, French, and Spanish, and distribution to our international mailing list of approximately 1000 persons, preceded publication of the joint Puerto Rico and Hawaii Progress Report in September 1978. The Benchmark Soils News, a quarterly newsletter, was printed and distributed to our regular mailing list throughout the year.

Currently in process are the following publications, all of which are expected to be completed in the next fiscal year: Proceedings of the Workshop on Experimental Design (HAES DP 49); Leaflet 2, in Spanish; Leaflet 3, Soil Data Bank, in English and Spanish; Technical Report 1, Laboratory Data and Analysis of Sites of the Benchmark Soils Project--Vol. 1, Hawaii; Technical Report 2, Soil Series of Hawaii: Classification in Four Systems--A Guide to Correlating Tropical Soils; Technical Report 3, Report on Phosphorus-Level Methodology; Technical Report 4, Soil Classification of the Hawaii Agricultural Experiment Station; and Technical Report 5, Indonesia's Report on the Crop Production and Land Capabilities of the Hydric Dystrandepts. In addition, a slide presentation of the Project for cassettes is in production and is expected to be completed in fiscal 1978-79.

Benchmark Soils News Issued Quarterly

The Benchmark Soils News was first printed in March 1977 to disseminate information on Project activities and on the progress of Project planning to in-country cooperating government agencies and institutions, local AID missions, and other interested parties. Combining contributions from Project personnel in Brazil, Hawaii, Indonesia, the Philippines, and Puerto Rico, the News is produced and printed by the

Hawaii Project for worldwide distribution. It is mailed regularly to over 1000 persons.

Hardbound Book Printed

The book entitled Soil-Resource Data for Agricultural Development, edited by L. D. Swindale and published by the BSP through the Hawaii Agricultural Experiment Station, was printed and is expected to be ready for distribution at the conference at ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) in October (see section on Seminars and Workshops). This book is the end-product of the seminar on the "Uses of Soil Survey and Classification in Planning and Implementing Agricultural Development in the Tropics" held in Hyderabad, India in 1976.

Progress Report Compiled

A joint report from the Universities of Hawaii and Puerto Rico, a compilation of BSP's achievements from 1974 to December 1977, was titled Research on Agrotechnology Transfer in the Tropics Based on the Soil Family. It was being prepared by the Hawaii Project for distribution in October 1978. A summary of Project objectives, the report explains the concept of agrotechnology transfer, reports on field activities, and describes existing information dissemination activities.

Brochures Prepared

Two brochures describing the Project were prepared for a quick overview by planners, scientists, and other interested people. Leaflet 1, A Key to Agrotechnology Transfer, was published in English, French, and Spanish; Leaflet 2, Basic Information, was published in English and is being translated into Spanish for publication in October 1978.

Seminars and Workshops

Second International Soil Classification Workshop

In late August and early September the Second International Soil Classification Workshop was held in Malaysia and Thailand. Participants critically examined the taxonomy of certain classes of tropical soils and formulated a series of recommen-

It will be determined which systems of soil classification are used in tropical countries and how they relate to the Soil Taxonomy.

dations for Soil Taxonomy and associated subjects. It was obvious at the workshop that Soil Taxonomy is emerging as the de facto language for international communication. The workshop was financed by AID through a grant to the University of Puerto Rico, and cosponsored by the Department of Agriculture of Malaysia, the Land Development Department of Thailand, and the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA). Technical assistance was provided by the Consortium of Soils of the Tropics (CST), the Soil Conservation Service, USDA, and the University of Ghent, Belgium. The conference was organized by the National Soil Survey of Malaysia and the Soil Survey Division of the Land Development Department of Thailand. F. H. Beinroth, Principal Investigator of the Benchmark Soils Project/Puerto Rico, chaired the conference; H. Ikawa and G. Uehara represented the Hawaii Project at the conference.

Workshop on Soil Research Inventory and Evaluation

The Philippine Council for Agriculture and Resources Research (PCARR), the Philippine Bureau of Soils, and the Soil Science Society of the Philippines sponsored a 3-day national conference-workshop on Soil Resources Inventory and Evaluation for Countryside Development on January 18-21, 1978 in Manila. A major component of the workshop was the use of Soil Taxonomy in development planning. Group sessions identified the need for soil resources inventory by farmers, researchers, and planners and resulted in proposals for soil resources inventory programs to support development planning. M. E. Raymundo and A. A. Briones were participants from Benchmark at this workshop.

Land Evaluation Standards Workshop

Goro Uehara attended a meeting sponsored by the FAO in Rome, Italy, on October 25-28, 1977, entitled Expert Consultation on Land Evaluation Standards. The Benchmark Soils Project is expected to contribute significantly to the quantification of land quality, a new concept of land evaluation that was highlighted at the meeting. The meeting was called to obtain expert advice on the assessment of land suitability for the world's most important food crops grown under "traditional" (low capital intensive) and "improved" (more capital intensive) agricultural prac-

The information derived will provide decision-makers with alternatives for the agricultural development planning policy of their region or country.

tices, and as they relate to the major agro-ecological zones. Such data may later be useful in evaluating land quality--a complex attribute of land that integrates the effect of individual land characteristics and exerts influence on the suitability of land for a specified kind of use..

Minimum Sets of Data for Field Experiments Workshop

M. E. Raymundo presented a paper on Minimum Sets of Pedological Data for Field Experiments at the seminar-workshop in Los Banos, the Philippines, on September 29-30, 1978. The conference was organized by PCARR and was related to their technology development and dissemination program.

Workshop on Operational Importance of Agrotechnology Transference

The Benchmark Soils Project concepts will form the core of the discussion at a workshop to be held in India in October 1978 entitled the Operational Implications of Agrotechnology Transference Research and sponsored by ICRISAT (International Crops Research Institute for the Semi-Arid Tropics). J. A. Silva, Principal Investigator/Hawaii, will present a progress report of the Project since its inception in 1974. G. Uehara and H. Ikawa will prepare a position paper on assembly of information, reliability testing, and transference of knowledge (including assembling pedologic and performance data; determining the range of applicability of results; dissemination of information; and the Soil Data Bank). This workshop is a follow-up to the workshop held in Hyderabad in January 1976 and illustrates the continuing effort of research organizations in the tropical world to cooperate in information exchange and utilization.

Soils with Variable Charge Conference

The Benchmark Soils Project has been extended an invitation by Commissions IV, V, and VI of the Internatiolnal Society of Soil Science through Dr. Mike Leamy of the New Zealand Soils Bureau to participate in an international conference entitled "Soils with Variable Charge" in Palmerston North, New Zealand, on February 11-18, 1981. A full day has been set aside for a symposium on the Benchmark Soils Project. Project personnel have been asked to prepare a program for that day. The conference

is being held under the auspices of both the New Zealand Society of Soil Science and The Royal Society of New Zealand.

Correspondence and Visitors/Linkages

A list of the people and organizations who have corresponded and visited with Project personnel follows on pages 46-48.

With each issue of the Benchmark Soils News and other publications, our national and international affiliations increase. Included in the over 1000 names on the computerized mailing list are international agencies, national organizations, and universities. Technical publications from the BSP are sent to the 50 land-grant colleges and approximately 120 U.S. and Hawaii libraries and institutions. A copy of the mailing list can be obtained by writing the Hawaii Project.

LDC Involvement and Feedback

The utilization of concepts developed by the Benchmark Soils Project for effective land-use planning is being initiated in both Indonesia and the Philippines.

In Indonesia, the Soil Research Institute (SRI) established its own experimental site on a soil family in Ultisol order in Lampung, South Sumatra, in the latter part of 1977 using Benchmark Soils Project concepts and methodology. Analyses are underway to characterize the soil in Sumatra and identify the family. Currently, there is an ongoing resettlement program to distribute the population center from Java to Sumatra, and to ease the trauma of transmigration, there is an urgent need to determine and transfer knowledge of the management practices best suited for the Ultisols. Indonesians have learned that the farming practices used on the Andepts in Java cannot be transferred to the Ultisols in Sumatra. This application of Benchmark Soils Project concepts on soils other than the three test families demonstrates the importance of soil classification to needs of individual countries. Similar activities will be extended to other important soil families in Indonesia. The SRI has a key role in identifiying the soils at nine agricultural stations that are established or to be established in Sumatra.

Visitors

Name	Country	Purpose of visit	Result
Hawaii			
R. L. Cunningham The Pennsylvania State University	U. S.	To discuss concepts and goals of Benchmark Soils Project and land use planning in Hawaii.	Visited with project personnel, Soil Conservation Service and Department of Planning and Economic Development.
G. Olson Cornell University	U. S.	To discuss concepts and goals of Benchmark Soils Project and land use planning in Hawaii.	Visited with project personnel, Soil Conservation Service and Department of Planning and Economic Development.
D. Muljadi Soil Research Institute	Indonesia	To consult with project personnel and coordinate project efforts in Indonesia.	Visited project and College personnel. Visited Benchmark sites.
D. M. Leslie New Zealand Soil Bureau	New Zealand	To discuss operations of the project and study some of the soils of Hawaii. To meet staff of Soil Conservations Service to discuss Soil Taxonomy and aspects of soil calssification.	Visited with project personnel and inspected Benchmark sites. Studied soils on Oahu and Hawaii.
D. Pedersen Practical Concepts, Inc.	U. S.	To discuss concepts and goals of Benchmark Soils Project.	Visited with project personnel and field trip to sites on Island of Hawaii.
J. McCullough Public Affairs, USAID	U. S.	To discuss concepts and goals of Benchmark Soils Project	Met with project personnel.
W. C. Tappan M. J. Korin USAID/Jakarta	Indonesia	To meet with project personnel and coordinate project efforts in Indonesia.	Met with project personnel and visited experiment sites.
J. L. McIntosh Cooperative CRIA-IRRI Program	Indonesia	To discuss concepts and goals of Benchmark Soils Project.	Met with project personnel.
W. Liwgasemsarn National Economic and Soil Development Board	Thailand	To discuss concepts and goals of Benchmark Soils Project.	Met with project personnel.
E. C. Alocilla L. A. Brion L. G. Nallana Philippine Council for Agriculture and Resources Research	Philippines	To discuss concepts and goals of Benchmark Soils Project and existing coordinated project efforts between PCARR and Benchmark Soils Project in the Philippines.	Met with project personnel.
N. Chien International Fertilizer Development Center	U. S.	To discuss possible cooperative efforts on phosphorus sources experiments.	Discussed possibility of UH/IFDC agreement with Benchmark personnel. Visited experiment sites.
G. W. van Barneveld FAO Soil Resources Project	Cameroon	To discuss operations of the project in Cameroon and possible agreement between University of Hawaii and IITA or ONAREST.	Met with project personnel and drafted Hawaii-IITA agreement.
M. Leamy New Zealand Soil Bureau	New Zealand	To discuss inclusion of Benchmark Soils Project in Inernational Workshop, 1981.	Outlined a one-day symposium on Benchmark Soils Project.
T. Kosaki Kyoto University	Japan	To discuss operation of Benchmark Soils Project data bank.	Shown the retrieval capability of the soil data bank with sample data of a soil.
R. Isbell CSIRO	Australia	To meet with project personnel and study soils of Hawaii.	Taken on a field trip to see Oxisols and Ultisols of Hawaii.

Visitors

Name	Country	Purpose of visit	Result
Indonesia			
Benchmark Soils Project Technical Committee Members S. Effendi S. Partohardjono N. Sumarlin Iskandar Wagiyono M. Soepraptohardjo M. Soepartini	Indonesia	To attend second Technical Committee meeting; inspect sites.	Visited transfer, variety, and management experiments at PLP and ITKA sites. Met and discussed Project plans with Benchmark Soils Project personnel.
J. A. Silva G. Y. Tsuji University of Hawaii, Benchmark Soils Project	U. S.	To participate in discussion and evaluation of USAID "Assistance to Agriculture" Project. To meet with Benchmark Soils Project personnel regarding project operations.	Met with USAID Mission personnel to discuss existing and future cooperative efforts between Benchmark Soils Project and Assistance to Agriculture Project. Met with Benchmark personnel and inspected sites.
W. C. Tappan M. J. Korin USAID/Jakarta D. Muljadi Soil Research Institute	Indonesia	To visit maize, soybean, and potato transfer, residual, fertility, variety and management experiments.	Field trip to experiment sites. Discussions with Benchmark personnel regarding progress of experiments.
Agricultural Extension Soil Specialists of Indonesia (25 participants)	Indonesia	To orient participants on project methodologies and objectives.	Field trip to ITKA experiment sites. Presentation on project objectives.
W. R. Gardner University of Wisconsin-Madison	U. S.	To visit project sites and provide orientation of project.	Field trip to experiment sites to observe drip irrigation and weather instruments.
E. F. Mass Land Evaluation, CIDA	Indonesia	To visit project sites and provide orientation of project.	Field trip to experiment sites. Met with project personnel.
B. T. Kang International Institute of Tropical Agriculture	Nigeria	To discuss performance of crops and progress of experiments.	Discussions with project personnel regarding progress of experiments.
J. L. McIntosh Cooperative CRIA-IRRI Program	Indonesia	To obtain information on drip irrigation systems.	Provided information and material on drip irrigation used by Benchmark Soils Project.
S. Krashevski D. E. Hammer USAID/Jakarta	Indonesia	To visit project sites and provide orientation of project.	Field trip to experiment sites. Met with project personnel.
Philippines			
Cotabato Farmers Association (20 participants)	Philippines	To orient participants on project methodologies and objectives.	Field observation and practicum trip to Davao experiment site.
J. G. Davide C. Sagrado Planters Products	Philippines	To visit and discuss progress of experiment sites.	Met with project personnel and taken on field trip to experiment sites.
Bicol River Basin Development Project seminar participants	Philippines	To orient participants on project methodologies and objectives.	Field trip to PUC experiment sites.
B. C. Felizardo Z. G. Tapawan B. P. del Rosario Soils and Water Research Division, PCARR	Philippines	To review and evaluate ongoing soil research in Davao region.	Visited Benchmark experiment site in the BPI-Davao Experiment Station and discussed progress and future plans with Benchmark personnel.

Correspondence and Feedback

Name/Organization	Country	Purpose/Result
J. H. V. van Baren International Soil Museum	Netherlands	Possible linkage between Benchmark Soils Project and International Soil Museum.
J. L. Demeterio University of Guam	Guam	Possible linkage between Benchmark Soils Project and University of Guam; possibility of Project doing soil profile analysis.
L. L. Hammond International Fertilizer Development Center	U. S.	Possible collaborative project on phosphorus fertilization and soil managament.
S. Rojanasoonthon Department of Soils Kasetsart University	Thailand	Provided information regarding meteorological instruments used at Benchmark Soils Project experimental sites.
E. A. Soucie Pomape Agriculture and Trade School	Caroline Islands	Provided with analytical soil analysis on soils sent to Hawaii.
Y. Kitagawa Department of Agriculture State of Hawaii	U. S.	Provided results obtained for corn and soybean culture on Island of Hawaii for assessment of land use alternatives.
D. Y. Teramishi AMFAC, Inc.	U. S.	Provided consultation on growing corn on Ewa plantations, Oahu, Hawaii.
W. Golden Hawaii Agronomics	U. S.	Provided analytical soil analysis for Solomon Island samples.
E. H. Shikuma College of Agriculture University of Hawaii at Hilo	U. S.	Provided information and samples of soybean varieties used by Benchmark Soils Project.
T. S. Gill USAID/Washington	U. S.	Provided chemical analysis on soils from Djibouti, Africa.
F. Tyamuremye Institut des Sciences Agronomiques du Rwanda	Rwanda	Provided profile description and laboratory data of Kinigi, Rwanda soils.
W. Siderius Kenya Soils Survey Project	Kenya	Provided chemical analysis on Murinduko, Kenya soils.
J. M. Menyonga Institute of Agricultural and Forestry Research	Cameroon	Provided maize hybrid seeds (H610, H788, and H634) and University of Hawaii general and graduate catalogs.
D. M. Leslie New Zealand Soil Bureau	New Zealand	Provided publications on Benchmark Soils Project and University of Hawaii general and graduate catalogs.
J. N. Awemo Institute of Agricultural and Forestry Research	Cameroon	Provided University of Hawaii general and graduate catalogs.
J. R. F. Hansell Indonesia-United Kingdom Transmigration Project	Indonesia	Provided Benchmark Soils Project consultant report on samples sites in Indonesia, as well as laboratory data, descriptions, and classification of soils at sample sites.
J. Chung private citizen, Hawaii	U. S.	Provided information on soybean inoculum used by Benchmark Soils Project.
R. C. Huff Soil Conservation Service, USDA, Hawaii	U. S.	Provided laboratory data of five soil profiles from Lahaina, Maui, Hawaii.
E. Tedeschi private farmer, Hawaii	U. S.	Provided chemical analysis on soils from Kula, Maui, Hawaii.
East West Center INPUTS Group (Increasing Productivity Under Tight Supplies)	various	Provided chemical analysis on soils from various countries participating in INPUTS group.
F. F. Campos Cental Luzon State University	Philippines	
Z. H. Bhuiya Bangladesh Agril. University	Bangladesh	
D. L. Demeterio University of Guam	Guam	
S. M. Qureshi Agriculture Research Institue	Pakistan	
M. Monajemi Soil Institue of Iran	Iran	
R. Ul-Qayyum Esso Pakistan Fertilizer Co., Ltd.	Pakistan	
T. C. Juang Chung Hsing University Farm	Taiwan	
T. Marumoto Yamaguchi University Farm	Japan	
T. I. Ashaye Department of Soil Science University of Ife	Nigeria	Provided publications on Benchmark Soils Project
B. B. Tamyo Bureau of Plant Industry	Philippines	
R. C. Hills Development Studies Centre The Australian National University	Australia	
A. Rosales Cornell University	U. S.	
R. L. Cunningham The Pennsylvania State University	U. S.	
B. N. Okigbo International Institute of Tropical Agriculture	Nigeria	
Approximately 600 recipients	Local National International	Benchmark Soils Project mailing list regularly provided with project publications.

Participants agreed that the soil family concept would be an appropriate means of extending information to other locations.

A technical committee was organized in 1977 under the leadership of D. Muljadi, Director of SRI. It is composed of scientists in agrotechnology, associated either directly or indirectly in the dissemination of scientific findings in Indonesia. The group comprises members representing various areas of agricultural research, agricultural planning and plan implementation, agricultural extension and training, and food technology, and the SRI. The objectives of the committee are (1) to coordinate and disseminate scientific findings among the allied scientific bodies in Indonesia; (2) to actively participate in agrotechnology transfer within Indonesia; (3) to discuss and suggest management and variety experiments to be undertaken at the primary sites in Indonesia; (4) to make periodic visits to Benchmark Project sites and gather first-hand information on management-level experiments;(5) to participate in the monitoring of agroclimatic data; and (6) to establish a close link with the activities of the BSP within and outside the borders of Indonesia. The Technical Committee met twice during 1977. The members agreed that experimental findings obtained thus far will go a long way in creating a positive impact on the local small farmers and decision-makers.

To ensure a correlation of the Indonesia soil classification system to Soil Taxonomy and the continuing use of Soil Taxonomy to interpret soil surveys of Indonesia, SRI has ordered 50 copies of Soil Taxonomy for distribution to agencies and institutions involved in agricultural research and development.

In addition, the Bureau of Soils in the Philippines has made plans to utilize the concepts of the Benchmark Soils Project to make recommendations on land utilization and management to the national government. Currently, soil surveys are being conducted throughout the Philippines. Key and extensive soils will be identified prior to implementation of field research activities.

PCARR, the Bureau of Soils, and the Soil Science Society of the Philippines organized a 3-day national conference on Soil Resources Inventory for Countryside Development (see section on Seminars and Conferences). A major component was the use of Soil Taxonomy in development planning. Group sessions identified the need for soil resources inventory for farmers, researchers, and planners, and proposals were sought for soil resources inventory programs to support development planning.

Extensive training in soil classification and soil survey is to be provided.

This activity, as well as Indonesia's own soil management experiments, utilizes the concepts of the Benchmark Soils Project.

LDC Training

Graduate assistantships were awarded to three new students in fiscal year 1977-1978. A total of five students are now under the sponsorship of the Project: two from Indonesia (I P. G. Widjaja-Adhi and D. Santoso) from the Soil Research Institute in Bogor; two from the Philippines (C. R. Escano and B. P. del Rosario) from the Philippine Council for Agriculture and Resources Research; and one from the United States (D. J. Harris). The Project anticipates two additional students for the spring term of 1979.

The curriculum of each of the students involves courses in soil classification and Soil Taxonomy and an introduction to concepts of agrotechnology transfer. Their thesis topics are to be related, in part, to the objectives of the Project.

Training courses on Soil Taxonomy are being planned for soil scientists and planners in both Indonesia and the Philippines for mid-1979.

Statement of Expenditures and Obligations

The following are the line item expenditures and obligations incurred by the Project from October 1, 1977, to September 30, 1978.

Line Item	Expenditures/Obligations
Salaries and Wages	$278,432
Fringe Benefits	36,153
Consultants	17,071
Equipment, Supplies and Services	220,792
Vehicles	25,264
Freight	17,097
Travel and Subsistence	66,588
Publications	5,801
Indirect Costs	140,311
Advances to Philippines and Indonesia	93,672

The dollar difference between our projected budget and actual expenditures and obligations is due to delays in implementing Project operations in Africa. The target country continues to be the United Republic of Cameroon. Upon completion of all negotiations, a project leader will be hired and field operations initiated with shipment of materials from Hawaii. The excess available in fiscal year 1977-1978 will be carried over to fiscal year 1978-1979 and expended for Project operations in Africa.

Work Plan and Budget Forecast

The network of Hydric Dystrandepts and Tropeptic Eutrustox will have been operational during the period of October 1, 1977, to September 30, 1978. During the same period, one site in the Philippines and three sites in Indonesia on the third soil family, the Typic Paleudults, will also have been established. Soil survey investigations for two additional sites each in the Philippines and Cmaeroons will have been completed.

Staffing of personnel on established sites will be completed with the selection of a new project leader for the Philippines. Data continued to be collected from transfer experiments to test the hypothesis of agrotechnology transfer. Management experiments will also have been planted by the end of fiscal year 1977-1978.

Publication of Project information and activities increased with the employment of an editor/publications specialist. Activities related to the dissemination and utilization of Project concepts and information will have been initiated through workshops and seminars organized by the Project's training coordinator.

Anticipated Accomplishments by October 1979

A. Complete soil survey investigations for soil family of Typic Paleudults in the Philippines.
B. Complete establishment of experimental sites on Typic Paleudult soil family in the Philippines and Cameroon.
C. Arrange agreement with ONAREST to establish Typic Paleudult sites in Cameroon.
D. Select project leader for Cameroon.
E. Conduct a total of 33 transfer experiments with maize on soil families of Hydric Dystrandepts, Tropeptic Eutrustox, and Typic Paleudults.
F. Conduct a total of 13 variety experiments with maize on the three soil families.
G. Conduct a series of management experiments with maize and other crops on the three soil families.
H. Carry out second assessment of transfer hypothesis on Hydric Dystrandepts.
I. Participate in workshop on Operational Implications of Agrotechnology Transference Research to be held in Hyderabad, India.
J. Participate in workshop on Soil Taxonomy in Southeast Asia to be held in Malaysia and Thailand in October 1978.
K. Conduct survey questionnaires among planners in Southeast Asia on their needs for soils-related information.
L. Conduct training workshop on Soil Taxonomy in Indonesia and the Philippines.
M. Plan and initiate survey to identify current farmer management practices in the Philippines and Indonesia in regions of experimental sites.
N. Develop framework and data file for Soil Data Bank.

O. Select third graduate fellow from the Philippines.
P. Publish proceedings of workshop on experimental design.
Q. Publish technical report on soils of the Benchmark Soils Project network and other technical reports.
R. Publish fact sheets of Project for use in training and utilization of BSP results.
S. Continue publication of Benchmark Soils News, quarterly newsletter.

Budget Forecast

The budget forecast for the period October 1, 1978 to September 30, 1979 follows.

Line Item	Costs
Salaries and Wages	$431,400
Fringe Benefits	67,938
Consultants	24,900
Equipment, Supplies and Services	215,090
Vehicles	20,000
Freight	28,200
Travel and Subsistence	181,325
Publications	14,000
Indirect Costs	168,679

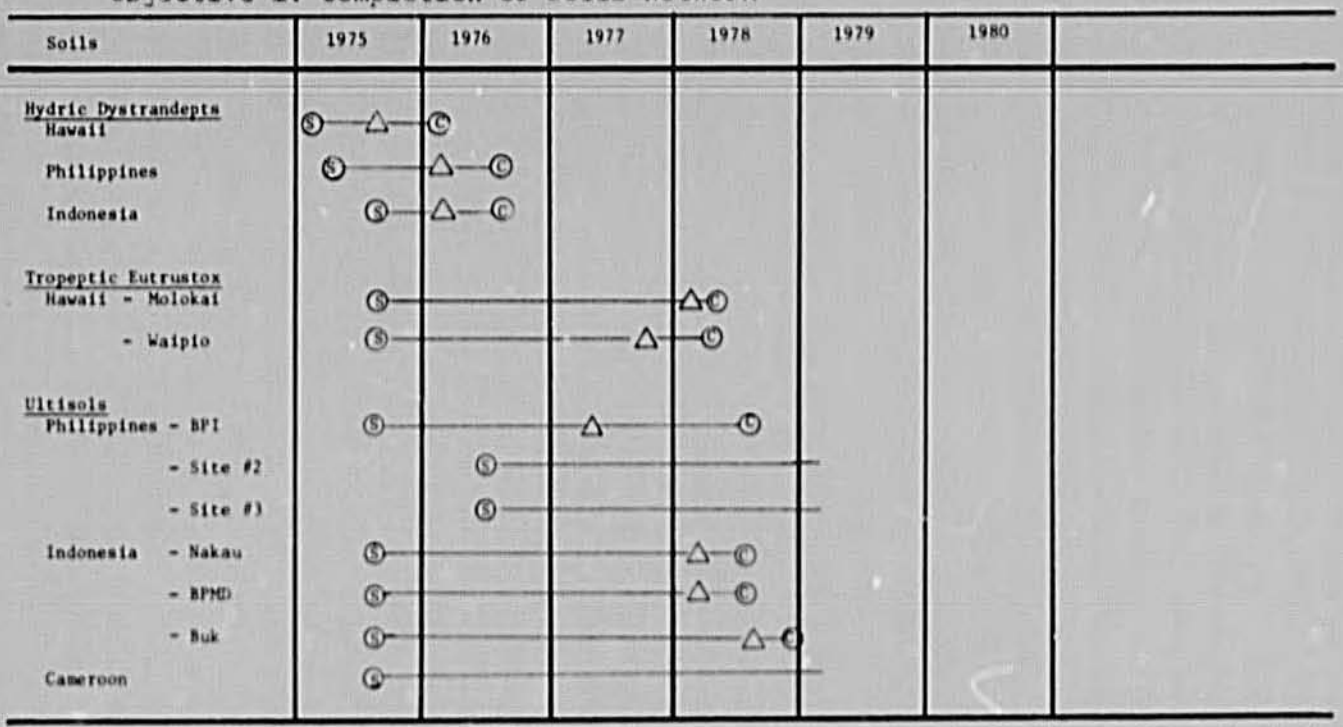
The budget forecast is similar to that proposed in our contract except that $20,000 was moved from Travel and Subsistence to Vehicles. This change was made in anticipation of vehicle purchases in Cameroon upon successful completion of negotiations there.

Decreasing the amount for Travel and Subsistence was due to the postponement of the proposed international seminar on agrotechnology transfer. This decrease, however, should not affect funds required to provide support for a workshop on the Operational Implications of Agrotechnology Transference Research to be held in Hyderabad, India, on October 23-26, 1978.

Appendixes

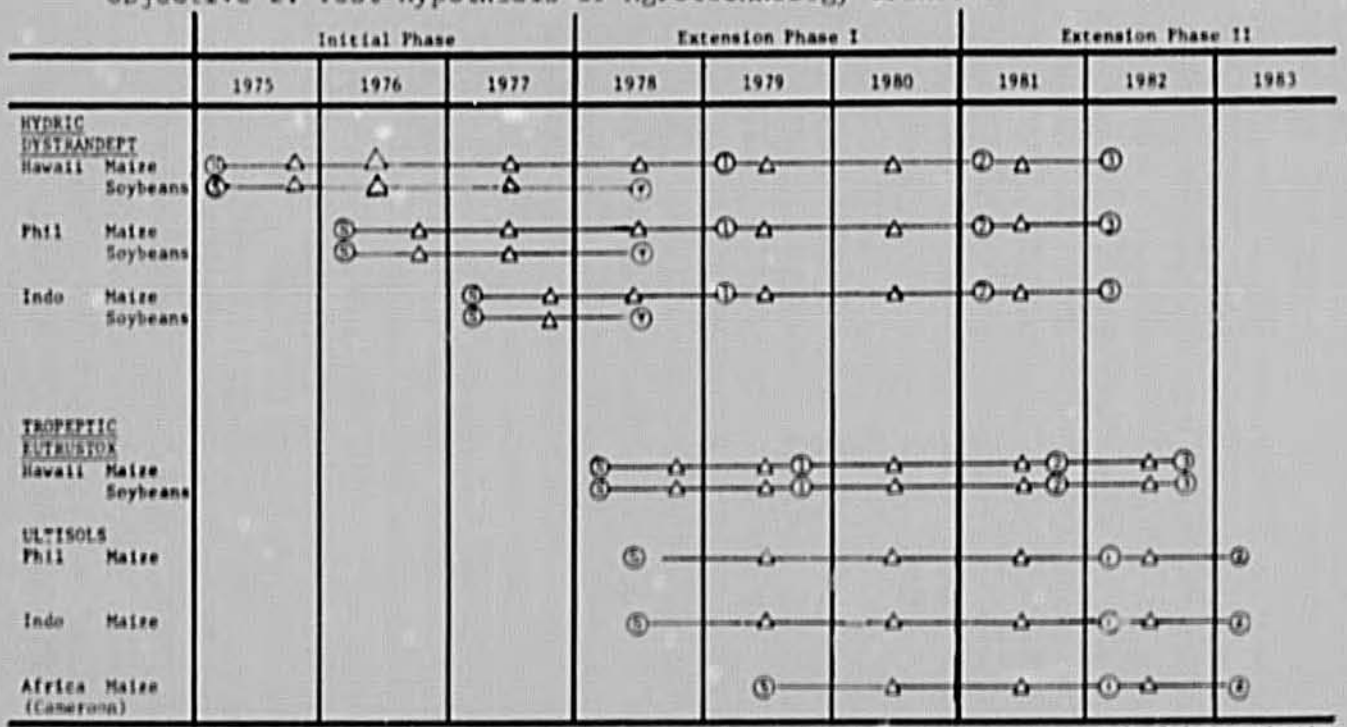
Appendix 1. Milestone Event Charts

Objective 1. Completion of Soils Network



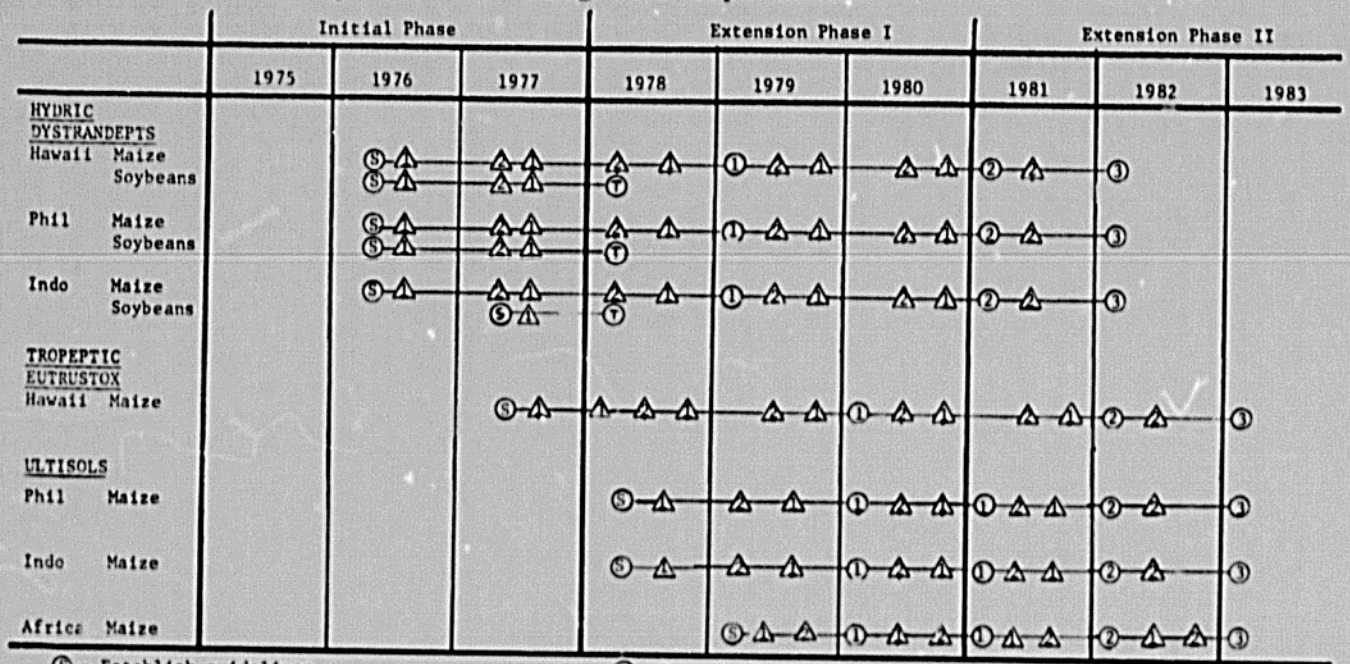
Ⓢ - Preliminary survey of potential sites △ - Long-term agreements negotiated and signed Ⓒ - Sites staffed, equipped and prepared

Objective 2. Test Hypothesis of Agrotechnology Transfer



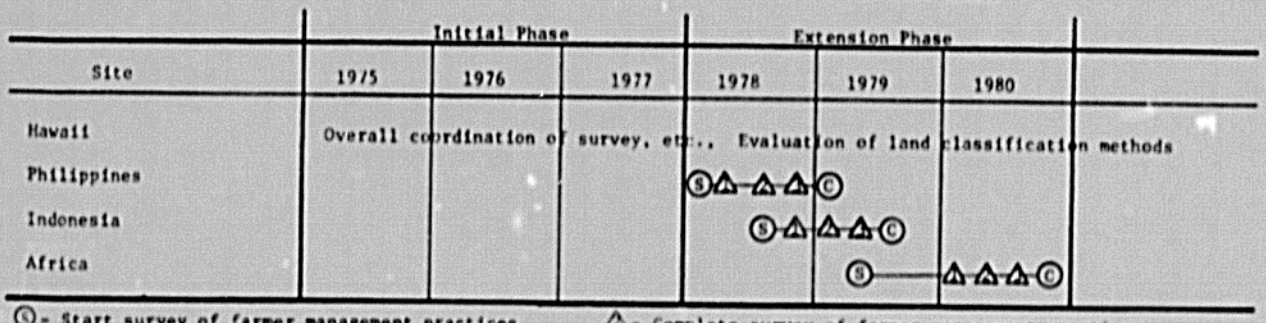
Ⓢ - Set up sites and install experiments
△ - Harvest experiments and collect data
① - Test hypothesis across the network, 1st approximation
② - Test hypothesis across the network, 2nd approximation
③ - Test hypothesis across the network, 3rd approximation
Ⓣ - Terminated

Objective 3. Crop and Soil Management Experiments



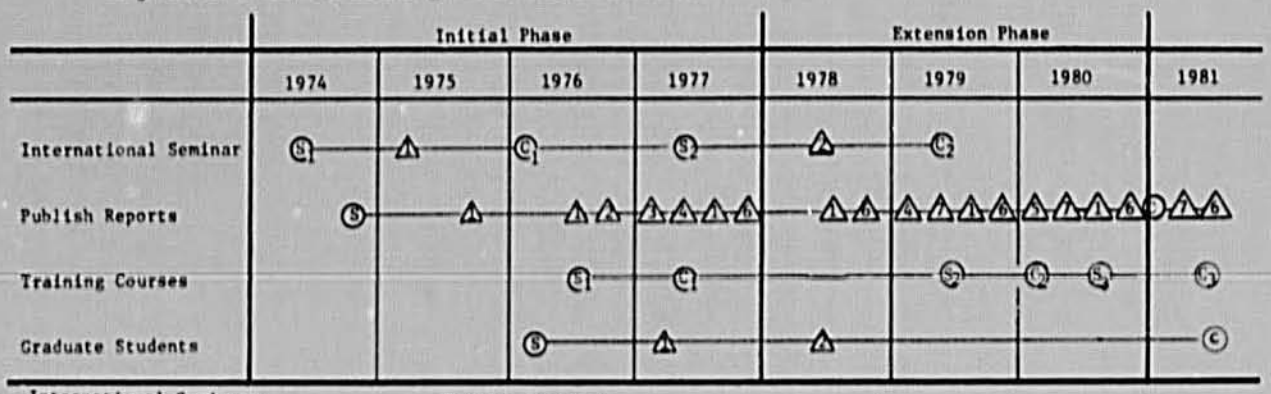
- Ⓢ - Establish guidelines
- △ - Design and install experiments
- △ - Harvest experiments and collect data
- ① - Recommendations formulated - 1st approximation
- ② - Recommendations formulated - 2nd approximation
- ③ - Recommendations formulated - 3rd approximation

Objective 4. Soil Interpretation and Land Classification



- Ⓢ - Start survey of farmer management practices
- △ - Analyze and interpret transfer and management experiments (first approximation)
- △ - Complete survey of farmer management practices
- △ - Suitability for benchmark soils for agriculture determined
- Ⓒ - Material for courses and workshops prepared

Objective 5. Training and Utilization



International Seminars

- S_1 - Plan Hyderabad seminar
- I_1 - Invite Participants
- C_1 - Hold Hyderabad seminar
- S_2 - Plan Transfer seminar
- I_2 - Invite participants
- C_2 - Hold Transfer seminar

Publish Reports

- S - Report on Workshop on Expt. Design
- I - Annual Reports and reports of annual mtg.
- I - Proceedings Workshop on Expt. Design
- I - Proceedings Hyderabad seminar
- I - Training materials
- I - Proceedings Transfer seminar
- I - Research articles
- I - Utilization materials
- C - Final report of Project

Training Courses

- S_1 - Plan Agrotechnology Transfer course -Philippines
- C_1 - Conduct Agrotechnology Transfer course - Philippines
- S_2 - Plan international Agrotechnology Transfer course
- C_2 - Conduct international Agrotechnology Transfer course
- S_3 - Plan Agrotechnology Transfer workshop - Africa
- C_3 - Conduct Agrotechnology Transfer workshop - Africa

Graduate Student Training

- S - Select first graduate student - Philippines
- I - Complete graduate student quota - Philippines and Indonesia
- I - Complete quota - Africa
- C - All graduate students graduated

Table 1. The 13 soil profiles, or pedons, representing the 19 sites of the Benchmark Soils Project/Hawaii

Profile number	Benchmark site	Soil name[a] or code	Location	Milestone[b] achieved
thixotropic, isothermic Hydric Dystrandepts				
75HA-1-1	Secondary 1	Kukaiau (KUK)	Honokaa, Island of Hawaii, Hawaii, U.S.A.	5
75HA-1-2	Primary and Secondary 2	Niulii (IOLE) Niulii (Halawa, HAL)	North Kohala, Island of Hawaii, Hawaii, U.S.A.	5
75-RP-1-1	Primary	PUC	Philippine Union College, Panicuason, Naga City, Island of Luzon, the Philippines	5
75-RP-1-2	Secondary 1 and Secondary 2	PAL BUR	Palastina, Pili and Burabod, Camarines Sur Province, Island of Luzon, the Philippines	5 5
75-IN-1-4	Secondary 1	LPH	Lembaga Penelitian Hortikultura (Horticultural Research Institute), Segunung, Cipanas, West Java Province, Island of Java, Indonesia	5
75IN-1-8	Primary and Secondary 2	ITKA PLP	Institut Theologia Keguruan Advent (Seventh-Day Adventist Theological Church School) and Pusat Latihan Pertanian (Agricultural Training Center), Cisarua and Lembang, Bandung Province, Island of Java, Indonesia	5 5
clayey, kaolinitic, isohyperthermic Tropeptic Eutrustox[c]				
77HA-7-1	Secondary	Waihiawa (Waipio, WAI)	Waipio, Island of Oahu, Hawaii, U.S.A.	5
77HA-5-1	Primary	Lahaina taxadjunct (Maunaloa, MOL)	Maunaloa, Island of Molokai, Hawaii, U.S.A.	5
clayey, kaolinitic, isohyperthermic Typic Paleudults[d]				
77RP-2-1	Primary and Secondary 1 and Secondary 2	BPI	Bureau of Plant Industry, Davao City, Mindanao, the Philippines	5 1 1
78IN-2-2	Secondary 1	BPMD	Balai Pendidikan Masyarkat Desa (Community Education Center), Kotabumi, North Lampung, Lampung Province, South Sumatra, Indonesia	5
78IN-2-3	Primary	NAK	Nakau Estate, Kotabumi, North Lampung, Lampung Province, South Sumatra, Indonesia	5
78IN-2-7	Secondary 2	BUK	Bukit Kemuning, Sukanegeri, North Lampung, Lampung Province, South Sumatra, Indonesia	3
77CM-1-5	Primary and Secondary	CAM KAN	Barombi-Kang, Cameroon	2 2

[a]The Hawaii soils are soil series names according to classification in Soil Taxonomy (Soil Survey Staff, 1975); the three- or four-letter codes are reference abbreviations only for computer and other coding.
[b]Milestone: 1= soil survey initiated; 2 = soil survey completed; 3 = agreements signed; 4 = site prepared and staffed; 5 = experiments underway; 6 = experiments completed. (See Appendix 1 for charts on Milestone Events.)
[c]One more site on Tropeptic Eutrustox is to be established by the Hawaii Project; the other 6 sites on Tropeptic Eutrustox are underway in the Puerto Rico Project. This soil family provides the link between the two Projects.
[d]Two more sites on Typic Paleudults are to be established by the Hawaii Project.

Table 2. Summary of the general characteristics of the Benchmark Project soils

Hydric Dystrandepts	Tropeptic Eutrustox	Typic Paleudults
1. Cambic horizon.	1. Oxic horizon.	1. Argillic horizon.
2. Udic moisture regime generally.	2. Ustic moisture regime.	2. Udic moisture regime.
3. Bulk density (at 1/3-bar water retention) of fine-earth fraction of soil is less than 0.85 g/cc and exchange complex is dominated by amorphous material (thixotropic in some horizon) *and/or* vitric volcanic ash, cinders, or other vitric pyroclastic material (by weight) is 60 percent or more of soil.	3. Cation-exchange capacity (by NH_4OAc) is 16 meq or less/100 g clay. Cation retention from NH_4Cl is 1.5 meq/100 g clay (or over 1.5 meq of extractable bases plus extractable aluminum per 100 g clay) in oxic horizon. Oxic horizon does not extend to a depth of 1.25 m below soil surface and/or structure is at least moderate in grade.	3. Weatherable minerals are less than 10 percent in the 20- to 200-micron fraction of upper 50 cm of argillic horizon. Clay distribution decrease is not more than 20 percent of the maximum within 1.5 m of soil surface.
4. Organic carbon is in large amount.	4. Organic carbon is less than 16 kg/surface cubic meter of soil.	4. Organic carbon is less than 0.9 percent in the upper 15 cm of argillic horizon or less than 12 kg/surface cubic meter of soil.
5. Base saturation is less than 50 percent (by NH_4OAc) in all subhorizons between depths of 25 and 75 cm.	5. Base saturation is 50 percent or more (by NH_4OAc).	5. Base saturation is less than 35 percent at 1.25 m below upper boundary of argillic horizon or 1.8 m below soil surface.

Table 3. Summary of the range in characteristics of the Hydric Dystrandepts

Hawaii	Philippines	Indonesia
1. Surface horizons are dark brown (7.5YR 3/2); B2 horizons range from dark reddish brown (5YR 3/2, 3/3, 3/4) to brown and dark brown (7.5YR 4/4).	1. Surface horizons are black (N 2/ , 10YR 2/1) and very dark grayish brown (10YR 3/2). B2 horizons are very dark grayish brown (10YR 3/2) and dark yellowish brown (10YR 3/3, 3/6, 4/4, 4/6).	1. Surface horizons are dark brown (7.5YR 3/2) and very dark grayish brown (10YR 2/2); B2 horizons range from dark brown to brown (7.5YR 3/2, 4/4; 10YR 3/3) to dark yellowish brown (10YR 3/4) with a horizon that can be black (10YR 2/1) and very dark brown (10YR 2/2).
2. Organic carbon ranges from 3.5 to 7 percent.	2. Organic carbon ranges from 2 to 13 percent decreasing with depth.	2. Organic carbon ranges from 4 to 6 percent in one pedon and from 3 to 10 percent in another.
3. Extractable calcium ranges from less than 0.5 to 1 meq (except for the surface which is 8 meq) for one pedon and from 2 to 6 meq in the other.	3. Extractable calcium is 4 to 8 meq.	3. Extractable calcium is less than 6 meq in the surface but ranges from 6 to 22 meq in the subsoil.
4. Base saturation is less than 2 percent (except for the surface) for one pedon and ranges from 2 to 8 in the other.	4. Base saturation is approximately 10 to 20 percent.	4. Base saturation ranges from 10 to 30 percent with variations in the surface horizon.
5. Depth of surface soil is less than 25 cm.	5. Depth of surface soil is 40 to 60 cm.	5. Depth of surface soil is 15 to 30 cm.
6. Layerings attributed to several ash deposits are apparent.	6. Layerings are not apparent.	6. Layerings are not apparent.

Table 4. Summary of the range in characteristics of the Tropeptic Eutrustox

Hawaii	Puerto Rico
1. Surface horizon is dark reddish brown (2.5YR 2.5/4, 3/4). B2 horizons are either dusky red (10R 3/3) or dark reddish brown (2.5YR 2.5/4, 3/4).	1. Surface horizon is dark brown (7.5YR 4/4); B2 horizons are reddish brown (5YR 4/4) to yellowish red (5YR 4/8) to strong brown (7.5YR 5/8) in the lowest horizons.
2. Soil is derived from basalt.	2. Soil is overlying limestone and quartzitic sands.
3. Cation exchange capacity of oxic horizon is slightly less than 16 meq/100 g clay.	3. Cation exchange capacity of oxic horizon is 5 to 9 meq/100 g clay.
4. Extractable calcium in the oxic horizon is 3 to 6 meq and extractable magnesium is 1 to 4 meq.	4. Extractable calcium in the oxic horizon is 1 to 2 meq and extractable magnesium is less than 1 meq.
5. Base saturation is slightly over 50 percent in the major portion of the oxic horizon; sum of bases is 6 to 9 meq.	5. Base saturation is slightly over 50 percent in the major portion of the oxic horizon; sum of bases is 2 to 3 meq.

Table 5. Summary of the range in characteristics of the Typic Paleudults

Philippines	Cameroon	Indonesia
1. Surface horizon is black (5YR 2.5/1). B2 horizons are dark reddish brown (5YR 3/2, 3/3) and reddish brown (5YR 4/4).	1. Surface horizons are dark brown to brown (10YR 4/3) to dark yellowish brown (10YR 4/4). B2 horizons are yellowish brown (10YR 5/5).	1. Surface horizons of 3 pedons are dark reddish brown (5YR 3/2), dark brown to brown (7.5YR 4/2), and dark grayish brown (10YR 4/2), respectively. B2 horizons with increasing depth are reddish brown (5YR 4/4), yellowish red (5YR 4/6), and dark red (2.5YR 3/6) for one pedon, yellowish red (5YR 4/6), dark yellowish brown (10YR 4/6), and red (2.5YR 4/6) for the second pedon; and strong brown (7.5YR 4/6) and yellowish brown (10YR 5/6) and yellowish red (5YR 4/6) for the third pedon.
2. Cation exchange capacity of the subsoil ranges from 17 to 21 meq/100 g of soil.	2. Cation exchange capacity of the subsoil ranges from 11 to 17 meq/100 g of soil.	2. Cation exchange capacity of the subsoil ranges from 7 to 12 meq/100 g of soil.
3. Sum of bases of the subsoil ranges from 4.5 to 6.5 meq.	3. Sum of bases ranges from 1.7 to 3.7 meq.	3. Sum of bases is less than 2 meq, in most cases being less than 1 meq.
4. Base saturation ranges from 27 to 31 percent.	4. Base saturation ranges from 16 to 24 percent.	4. Base saturation ranges from 4 to 16 percent.
5. Extractable aluminum ranges from 3 to 4 meq.	5. Extractable aluminum is less than 0.2 meq.	5. Extractable aluminum ranges from 1 to 4 meq.

Table 6. Maize grain yields (kg/ha) of transfer experiments, Hydric Dystrandepts, Hawaii, 1977-78

Treatment Coded P	Coded lime	Location/site HAL-B2 D77	HAL-D W77	KUK-A2 D77	KUK-C2 W78
+0.85	+0.85	8900	4850	8260	9623
+0.85	0	8517	5080	7421	8124
+0.85	-0.85	8955	4539	7972	7610
+0.40	+0.40	8384	4957	7875	8299
+0.40	-0.40	8388	5673	7417	7112
0	+0.85	8385	4603	6053	8603
0	0	8854	4762	7395	8311
0	-0.85	8442	5149	8454	7195
-0.40	+0.40	8037	4893	8157	7253
-0.40	-0.40	8914	5045	7703	7650
-0.85	+0.85	7540	5389	7752	6752
-0.85	0	7947	4843	7689	7320
-0.85	-0.85	8042	5102	7761	6481
Complete control		1439	1977	5813	2540
Partial control		6276	4458	6769	4578

Treatment Coded P	Coded N	Location/site IOLE-E D78	IOLE-F W78	KUK-D2 W78	KUK-A3 D78	HAL-A3 D78	HAL-B3 D78
+0.85	+0.85	7768	5555	8471	7852	7958	8169
+0.85	0	7113	3117	8254	7113	8025	7059
+0.85	-0.85	6016	1759	6293	6982	8622	4971
+0.40	+0.40	6478	4848	8291	7107	8187	7622
+0.40	-0.40	6819	3141	7663	6599	7946	6441
0	+0.85	7218	4322	8606	6993	8076	8191
0	0	6679	3377	7382	7041	7856	6324
0	-0.85	5416	3130	5753	6532	8629	4517
-0.40	+0.40	7050	3905	7249	7240	7851	7009
-0.40	-0.40	7042	2851	6757	6119	8187	5499
-0.85	+0.85	6659	4683	6547	6040	7499	7697
-0.85	0	6631	4143	7014	5528	7792	7016
-0.85	-0.85	5300	2961	5164	5982	7972	4595
0	no N[a]		1669				
no P	0		3590				
Partial control		4835	2428	3715	4049	3636	2993
Complete control				3963	3184	707	2317

[a]See section on Changes in Research Design for Additional Treatments. A blank space indicates no treatments were installed on this plot on Tables 6 through 11.

Table 7. Maize grain yields (kg/ha) of transfer experiments, Hydric Dystrandepts, Indonesia, 1977-78

Treatment Coded P	Coded lime	Location/site ITKA-K1 D77	ITKA-K2 W78	PLP-D1 D77	PLP-D2 W78	LPH-D1 D77	LPH-D2 W78
+0.85	+0.85	8021	2289	6153	4558	8074	6266
+0.85	0	7909	2494	6160	5218	6914	5430
+0.85	-0.85	7693	1904	5406	5344	7588	5473
+0.40	+0.40	7281	2880	6301	4780	7483	5235
+0.40	-0.40	7804	1598	5998	5697	7594	5647
0	+0.85	7643	2444	5435	4991	7227	5798
0	0	7853	2117	5485	4785	7434	5748
0	-0.85	7755	2144	5980	4679	6910	5602
-0.40	+0.40	7503	1952	5338	5799	7160	5986
-0.40	-0.40	7484	2014	5229	5110	7521	4997
-0.85	+0.85	7049	1656	5139	4248	5565	5271
-0.85	0	7050	2082	5113	4849	6389	4787
-0.85	-0.85	7401	1997	4864	4348	5389	5153
Complete control		5975	1438	2841	1413	1841	1781
Partial control		6442	1692	3647	3965	3129	3316

Treatment Coded P	Coded N	Location/site LPH-E W78	PLP-F W78	ITKA-C W78
+0.85	+0.85	4586	2547	3343
+0.85	0	4227	2641	3231
+0.85	-0.85	3126	1095	2899
+0.40	+0.40	4260	2712	3301
+0.40	-0.40	3734	1322	2894
0	+0.85	3223	2474	4047
0	0	3747	2150	3308
0	-0.85	3760	778	2611
-0.40	+0.40	3905	2140	3535
-0.40	-0.40	3818	2809	3615
-0.85	+0.85	2954	1614	2985
-0.85	0	3098	2428	3356
-0.85	-0.85	2770	536	2052
0	no N	2997	970	2212
no P	0		1464	3263
Complete control		2632	1465	2744

Table 8. Maize grain yields (kg/ha) of transfer experiments, Hydric Dystrandepts, Philippines, 1977-78

Treatment		Location/site			Treatment		Location/site				
Coded P	Coded lime	PAL-A2 D77	PAL-C2 D78	BUR-A1 D77	Coded P	Coded N	PUC-K D78	PAL-A3 D78	BUR-A2 D78	BUR-B D78	PUC-A4 D78
+0.85	+0.85	2751	9265	2672	+0.85	+0.85	5462	4559	7764	6931	6858
+0.85	0	2975	8195	3224	+0.85	0	5245	4598	6989	6177	5440
+0.85	-0.85	2950	7967	2975	+0.85	-0.85	4887	4693	6595	4861	2731
+0.40	+0.40	2478	7552	2547	+0.40	+0.40	5875	5933	5829	6071	5704
+0.40	-0.40	2365	8421	3018	+0.40	-0.40	5300	5016	6978	6275	4041
0	+0.85	1988	8038	2951	0	+0.85	5634	3966	6780	6848	4942
0	0	2985	7451	2702	0	0	5288	5105	5112	6122	5560
0	-0.85	2867	8422	2372	0	-0.85	5063	4567	5131	5352	3231
-0.40	+0.40	2329	8324	1680	-0.40	+0.40	5395	4084	4435	6559	4569
-0.40	-0.40	2731	7435	2510	-0.40	-0.40	5048	4049	4881	5492	3451
-0.85	+0.85	3326	6582	798	-0.85	+0.85	3337	2988	302	3276	827
-0.85	0	1931	7286	1467	-0.85	0	2934	2860	656	2877	1414
-0.85	-0.85	2093	7504	758	-0.85	-0.85	3187	3893	448	3589	1051
Complete control		1654	1916	0	no P	0	0	1428	159	674	
Partial control		1178	1239	976	Partial control		0	264	258	577	499

Table 9. Maize grain yields (kg/ha) of transfer experiments, Tropeptic Eutrustox, Hawaii, 1977-78

Treatment		Location/site	
Coded P	Coded N	WA-A D 78	MO-A D 78
+0.85	+0.85	10513	10462
+0.85	0	11035	9928
+0.85	-0.85	9456	7957
+0.40	+0.40	10875	9576
+0.40	-0.40	9751	9266
0	+0.85	10920	9887
0	0	10782	9368
0	-0.85	9465	7970
-0.40	+0.40	9744	9894
-0.40	-0.40	9995	8837
-0.85	+0.85	9685	8451
-0.85	0	9633	9136
-0.85	-0.85	8177	7301
0	No N	7947	
No P	0	9865	
Partial control		7696	7092

Table 10. Maize grain yields (kg/ha) of transfer experiments, Typic Paleudults, Philippines, 1977-78

Treatment		Location/site	
Coded P	Coded N	BPI-A D 78	BPI-D Wet 78
+0.85	+0.85	7507	5153
+0.85	0	7105	5191
+0.85	-0.85	6845	4800
+0.40	+0.40	7244	5047
+0.40	-0.40	6947	4452
0	+0.85	6619	5103
0	0	7133	4569
0	-0.85	6436	4618
-0.40	+0.40	7164	4846
-0.40	-0.40	6873	4749
-0.85	+0.85	5843	3828
-0.85	0	6682	3770
-0.85	-0.85	5788	4503
Complete control		5785	2656
Partial control		6231	3429

Table 11. Soybean grain yields (kg/ha) of transfer experiments, Hydric Dystrandepts, Hawaii and Indonesia, 1977-78

Treatment		Location/site			
Coded P	Coded lime	HAL-F D 77	KUK-B2 D 77	ITKA-J D 77	LPH-C D 77
+0.85	+0.85	2989	3351	3034	2720
+0.85	0	2862	2985	3269	2689
+0.85	-0.85	2843	3414	3298	2689
+0.40	+0.40	2783	3362	3421	2920
+0.40	-0.40	2850	2993	3288	2526
0	+0.85	2948	3310	2923	2959
0	0	2887	2855	3240	2674
0	-0.85	2737	3118	3191	2828
-0.40	+0.40	2870	3317	3203	2802
-0.40	-0.40	2719	3096	3510	2645
-0.85	+0.85	2639	3031	2922	2310
-0.85	0	2795	3059	2895	2435
-0.85	-0.85	2758	3118	2927	2238
Complete control		2225	2750	2632	727
Partial control		2620	3151	2616	749

Table 12. Grain yields (metric tons/ha) in maize variety trial, fertility treatments of phosphorus and nitrogen, Hydric Dystrandepts, Hawaii, 1977-78

Treatment		Variety							
Coded P	Coded N	Pioneer varieties							
		'H610'	'H788'	'X304A'	'X304B'	'X304C'	'X5800'	'X4816'	'X4817'
-0.85	-0.85	4.7	4.0	5.1	4.1	5.0	4.3	4.4	4.9
-0.85	0	4.9	5.0	5.5	5.7	6.4	6.4	6.3	6.0
0	-0.85	5.0	3.9	4.3	4.7	5.7	4.3	5.7	5.5
0	0	4.9	4.5	4.7	5.0	7.0	5.3	6.7	5.6
	Mean	4.87	4.33	4.89	4.88	6.02	5.08	5.77	5.50

Table 13. Grain yields (metric tons/ha) in maize variety trials, two fertility treatments, Hydric Dystrandepts, Indonesia, 1977-78

Treatment		Variety					
ITKA-O--dry season 1977							
Coded P	Coded lime	'Bastar Kuning'	'Bima'	'H61C'	'DMR Comp. 1'	'H6'	'Harapan'
-0.85	-0.85	6.4	4.6	4.7	5.7	7.3	6.5
-0.85	0	5.7	3.8	3.9	5.2	6.8	6.0
0	-0.85	6.9	5.2	5.4	6.0	6.8	6.7
0	0	7.3	5.9	5.2	5.9	7.1	7.1
	Mean	6.57	4.89	4.78	5.69	6.97	6.57
ITKA-L--wet season 1978							
Coded P	Coded N	'Bastar Kuning'	'Bima'	'H61O'	'UPCA Var. 1'	'H6'	'Harapan'
-0.85	-0.85	2.4	2.3	2.1	2.0	3.7	2.5
-0.85	+0.40	3.2	1.9	1.9	1.8	3.5	2.7
+0.40	-0.85	2.0	2.3	2.6	2.8	2.3	3.1
+0.40	+0.40	4.1	3.2	2.6	2.4	4.3	3.3
	Mean	2.97	2.45	2.34	2.29	3.51	2.96

Table 14. Grain yields (metric tons/ha) in maize variety trial, fertility treatments of phosphorus and nitrogen, Hydric Dystrandepts, Philippines, 1977-78

Treatment		Variety				
Coded P	Coded N					
PUC-F--dry season						
		'H6'	'Bima'	'H61O'	'H788'	'UPCA Var. 1'
-0.85	-0.85	1.6	1.6	1.7	1.8	1.5
-0.85	0	2.5	2.6	2.6	2.7	2.3
0	-0.85	3.0	2.7	2.8	3.2	3.2
0	0	4.5	4.4	5.1	5.0	4.7
	Mean	2.32	2.82	3.01	3.19	2.93

Table 15. Grain yields (metric tons/ha) in soybean variety trial, fertility treatments of phosphorus and lime, Hydric Dystrandepts, Indonesia, 1977-78

Treatment		Variety					
Coded P	Coded lime						
ITKA-P--dry season							
		'Orba'	'Shakti'	'Kahala'	'Jupiter'	'TK5'	'B/66/7'
-0.85	-0.85	2.5	2.3	1.1	0.9	2.1	2.0
-0.85	0	3.1	2.4	1.2	0.9	2.0	2.0
0	-0.85	2.7	2.3	1.4	1.0	2.0	2.0
0	0	3.2	2.7	1.5	1.4	2.1	2.2
	Mean	2.87	2.42	1.29	1.06	2.05	2.04

Table 16. Treatment combinations for rate x placement of phosphorus experiment, Hydric Dystrandepts, PUC, the Philippines, 1978

Placement of P											
Width relative to broadcast treatment[b]	Band width (cm)	Rate of P (kg/ha)[a]									Number of treatments
		0	10	20	40	80	113	160	226	320	
1	75		X	X	X	X		X	X	X	7
1/2	37.5			X	X	X	X	X			5
1/4	18.8			X	X	X		X			4
1/8	9.4		X	X	X			X			4
Drill	--		X	X				X			3
Control	--	X									1

[a]The lines connecting X's indicate treatments with equal concentration of phosphorus in the volume of soil fertilized.

[b]1 = broadcast application; drill is estimated at 1/225.

Appendix 3. Discussion of the Statistical Test of the Transfer Hypothesis

An initial evaluation of the hypothesis of transferability used yield and climatic data from the thixotropic, isothermic family of Hydric Dystrandepts. Maize grain yield data selected for this test came from five experimental sites--three from Hawaii (KUK-A, KUK-C, and HAL-B) and two from the Philippines (PUC-A and PAL-C) (see table on page 67 for data).

The Combined Model Approach

One approach followed in the test of the transfer hypothesis was to calculate a quadratic response surface equation to describe the yield response to phosphorus and lime for each site using the model $Y = b_0 + b_1P + b_2L + b_3P^2 + b_4L^2 + b_5PL$ where Y is the predicted maize yield (kg/ha); b_0 is the "intercept," the estimated yield when P and L are both zero in the coded values (this is the center of the design); b_1 to b_5 are regression coefficients for the respective variables; P is the coded value of the phosphorus differential; and L is the coded value of the lime differential.

If the transfer hypothesis is shown to be acceptable, then a separate response surface does not have to be estimated for each site, but one common response surface model will suffice. Thus, the regression coefficients in the equations for the individual sites should not be different from each other. The null hypothesis to be tested, therefore, was that the regression coefficients for all sites are the same.

The F statistic for testing the null hypothesis followed the general procedure of calculating (1) the response model sum of squares (SS) fitted separately for each site, and (2) the response model SS for all sites combined.

If the sum of the separate model SS is not much different from the combined model SS, the null hypothesis cannot be rejected. Since site variables affect yield levels, the appropriate intercept value (b_0) for each site should be included in the combined model response surface equation.

When the F test was applied to data from the five experiments, it was found that the null hypothesis could not be rejected. This implies that within the range of experimental error there is no evidence that a different response surface model holds for each site. Thus, it follows that the combined model response surface equation with the appropriate intercept may be used for all five sites, and, in this sense, the response model describing the yield response of maize to phosphorus and lime is transferable among sites of the same soil family.

The Transfer Equation Approach

Another approach to testing the transfer hypothesis entailed determining whether or not a transfer function, estimated from one series of experiments, can be used in another area where experiments have not been carried out. This is really the major goal of the Benchmark Soils Project. To evaluate the transfer hypothesis with the five sites used, the transfer function (the combined response surface with the temperature site variable) on four sites was estimated and then yields were predicted for the fifth site. The theory is that if this "new" residual SS, called the transfer SS, has not increased over the residual SS obtained by a response surface estimated from the actual data for the fifth site, then agrotechnology can be transferred successfully. This ratio of the transfer SS to the residual SS is a newly developed test that gave promising results for sites with values intermediate in the range of maximum daily temperatures.

These initial tests, then, have suggested that agrotechnology can be transferred between soils of the same family. A conclusive test of the transfer hypothesis awaits more yield and site variable data as well as additional work on the properties of the newly developed statistic.

Grain yield of five sites used in evaluation of the transfer hypothesis

Treatment		Site 1: PUC-A (May 1976 planting)				Site 2: Palestina C (PAL-C) (May 1977 planting)				Site 3: Kukaiau A (KUK-A) (August 1975 planting)			
Coded P	Coded lime	Rep 1	Rep 2	Rep 3	Average	Rep 1	Rep 2	Rep 3	Average	Rep 1	Rep 2	Rep 3	Average
-0.85	-0.85	4860	4258	4750	4623	5040	4809	4969	4939	4906	4887	5940	5244
0	-0.85	4868	5270	5228	5122	6204	5555	4964	5574	6309	6334	4649	5764
+0.85	-0.85	4743	5370	5363	5159	5214	5139	5565	5323	7931	5913	5692	6512
-0.40	-0.40	4107	4963	4840	4637	5021	4956	5710	5229	6156	5399	6192	5916
+0.40	-0.40	4930	5393	4947	5090	5710	6241	4640	5530	6339	5230	6277	5949
-0.85	0	5098	4257	4110	4488	4662	4761	6118	5180	5745	4983	4924	5217
0	0	5247	5483	4190	4973	5311	5009	4784	5035	6360	5979	6070	6136
+0.85	0	4372	5433	5506	5104	5652	6507	6640	6266	6179	6245	7226	6550
-0.40	+0.40	5060	5137	4629	4939	5681	5101	6036	5606	4890	6532	6883	6102
+0.40	+0.40	5367	5037	4742	5049	4984	5447	5530	5320	5728	5228	6031	5662
-0.85	+0.85	5190	5195	4068	4818	4622	5368	4837	4942	6049	5309	5466	5608
0	+0.85	4300	4657	4573	4510	4992	5387	5301	5227	4669	6102	6533	5768
+0.85	+0.85	4878	4270	6507	5218	5921	4856	4671	5149	5917	5924	6017	5953

Treatment		Site 4: Kukaiau C (KUK-C) (December 1976 planting)				Site 5: Halawa B (HAL-B) (July 1977 planting)			
Coded P	Coded lime	Rep 1	Rep 2	Rep 3	Average	Rep 1	Rep 2	Rep 3	Average
-0.85	-0.85	5935	7076	7056	6689	6823	8793	8510	8042
0	-0.85	7788	6974	7973	7578	8271	9195	7860	8442
+0.85	-0.85	7878	8411	8136	8142	8225	9918	8721	8955
-0.40	-0.40	5936	7214	7050	6733	8737	8157	9847	8914
+0.40	-0.40	8505	7728	8044	8092	8102	8957	8105	8388
-0.85	0	6353	7044	6706	6701	8689	6884	8268	7947
0	0	7468	8036	8862	8122	7881	8997	9683	8854
+0.85	0	7453	7509	8130	7727	8642	8680	8378	8567
-0.40	+0.40	6111	5688	7494	6398	7297	8083	8730	8037
+0.40	+0.40	7060	8870	7627	7852	7669	8530	8954	8384
-0.85	+0.85	6482	4908	7523	6304	7010	7714	7897	7540
0	+0.85	7132	7853	8438	7808	8374	8128	8652	8385
+0.85	+0.85	7684	7676	8117	7826	8639	9339	8722	8900

Weather data gathered at all sites, Benchmark Soils Project/Hawaii, 1977-78

Site/ season/variety	1978 Plant date	Harvest date	Solar radiation (g cal/day)	Cumulative rainfall (mm)	Temperature (°C) Max.	Min.	Relative humidity (%) Max.	Min.	Wind run (km/hr)	Yield (kg/ha) Partial Control	Mean	High
Hydric Dystrandepts												
Hawaii												
KUK-A-Dry H-610	06/29	11/29	320.60	461.4	27.3	20.1	92.1	69.9	10.01	4049	6318	7852
KUK-C-Wet H-610	02/16	08/01	404.45	585.0	26.5	18.8	92.6	65.2	9.66	4578	7718	9623
KUK-D-W H-610	01/06	07/03	405.48	586.0	25.8	17.5	92.0	63.0	9.33	3963	7188	8606
IOL-E-D H-610	06/09	11/21	437.44		24.8	18.7	97.2	67.8	16.38	4835	6630	7768
IOL-F-W H-610	01/18	07/18	454.76	394.5	23.8	16.8	95.2	62.2	15.42	2428	3805	5555
HAL-A-D H-610	06/30	12/06	415.85	623.0	24.6	17.4	99.6	77.3	10.72	3636	8046	8629
HAL-B-D H-610	07/13	12/20	414.83		24.6	17.4	99.6	76.8	10.39	2993	6547	8191
Philippines												
PUC-A-D UPCA War I	04/25	08/22	347.55	982.0	33.6	24.2	95.9	72.8	7.35	499	3832	6858
PUC-E-D UPCA War I	02/22	06/23	410.43	473.0	35.2	23.2	97.1	56.7	6.53	0	4820	5875
PAL-A-D UPCA I	04/14	08/08	178.18	830.0	32.3	21.9	83.1	56.1	5.13	264	4332	5933
PAL-C-D UPCA War I	12/29/77	04/28	403.04	161.3	31.9	19.0	83.9	46.2	4.89	1239	7880	9265
BUR-A-D UPCA I	12/21/77	05/08	299.53	281.3	29.0	20.4	95.0	58.2	10.26	258	4762	7764
BUR-B-D UPCA I	03/02	07/06	328.80	348.8	30.9	21.8	95.5	56.9	7.48	577	5418	6931

Indonesia												
ITKA-E-W Harapan	12/27	05/29	363.02	591.0	25.8	16.4	98.7	60.2	5.29	1692	2121	2880
ITKA-C-W Harapan	01/22	06/21	359.23	539.0	25.9	16.4	98.7	60.1	5.21	2744	3338	4047
PLP-D-W Harapan	12/22	05/26	378.52	1107.5+	28.7	17.4	99.5	59.5	3.33	3965	4954	5799
PLP-F-W Harapan	01/22	06/14	373.03	1190.5	28.6	17.2	99.5	59.6	3.29	1465	2017	2809
LPHS-D-W Harapan	12/26	05/22	314.50	578.1+	23.5	14.9	98.3	69.8	4.37	3316	5492	6266
LPHS-E-W Harapan	01/22	06/19	307.68	445.0+	21.8	13.8	97.9	68.0	4.29	2632	3862	4586
Tropeptic Eutrustox												
Brazil												
MOL-A X304C	07/06	12/07	588.97	114.0	29.8	21.9	97.5	73.0	22.55	7092	9589	10462
WAI-A X304C	07/10	11/28	453.63	29.0	30.8	21.8	98.1	41.5	7.76	7696	9868	11035
Typic Paleudults												
Philippines												
DAV-A-D TINIGUIB	04/15	07/26	486.04	409.0	32.8	21.1	99.7	56.7	5.10	6231	6784	7507
DAV-D-W TINIGUIB	08/17	11/23	538.48	439.4	31.1	24.7	99.1	57.7	4.48	3429	4664	5191

Appendix 5. Personnel

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BENCHMARK
SOILS
PROJECT

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