AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

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Batch #22

1. SUBJECT CLASSIFICATION	A. PRIMARY Serials	Y-AF20-0000-GG50
	B. SECONDARY Agriculture--Soil science--Tropics	

2. TITLE AND SUBTITLE
Agronomic-economic research on tropical soils; semi-annual administrative report, July-Dec.1970

3. AUTHOR(S)
(101) N.C.State Univ. Soil Science Dept.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1971	23p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
N.C.State

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*
(Adm.and activity summaries)

9. ABSTRACT

10. CONTROL NUMBER PN-RAB-369	11. PRICE OF DOCUMENT
12. DESCRIPTORS Tropics	13. PROJECT NUMBER
	14. CONTRACT NUMBER CSD-2806 Res.
	15. TYPE OF DOCUMENT

AID 590-1 (4-74)

Semi-Annual Administrative Report

Agronomic - Economic Research on Tropical Soils

AID/csd-2806

1 July - 31 December, 1970

North Carolina State University at Raleigh

Status of Work in Progress

General Activities

Coordination with other AID-funded activities in the general area of tropical soils and fertilizers was established on a continuing basis through an AID project "coordinators conference" held November 12-13, 1970 at North Carolina State University. Representatives from Cornell University, University of Puerto Rico, University of Hawaii, Prairie View A & M University, Tennessee Valley Authority, AID-Washington, and North Carolina State University met in this conference to exchange information on plans and objectives and to establish a network of groups with continued coordination in the area of tropical soils and fertilizer technical assistance, research, and development. A copy of the report of this conference is attached. Also, additional discussions have been held with Cornell University (especially with Dr. Matt Drosdoff, coordinator of their AID-funded Tropical Soils Research Contract) relative to close coordination of the two universities to insure high complementarity, minimum duplication, and possibly sharing of effort at certain locations in Latin America. R. J. McCracken traveled to Cornell in December to discuss and work out such joint arrangements and coordination.

A trip to study the general situation with and to obtain data from potential cooperators in regional institutes and host countries was taken by R. J. McCracken, R. K. Perrin and P. A. Sanchez in October, 1970. This two-week trip, specified in the contract, had as one of its purposes the designing and structuring of the research program for the highest level of mutual interest and importance to USAID, host countries and regional centers. This trip was also designed to identify local personnel who would participate in the research activities and to select sites for agronomic research needed to fill missing gaps in our knowledge about responses of tropical soils to fertilizers. Such sites were tentatively identified at Caramagua in the Llanos area of eastern Colombia (representative of savannah region with a strong dry season) and at Yurimaguas (representative of humid forest region) in the upper Amazon region (Huallaga Valley) of Peru. Discussions were also held with members of the Soils Department staff of IICA at Turrialba. Still another purpose of this trip was to obtain fertilizer response data on different tropical soils useful for economic analyses and interpretation, and also to study the design and interpretation of fertilizer-response experiments such as those of CIMMYT in the Puebla Project.

An in-depth literature review and development of a computer-based information storage-retrieval system are both in progress. Both activities pertain to fertilizer response on tropical soils, to properties of tropical soils that directly influence and determine their fertilizer response and productivity potential, and to statistical and economic analyses and interpretations of fertilizer response. During the literature review and summary of existing information, persons involved with this project have abstracted and summarized more than 1500 references to date. In a number of cases, translation from Spanish or Portuguese was made from Latin American publications. These references are being entered in the information storage-retrieval system. This computer-based system uses a specially developed program for recovery and printout of information on tropical soils and their fertilizer response. A copy of our subject list, which also functions as a keyword or keyphrase system, is attached to this report. This system is carefully cross-indexed such that one can retrieve subject matter topics by countries, or by interactions and interrelationships. Not only does this provide us with a rapid information recall system, but also our people now have a better grasp of the state of knowledge, the kind of information available, and some of the current tropical soil problems in the less-developed countries in Latin America. It is the plan to publish or otherwise distribute our literature list or bibliography.

Agronomic Activities

In the soil fertility area, some general conclusions may be drawn based on summarizations to date. The soils of the lowland humid tropics in Latin America are for the most part very deficient in phosphorus. Many of these are deficient in sulfur. These soils are also generally acid and have a large part of their effective cation exchange capacity occupied by exchangeable Al. Existing information on micronutrient (trace element) deficiencies and toxicities in Latin America is being surveyed but summarizations and maps are not yet completed. Laboratory studies on phosphorus fixation are being conducted on soils from Central America and southern Mexico formed from volcanic ash (Andepts and Ustalfs) and limestone residuum (Ustalfs) and on soils from the Colombia Llanos formed on old Andean alluvium-colluvium (Ustults and Ustox) and from the Brazilian campo formed from "basic" rocks (Eutrustox or "Latosol Roxa"). Determinations are being made on the amount of phosphorus necessary to be added to bring the soil solution level up to 0.1 and 0.2 ppm. The level of available soil phosphorus at these two soil solution levels is also being determined. The Eutrustox from Brazil, very rich in iron, was found to sorb large amounts of phosphorus but this was readily released to common "soil test" extractants - a possibly very important finding.

In the area of soil mineralogy and genesis, clay mineral determinations and classification system placements are being done on the soils previously listed and also from our proposed site of agronomic studies in the humid tropical upper Amazon Basin of eastern Peru (Huallaga Valley near Yurimaguas).

Agronomic-Economic Studies

A comparison of continuous and discontinuous models of fertilizer yield response and percentage of maximum crop yield on Latin American soils was completed by R. B. Cate, Jr. [1/] in part with support from this research contract. In this research, 200 soil fertility correlation data sets from Latin America were screened by preliminary statistical analyses with both continuous and discontinuous models. The discontinuous model

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[1/] Cate, R. B., Jr. 1970. Improving the interpretation of soil fertility correlation data - a comparison of continuous and discontinuous models, using a variety of data sets. Ph.D. Thesis, North Carolina State University, Raleigh, North Carolina.

has been identified as the "Cate-Nelson" technique and involves the establishment of a critical level of a plant nutrient based on an analyses of the plots of percentage of maximum yield versus the content of the nutrient in plant available form in the soil. This discontinuous model is based on division of the soil fertility correlation data into two independent populations, separated by the critical level. The discontinuous approach was concluded to have greater "practical predicability" of crop yield response to applied fertilizers and also a "theoretical superiority" over continuous curvilinear models of fertilizer response - under the conditions of the experimental data used and for the purpose of predicting relative response of crops to added fertilizer nutrients. It was conceded that the superiority of the discontinuous model in this study may be a statistical artifact. However, it was postulated that it (the apparent superiority) may also be the result of "biologic analogies" to the basic rules for achieving economic efficiency.

Economic Analyses of Agronomic Data

Activities by R. K. Perrin, J.G. Ryan and V. E. Ball during the period were directed toward (a) gathering and storing existing soil fertility-yield response data and (b) review of statistical and economic models which have been used to derive fertilizer recommendations from response data. As a part of these activities, 161 references were abstracted and indexed for the storage and retrieval bank.

A. Existing response data.

The initial and primary source of data for agronomic-economic analysis were to have been from field and greenhouse experiments conducted under the auspices of the International Soil Fertility Evaluation and Improvement Project. This source has provided a small amount of useful data. However, during the liaison trip to Mexico, Costa Rica, Colombia and Peru, three sets of data on wheat and four for corn were obtained from Peru. Liaison was established with CIMMYT (Mexico) and ICA (Colombia) and there are prospects of obtaining some specific sets of corn and wheat response data from those two sources. The most complete and useful set of data available is that obtained by McCollum and Waugh on potato response to fertilizers in Peru; these data soon will be entirely assembled in Raleigh.

Contrary to our expectations, the data assembled in Raleigh under the International Soil Fertility Evaluation and Improvement Project have been in part unsuitable for our purposes. R. B. Cate has assembled and examined data from about 40 separate sources, of which 6 were from Mexico, 8 were from other Latin American countries, and the remainder largely from the United States. Of the 14 data sets from Latin America, 9 are not usable for our purposes. The five remaining sets consist of 3 sets of corn response data collected by CIMMYT in Mexico, the potato data of Waugh and McCollum and a set of wheat data from Bolivia. These data sets are partially incomplete with respect to detailed plot yield information and meteorological data but can be analyzed when the additional information is received.

B. Statistical and economic models.

A review of the literature has revealed several empirical studies on the affect of soil variables on fertilizer response and a number of methods of incorporating this information and elements of uncertainty into fertilizer recommendation procedures. It is apparent that the problem of adjusting recommendations for uncertainty has not been very satisfactorily resolved.

Research personnel involved with Contract activity. December 31, 1970

Soil Science		Service Obligation to csd-2806
R. B. Cate, Jr.	Research Associate	Full time
W. V. Bartholomew	Professor	2 months per year
S. W. Buol	Professor	2 months per year
F. R. Cox	Associate Professor	2 months per year
G. A. Cummings	Associate Professor	1 month per year
E. J. Kamprath	Professor	2 1/2 months per year
J. F. Lutz	Professor	1 month per year
C. B. McCants	Professor	2 1/2 months per year
O. D. Philen	Research Assistant	2 months per year
Patricia Patrick	Research Technician	Full time
Faye Stadler	Typist	Full time

Economics

J. G. Ryan	Research Assistant	Full time
R. K. Perrin	Assistant Professor	2 months per year
V. E. Ball	Graduate Research Assistant	6 months per year
Sue Gardner	Statistical Aide	Full time

Statistics

L. A. Nelson	Associate Professor	1.2 months per year

Expenditures For Period 7-1-70 / 12-31-70, Contract AID/csd-2806

Category	Firm Budget Amount 6-30-70/12-31-71	Total To Date
Salaries & Wages	$162,347.00	$38,937.55
Fringe Benefits	18,887.00	3,138.63
Consulting	8,100.00	3,750.00
Travel	33,091.00	4,468.39
Other Direct Costs	20,428.00	331.59
Out of Pocket	25,000.00	4,159.10
Overhead	71,147.00	18,304.54
	$339,000.00	$73,089.80

Subject Matter Classification Guide Sheet for Information Storage and Retrieval System Relative to Literature on Tropical Soils.

No. of IBM Column	
31	1. Soil Physics
32	1.0 Soil Physics - Miscellaneous and Unclassified
33	1.1 Aeration (Soil)
34	1.2 Bulk Density - Compactness
35	1.3 Consistency - Swelling
36	1.4 Porosity
37	1.5 Structure
38	1.6 Temperature (Soil)
39	1.7 Texture
40	1.8 Water (Soil)
41	1.8.1 Constants (Available Water)
42	1.8.2 Irrigation
43	1.8.3 Movement
44	1.8.3.1 Drainage
45	1.8.3.2 Evapo-Transpiration
46	1.8.3.3 Hydraulic Conductivity
47	1.9 Plant Relations
48	2. Soil Chemistry
49	2.0 Soil Chemistry - Miscellaneous and Unclassified
50	2.1 Clay Minerals
51	2.2 Cation Exchange
52	2.3 Anion Exchange
53	2.3.1 Precipitaion
54	2.3.2 Adsorption
55	2.4 Organic Matter Complex
56	2.5 Sesquioxides
57	3. Soil Organisms
58	3.0 Soil Organisms - Miscellaneous and Unclassified
59	3.1 Biological Methods
60	3.2 Effects of Soil
61	3.3 Functions
62	3.3.1 N Fixation
63	3.3.2 N Transformation
64	3.3.3 Organic Matter Decay
65	3.4 Kinds
66	3.5 Numbers
67	3.6 Soil Properties Affecting
68	4. Soil Fertility
69	4.0 Soil Fertility - Miscellaneous and Unclassified
70	4.1 Calcium
71	4.2 Climatological
72	4.3 Experimental Procedures (See Data Sources in Economic Section for Pot Trials, Field Trials & Microplot)
73	4.4 Lime

74 4.5 Magnesium
75 4.6 Nitrogen
76 4.7 Nutrient Deficiencies
77 4.8 Nutrient Losses
78 4.9 Nutrient Uptake
79 4.10 Phosphorus
80 4.11 Placement
81 4.12 Potassium
82 4.13 Productivity Levels
83 4.14 Rotations
84 4.15 Soil
85 4.16 Soil Management
86 4.17 Soil Testing
87 4.18 Sulfur
88 4.19 Tissue Testing
89 4.20 Micronutrients
90 4.20.1 Boron
91 4.20.2 Chlorine
92 4.20.3 Copper
93 4.20.4 Manganese
94 4.20.5 Iron
95 4.20.6 Molybdenum
96 4.20.7 Zinc
97 4.21 Non-essential elements
301 4.21.1 Soil Acidity
302 4.21.2 Aluminum

98 5. Soil Classification, Genesis, Morphology and Survey
99 5.0 Soil Classification and Genesis - Miscellaneous & Unclassified
100 5.1 Maps: (Cross Index to Country)
101 5.1.1 Detailed Soil Maps
102 5.1.1.1 FAO Legend
103 5.1.1.2 7th Approximation Legend
104 5.1.1.3 1938 - U.S. Legend
105 5.1.1.4 Other Legend
106 5.1.2 General Soil Maps
107 5.1.2.1. FAO Legend
108 5.1.2.2. 7th Approximation Legend
109 5.1.2.3. 1938 - U.S. Legend
110 5.1.2.4. Other Legend
111 5.2 Characterization Data
112 5.2.1 Morphological Profile Descriptions
113 5.2.2 Micromorphological
114 5.2.3 Mineralogical
115 5.2.4 Physical, Chemical, Biological (Cross Index)
116 5.3 Classification
117 5.3.1 Tropical Soil (General)
118 5.3.2 Latosols, Laterite, Lateritic, Ferrisols, Ferralsol
119 5.3.3 USA Classification
120 5.3.3.0 Alfisols (Grey-Brown Podzolic, Grey Wooded)
121 5.3.3.1 Aridisols (Desert Soils)
122 5.3.3.2 Entisols (Alluvial, Lithosol, Regosol, Azonal)
123 5.3.3.3 Histosols (Organic Soils, Muck, Peat)

124 5.3.3.4 Inceptisol (Sol Brun Acide, Brown Forest, Etc.)
125 5.3.3.5 Mollisols (Prairie, Brunizem,Chernozem)
126 5.3.3.6 Oxisol (Laterite, Ground Water Laterite some Latosols)
127 5.3.3.7 Spodosols (Podzol)
128 5.3.3.8 Ultisol (Red-Yellow Podzolic)
129 5.3.3.9 Vertisol (Grumusol, Black Cotton, Regur, Etc.)
130 5.3.4 FAO Classification
131 5.3.4.0 Andosols, Gleysols, Cambisols
132 5.3.4.1 Rhegosols, Arenosols, Fluvisols, Lithosols, Rendzinas, Ranker
133 5.3.4.2 Vertisols
134 5.3.4.3 Acrisols, Nitrosols
135 5.3.4.4 Ferralsols
136 5.3.4.5 Yermosols, Xerosols, Solonchak, Solonetz
137 5.3.4.6 Luvisols, Planosols
138 5.3.4.7 Castanozems, Chernozems, Phaeozems
139 5.3.4.8 Histosols
140 5.3.4.9 Podzols, Podzoluvisols
141 5.3.5 Other Classification
142 5.4 Special Features (Study of)
143 5.4.1 Plinthite
144 5.4.2 Fragipan
145 5.4.3 Duripan, Silica Pan
146 5.4.4 Petrocalcic, Caliche, Calcic Horizons
147 5.5 Genesis Studies (Soil-Forming Factors & Processes)
148 5.5.1 Relation to Factors
149 5.5.1.1 Climate
150 5.5.1.2 Vegetation and Organisms
151 5.5.1.3 Parent Material
152 5.5.1.4 Relief
153 5.5.1.5 Time
154 5.5.2 Relation to Geomorphology
155 5.5.3 Relation to Weathering Processes
156 5.5.4 Relation to Pedoturbation Processes
157 5.5.5 Relation to Leaching

158 6. <u>Soil Conservation - Erosion</u>
159 6.0 Soil Conservation, Erosion, and Management - Miscellaneous and Unclassified
160 6.1 Conditions (Erosion)
161 6.1.1 Water
162 6.1.2 Wind
163 6.2 Economic and Social Aspects
164 6.2.1 Crop Yields
165 6.2.2 Standard of Living
166 6.3 Factors Affecting
167 6.3.1 Climate
168 6.3.1.1 Precipitation
169 6.3.1.2 Hydrology-Runoff
170 6.3.1.3 Wind
171 6.3.2 Land Use
172 6.3.3 Soil Properties

173 6.4 Methods of Conservation
174 6.4.1 Agronomic
175 6.4.2 Engineering
176 6.5 Soil Management
177 6.5.1 Management Systems
178 6.5.2 Crop Rotations and Sequences
179 6.5.3 Shifting Cultivation, Swidden, Etc.
180 6.5.4 Drainage

181 7. Forest Soils
182 7.0 Forest Soils - Miscellaneous and Unclassified
183 7.1 Forest Floor and Litter
184 7.2 Forest Types
185 7.3 Forest Ecology
186 7.4 Nutrient Cycling

187 8. Fertilizer Technology
188 8.0 Fertilizer Technology - Miscellaneous and Unclassified
189 8.1 Nitrogeneous Materials
190 8.2 Phosphatic Materials
191 8.3 Potassic Materials
192 8.4 Mixed Fertilizers
193 8.4.1 Bulk Blends
194 8.4.2 Fluid Fertilizers
195 8.4.3 Granular
196 8.5 Slow-Release Fertilizers

197 9. Soil Mineralogy
198 9.1 Particle Size Characterization
199 9.1.1 Sand Mineralogy
200 9.1.2 Silt Mineralogy
201 9.1.3 Clay Mineralogy
202 9.1.3.1 Kaolinite
203 9.1.3.2 Montmorillonite
204 9.1.3.3 Illite
205 9.1.3.4 Vermiculite
206 9.1.3.5 2:1 - 2:2 Intergrades
207 9.1.3.6 Chlorite
208 9.1.3.7 Hydrous Al & Fe Oxides
209 9.1.3.8 Allophane (Amorphous)
210 9.2 Analytical Methods
211 9.2.1 X-Ray Diffraction
212 9.2.2 Thermal
213 9.2.3 Infrared
214 9.2.4 Chemical
215 9.2.4.1 Elemental Analysis
216 9.2.4.2 Exchange Properties
217 9.2.5 Microscopy
218 9.2.6 Other

219 10. Geographic Locations
220 10.1 Argentina
221 10.2 Bolivia

222	10.3	Brazil
223	10.4	Chile
224	10.5	Colombia
225	10.6	Costa Rica
226	10.7	El Salvador
227	10.8	Guatemala
228	10.9	Guyana
229	10.10	Honduras
230	10.11	Mexico
231	10.12	Nicaragua
232	10.13	Panama
233	10.14	Paraguay
234	10.15	Peru
235	10.16	Uruguay
236	10.17	Venezuela
237	10.18	Africa South of Sahara
238	10.19	Africa North of Sahara
239	10.20	Europe exclusive of USSR
240	10.21	Australia
241	10.22	Indochina
242	10.23	Indonesia
243	10.24	India
244	10.25	Malaysia
245	10.26	Pakistan
246	10.27	Asia other than 10.21-26
247	10.28	Florida
248	10.29	Hawaii
249	10.30	Puerto Rico
250	10.31	USA other than 10.28-30
251	10.32	Canada
252	10.33	USSR
253	11. Crops	
254	11.0	Miscellaneous and Unclassified
255	11.1	Bananas
256	11.2	Beans
257	11.3	Corn
258	11.4	Cotton
259	11.5	Citrus
260	11.6	Coffee
261	11.7	Fiber crops other than cotton
262	11.8	Forage crops
263	11.9	Pastures
264	11.10	Potatoes
265	11.11	Rice
266	11.12	Sugar Cane
267	11.13	Wheat, rye, barley
268	11.14	Yucca (Mandioca, Cassava)
269	12. Climate	
270	12.1	Temperature
271	12.2	Rainfall
272	12.3	Evapotranspiration
273	12.4	Solar Radiation

274 13. Economics

275 13.0 Economics - Miscellaneous and Unclassified

276 13.1 Supply and Demand Studies

277 13.2 Budget Studies

278 13.3 Aggregate Statistical Data

279 13.3.1 Crops - prices, yield, production, acreage

280 13.3.2 Fertilizer - prices, production

281 13.4 Yield Response Studies

282 13.4.1 Type of Response

283 13.4.1.1 Absolute Yield

284 13.4.1.2 Relative Yield

285 13.4.2 Variables included (other than nutrients)

286 13.4.2.1 Soil Test Results

287 13.4.2.2 Weather or Climate Variables

288 13.4.2.3 Soil Characteristics

289 13.4.3 Data Sources (See Soil Fertility for Nutrient)

290 13.4.3.1 Pot Trials

291 13.4.3.2 Field Trials

292 13.4.3.3 Micro-plots

293 13.5 Decision Models

294 13.5.1 Traditional Marginal Analysis

295 13.5.2 Uncertainty Models

296 13.5.3 Other

297 13.6 Theoretical Studies

298 13.6.1 Economic

299 13.6.2 Statistical

300 13.6.3 Soil

Summary Of Coordination Conference For AID-Sponsored Research On Soils And Fertilizer In Latin America. Raleigh, N. C., November 12-13, 1970

AID has engaged the services of five U.S. universities and Tennessee Valley Authority to study the many faceted problems of tropical soils and their fertility requirements in increasing food production. Part of the charge to these institutions is to maintain close coordination and cooperation among their several programs in developing this U.S. competence. This conference was convened for that purpose; and it involved representatives from North Carolina State University, Cornell University, University of Hawaii, University of Puerto Rico, Prairie View A & M, TVA, USDA, and AID. The exchange of information covered activities under technical assistance funding, research contracts and institutional development (211(d)) grants.

I. The conference was opened with remarks by Dean J. A. Rigney, Office of International Programs at N. C. State University. He spoke of the need for U. S. universities to broaden the base and range of their International programs and to avoid isolation of these programs from other university activities, especially at the departmental level. He also called attention to the need for all in the university community to enlarge their understanding of the world in which we live. Dean Rigney identified what he thought and hoped to be two trends in the reorganization of International programs in the USA: (1) greater emphasis on "institution building" in the less-developed countries (LDC's) and (2) trend to networks of research and technical assistance, with linkages among U. S. and International institutions.

II. Dr. Alvin D. Ayers of the AID-Washington Technical Assistance Agriculture and Fisheries staff indicated that in the future, in his opinion, it appears likely that increased emphasis will be laid on partnership and cooperation with LDC's and on linkages and networks, including greater coordination and communication AID-funded research, technical assistance and 211(d) contracts and grants. He stated that it seemed likely AID would place high priority on soil and water management in the future. Dr. Ayers urged close coordination among various programs in LDC, as people within the country tend not to differentiate among programs and to be confused by different university and agency activities.

Mr. J. E. Walker of the AID Latin American Bureau reminded the group that AID and the contracting universities are subject to State Department policies when operating in host countries, and that the Rural Development Officer is responsible for coordinating agricultural programs in each country.

III. The International Soil Fertility Evaluation and Improvement Program (formerly International Soil Testing Project) of N. C. State University was described by the program director, Dr. J. W. Fitts. This program has been underway in Latin America nearly seven years. A part of the emphasis has been on working with host countries in improving their soil testing labs (including multiple sample analysis techniques and extraction methods), carrying out soil test-fertilizer response correlation studies and in installing all the phases of soil testing programs. Another type of emphasis has been on training and upgrading personnel, including a six to eight weeks seminar held in Raleigh each year. An average of four full-time soil scientists have been stationed in Latin America, working with 14 countries, during this period, plus part-time consultants in three other Latin American countries. Tentative plans for the future, as this program moves to a system of funding through the Latin American Bureau, include assignment of a soil scientist to each of the following countries or groups of countries: Brazil, Bolivia-Paraguay-Peru, Colombia-Ecuador-Panama, Costa Rica-Nicaragua and El Salvador-Guatemala-Honduras. In response to a question about technical problems encountered in the project activities, Dr. Fitts listed these as examples: unidentified sources of variation in soil test results, determination of lime requirement, fertilization needs for multiple cropping systems; need for estimating soil contributions of native nitrogen to crop plants, and dealing with cultivated soils differing in varying degree from similar but uncultivated soils. Dean Rigney urged that personnel of this program be drawn upon as in-country resource people for the various programs, and that this group summarize the research problems they have encountered to date.

IV. The new NCSU research contract (csd-2806) on "Agronomic-Economic Research on Tropical Soils" was summarized by members of the N. C. State Soil Science and Economics Departments. The two main overall objectives for this project were identified as:

A. To develop methodology for an economically sound system of making fertilizer recommendations based on information gained from soil analyses and fertilizer crop response data, primarily from Latin America, for developing countries in tropical regions.

B. To obtain basic soil fertility, chemistry and mineralogy data on key soils in major ecological regions - as needed to support objective A. The types of activities now getting underway for accomplishing these objectives are:

1. Agronomic-economic yield-fertilizer response evaluations:

1.1 Obtain and collate existing soil fertility-fertilizer application-yield response data from all available sources in tropical regions in Latin America, including especially those obtained through the North Carolina International Soil Fertility Evaluation and Improvement and Peru Contract programs and those which will be obtained from the priority area research to be conducted under this contract.

1.2 Design and conduct additional experiments needed to fill critical gaps, in close cooperation with regional institutes and cooperating countries.

1.3 Analyze all these data according to various models - including regression and response surface, critical level ("Cate-Nelson" plots of relative yield vs. soil test levels) and Bayesian decision analyses; evaluate these analytical models in terms of minimum amounts and types of data needed to make fertilizer recommendations and estimate fertilizer requirements in the LDC's, including risks and weather probabilities.

R. B. Cate, Jr. reported that more than 200 sets (groups of field experiments) of data have already been analyzed via the Cate Nelson critical level technique. He described this technique as a method of making soil testing correlations, not one of developing and making fertilizer recommendations. A lengthy discussion followed about the role and uses of this technique. For example, Dr. Lathwell of Cornell stated as his opinion that the Cate-Nelson critical level technique gives a "yes" or "no" answer with respect to the need for fertilizer, but field experimentation (via rate trials and treatments) is needed for determination of the quantity of fertilizer to apply.

R. K. Perrin and J. G. Ryan of the N. C. State Economics Department discussed the concept of "economically sound" fertilizer recommendations under conditions of considerable uncertainty as to actual yield response (because of weather variability or large experiment error, etc.). They suggested that recommendations need to be based not on expected cost-benefit ratios, but on confidence limits around these ratios. They indicated their intent to find a method of comparing the efficiency of alternative recommendation procedures under various uncertainty regimes. Plans to use existing data to correlate yield response with various soil and climatic variables were briefly discussed. A progress report was given on efforts to date in evaluating methodologies of analyzing and summarizing fertilizer response and soil test correlation results appropriate for LDC's under conditions of limited data availability.

2. Agronomic-soils aspects:

2.1 Conduct "basic" soil fertility and soil chemistry studies as needed to support objective 1, emphasizing corn, beans and small grain on key benchmark soils at two priority geographic locations - one in a savannah-dry season area and another in a humid forest region, possibly a third in a volcanic ash area.

2.1.1 Nitrogen: cyclic variation with dry seasons and leaching rains; positional availability in the soil profile, native nitrogen supply in various ecologic zones.

2.1.2 Phosphorus: fixation-sorption-release in wet-dry cycles and in relation to iron and allophane concentrations in the soils.

2.1.3 Lime needs in relation to exchangeable aluminum levels and saturation.

2.2 Prepare a survey of micronutrient deficiency and toxicity patterns by geographic locations - including analysis of soil and plant samples as needed.

2.3 Soil classification and characterization-identification and classification placement of soils at sites where data are collected to allow extrapolation of results; identification and measurement of those soil properties relevant for soil fertilization and management; determination of clay minerals as they relate to and control fertilizer needs and response.

2.4 Collection of soil moisture and climatic data as needed in explaining and interpreting fertilizer response.

It was reported that R. K. Perrin, P. A. Sanchez and R. J. McCracken of NCSU had just completed a study trip to Mexico, Turrialba (Costa Rica), Colombia and Peru in connection with this research contract.

V. The Cornell-Puerto Rico research contract program was described by M. Drosdoff and D. J. Lathwell and R. W. Pearson (ARS). Dr. Drosdoff described the types of emphasis in this program:

(1) Concentration in lowland (less than 1,000 meters altitude) humid-subhumid tropics.

(2) Well-drained infertile upland soils.

(3) Concentration on Latosols as previously classified - Oxisols and isothermic Ultisols in the present classification.

(4) Puerto Rico as base of operations and site of lab work initially, with extension of field trials to Latin America later.

Areas of priority research were identified as:

(a) Nitrogen: efficiency of usage; leaching, volatilization, and mineralization rates; crop usage.

(b) Phosphorus: rates needed and residual effects.

(c) Acidity: lime requirement and response, calcium-aluminum relationships.

Dr. Lathwell reported on results of the nitrogen experiments with corn in Puerto Rico (R. Fox and D. R. Bouldin also have been involved), on four different soils. Three of these soils are in different great groups of Oxisols, the fourth is a Tropohumult (Ultisol order). No response to nitrogen applications on corn was noted on Catalina clay, an Oxisol (Typic Haplorthox) in central Puerto Rico; corn yields were 92-100 bushels per acre using Pioneer 306 from Jamaica as the variety. This soil had been farmed 50 years, was located on sloping land, had six percent organic matter and 70 ppm inorganic nitrogen in the A horizon, and receives 70 inches of rain per year but can be cultivated very soon after rains. In contrast, the nearby Humatas soil, an Ultisol, displayed significant response of corn to nitrogen - with responses to 120 pounds per acre of nitrogen applied preplant and to 60 pounds per acre applied post plant.

A vigorous discussion followed, including causes of the apparent high native nitrogen supplying capacity of the Catalina soil and the lower N supply in the Humatas soil, the high water infiltration rate of this soil means for assessing N availability in tropical soils, and the need for much more research on organic matter and nitrogen mineralization and supply in tropical soils. Dr. Lathwell indicated that KCl-extractable N may provide a reasonable estimate of nitrogen availability in these kinds of soils.

R. W. Pearson reported the AID-funded research contract csd-2490 has led to great expansion of lime-soil acidity research in Puerto Rico - including work to establish reasons for response or lack of response to lime, Al-Mn interactions (some indication that Mn is alleviating Al toxicity), rates of lime, and attempts to substantiate so-called "over-liming" injury on Oxisols and Ultisols.

Dr. R. Pietri, University of Puerto Rico College of Agriculture at Mayaquez, cautioned about using previously reported data and experimental results on Catalina and Nipe soils because the concepts and ranges of these soils have recently been greatly revised. He reported response to slag as a liming material in pot work, and to calcium and magnesium silicates also applied to soil in pots growing test plants.

VI. The TVA programs in fertilizers for developing countries and their AID-funded project on "Tailoring Fertilizer for Rice" was described by P. J. Stangel. He reported that TVA has sent a total of 45 teams to 22 countries; emphasis has been on engineering, fertilizer manufacturing technology, plant location and timing of development of fertilizer technology. In the rice fertilizer program, an advisory committee is aiding in the evaluation of the various experimental materials. Among the resources of the TVA National Fertilizer Development Center are a library of fertilizer information with an Eastman Miracode retrieval system, indices of fertilizer production facilities in the LDC's computer storage of information on all known phosphate deposits, computer-stored country fertilizer statistics compiled cooperatively with FAO, plus facilities and personnel for training personnel from LDC's. Mr. Stangel reported on the TVA program of developing sulfur-coated urea for slow N release and indicated a number of technical improvements have been made in this material. He remarked that ammonium sulphate is now very low in price, is competitive with urea, and might be considered for granulation with rock phosphate.

VII. Dr. Drosdoff gave a progress report on the NAS-NRC Tropical Soils Committee of which he is chairman. This committee is composed of six European soil scientists with extensive tropical soil experience (some have spent almost their entire professional lifetime in the tropics) and five North American, plus a number of special consultants.

Priority topics for tropical soil research have been tentatively identified by the committee as:

(a) Nitrogen: mineralization, availability and native supply, soil tests for availability, economics of native vs. commercial sources.

(b) Liming and soil acidity.

(c) Phosphorus: availability in various soils, residual effects, types of sources.

(d) Sulphur: soil levels, crop needs.

(e) Soil classification and mapping: at least at the reconnaissance level for each country.

(f) Characterization of basic properties of soil groups as means of extrapolation of research results.

Drosdoff commented on the high similarity among the Cornell, North Carolina and NAS-NRC tropical soil research priorities which had been arrived at independently.

VIII. Comments were made by representatives of two groups represented in the 211(d) consortium but not holders of AID research-technical assistance contracts. There were Dr. W. G. Sanford, Head of the Agronomy and Soil Science Department of the University of Hawaii, and Dr. A. S. Mangaroo of the Soil Science Department of Prairie View A & M.

1. Among the overall interests and capabilities of the Hawaii Agronomy-Soil Science group are soil and water management and control of aquatic weeds, according to Sanford. More specialized interests of their soil science group were identified as follows:

Soil characterization and mineralogy: Swindale, Ikawa, Jones, G. Uehara.

Soil physics and soil water: Ekern (evapotranspiration and ecology re rainfall distribution), Uehara, and Green (pesticides in water).

Soil chemistry and fertility: R. Fox, J. Silva and Y. Kanihiro (also interested in nitrogen mineralization).

Soil microbiology: B. Koch.

Commodity crop interests were identified as:

Pastures: Plucknett, Whitney, Tamini, Thomas

Pineapples: Sanford

Sugar cane: Silva

A rice production training center is maintained on the island of Kauai. It was reported that Fox and Silva of Hawaii have done research on application of calcium silicate to sugar cane and lettuce with beneficial results, believed due in part to elimination of manganese toxicity and to the addition of silica.

2. Dr. Mangaroo of Prairie View A & M identified some of the research interests of his group in relation to tropical soils as:

(a) Soil mineralogy with respect to silica and aluminum.

(b) Soil organic matter studies, especially under prairie or savannah conditions since this is the type of vegetative-ecological zone in which Prairie View is located.

(c) Nontillage farming

(d) Zinc as a micronutrient

IX. Summary comments made by Mr. Walker included the following points:

(1) Emphasis is needed on the actual dissemination and application of the research results in the LDC's.

(2) There is a greater need than ever for coordination among those working with tropical soils and their management - foundations, regional institutes, FAO, university contractors, and AID direct hire personnel.

(3) Need to determine the specific needs and problems of each LDC.

Dr. Ayers suggested that summaries of tropical soil research problems be circulated among cooperating universities and other interested groups, and that each should respond with knowledge or ideas they have on solutions to these problems; perhaps a regular newsletter or periodic issuance of a bulletin on tropical soils could be initiated.

X. The consensus of the group was that they should meet at least once a year, and that such a meeting could be coordinated with meetings of the 211(d) consortium on tropical soils. A tentative date and place for the next meeting is October, 1971 in Hawaii.

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November 12-13, 1970

Raleigh, North Carolina

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