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CROP PRODUCTION AND LAND POTENTIAL OF BENCHMARK SOILS OF LATIN AMERICA

Contract AID/ta-C-1158

ANNUAL RESEARCH REPORT
for the period
1 October 1979 to 30 September 1980

Submitted to the
U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT
by the

DEPARTMENT OF AGRONOMY AND SOILS
COLLEGE OF AGRICULTURAL SCIENCES
UNIVERSITY OF PUERTO RICO
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REPORT SUMMARY

A. Statistical Summary

1. Project Title and Contract Number: Crop Production and Land Potential of Benchmark Soils of Latin America - AID/ta-C-1158

2. Principal Investigator, Contractor and Mailing Address:
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3. Contract Period (as amended): 1 January 1975 to 31 December 1981

4. Period covered by Report: 1 October 1979 to 30 September 1980

5. Total AID funding of contract to date: $2,110,555.00

6. Total expenditures and obligations through previous fiscal year: $1,448,674.12

7. Total expenditures and obligations for current year: $438,738.22

8. Estimated expenditures for next year $223,142.66

B. Narrative Summary of Accomplishments

The objective of the Benchmark Soils Project is to demonstrate that agroproduction technology can be transferred among tropical countries on the basis of soil classification. To verify the transfer hypothesis, a series of crop production and soil management experiments are conducted in various countries by this contract and a parallel project of the University of Hawaii.

The soils selected for experimentation by the University of Puerto Rico project are highly weathered, red upland soils of the subhumid tropics defined as Eutrustox in the U.S. Soil Taxonomy. Six experiment sites in such soils were established, three in Puerto Rico and three in Minas Gerais, Brazil. Following previously developed standard procedures, a total of 23 transfer, 3 variety and 13 management experiments with maize and soybeans were completed or begun during FY 80.

Maize yields obtained in the transfer experiments were generally good to excellent. But statistical analyses of the field data revealed considerable variability, both within and among sites and from season to season. While this is to be expected in view of divergences in past management and other site variables, it renders the transfer test difficult. Statistical analyses of the yield, weather and laboratory data using standard multiple regression and analysis of variance techniques are in progress and will be reported at a later date. It is expected that these studies will corroborate the transfer hypothesis, at least in essence.

Management experiments conducted in FY 80 focused on irrigation (3), tillage (2), phosphorus placement (2), liming (2), multicropping (2), and composite maize formation (2). These studies and three variety trials with maize and soybeans generated valuable information of local applicability.

Dissemination of project rationales and results through technical papers, workshops, field days, and a quarterly published newsletter led to a growing international awareness and acceptance of the project. A panel consultation on the Strategy for Land Evaluation and Agrotechnology Transfer in the Tropics produced specific recommendations regarding the utilization of project concepts.

INTRODUCTION

This is the fifth annual report on the Benchmark Soils Project of the University of Puerto Rico which became effective in January 1975 under contract AID/ta-C-1158 as a companion project to a similar AID contract of the University of Hawaii.

The report covers the period from 1 October 1979 to 30 September 1980 and deals mainly with the accomplishments achieved during that time. Emphasis is placed on the presentation of the results of field experiments and their interpretation relative to the project hypothesis. No effort is made to reiterate the basic rationale of the project or the generalities regarding research strategy and experiment methodology. For detailed information on these aspects, previous annual reports and two joint progress reports on the Benchmark Soils Project published by the University of Hawaii (PRBSP-01-8/78 and PRBSP-02-9/79) should be consulted.

An administrative and fiscal report containing a complete account of expenditures and a budget forecast for FY 81 was submitted to the AID Contract Office in December 1980. Fiscal data are, therefore, not reported here. It should also be pointed out that the present report has been prepared primarily for AID review and is not intended for wide circulation.

As the Benchmark Soils Project of the University of Puerto Rico will terminate in December 1981, a comprehensive summary report with complete agronomic and statistical data and an in-depth analysis of the validity of the project hypothesis will be published and distributed in late 1981.

PROJECT PURPOSE AND OBJECTIVES

The purpose of the Benchmark Soils Project (BSP) is to test a soil classification-based approach to agrotechnology transfer

in the tropics and develop a methodology designed to assist LDC's in appropriately utilizing their land resources for increased and better quality food production by bypassing key constraints. Principal among the constraints prevalent in LDC's are insufficient capital, scarcity of qualified research personnel, and lack of time to close the widening gap between agroproduction and food requirements.

The primary research objectives of the BSP are:

1. To demonstrate that soil management and crop production knowledge can be directly transferred among tropical countries at the family level of Soil Taxonomy, and
2. To establish that the behavior of tropical soils and their potential for food production under various levels of management inputs can be predicted on the basis of soil taxonomic units.

Implicit in these objectives are the substantiation of the value of soil survey and classification for land use planning and the testing of the validity of the established taxonomic criteria. For a limited number of soil families, the BSP further attempts to indicate management alternatives conforming to the economic decision environment of small farmers in tropical LDC's.

ACCOMPLISHMENTS

I. General Scope of Work

With all six experiment sites in Puerto Rico and Brazil fully operational, project activities during the report period were concentrated on agronomic field work. Particular emphasis was placed on transfer and management experiments. Table 1 shows the number of field experiments conducted during FY 80 and since project implementation by crop, kind of experiment and country. A detailed timetable of the experiments carried out in Puerto Rico and Brazil is presented in Appendix A.

Table 1. Experiments completed or begun during FY 80 and life-of-project

Experiment	Crop			
	Maize	Soybean	Other	Total
Transfer				
Puerto Rico	11 (39)*)	(5)	-	11 (44)
Brazil	12 (36)	(1)	-	12 (37)
Variety				
Puerto Rico	(5)	-	-	(5)
Brazil	2 (11)	1 (6)	-	3 (17)
Management				
Puerto Rico	6 (12)	(3)	-	6 (15)
Brazil	5 (12)	(1)	2 (5)	7 (18)
	36 (115)	1 (16)	2 (5)	39 (136)

*) Numbers in parentheses indicate total number of experiments completed or begun to date.

Field experimentation followed the research methodology and design developed jointly with the University of Hawaii. Although these procedures were essentially established in previous years, refinements in the method of phosphorus determination were made in 1978 and 1979 in accordance with the recommendations of coordination meetings of the two Benchmark Soils Projects.

The yield and most crop phenology data of all experiments were statistically analyzed at UPR's Agricultural Experiment Station. In addition, the project's statistics consultant, Dr. Larry A. Nelson, scrutinized the data relative to the project hypothesis.

Continuing efforts were made to strengthen the existing linkages and to establish new contacts. Dissemination of project concepts and results was accomplished through technical papers, a field day, seminars and periodical publications. Strategies for and the nature and scope of a possible follow-up program to the current project were discussed at a workshop.

As detailed in the administrative report, 7 professionals, 9 nonprofessionals and a varying number of field laborers and students were engaged in project activities during the report period. (The current regular project staff is listed in Appendix C). In FY 80, the total work effort amounted to about 275 man-months.

II. Testing the Transfer Hypothesis

A. Results of Transfer Experiments

1. General

The reader is referred to previous BSP Annual Research Reports for more complete information regarding experiment design. In short, the transfer experiments are designed specifically to generate data for testing the technology transfer hypothesis. They are conducted with maize as the test-crop and with two controlled variables, phosphorus and nitrogen levels, in a partial factorial design. Initial plantings of transfer experiments are followed in the same plots by residual transfer experiments, whereby a measure is obtained of maize response to residual phosphorus left in the soil after the initial transfer experiment is harvested. No additional phosphorus is applied to residual trials but nitrogen treatments are repeated at the same levels used for the initial plantings. Both the initial and residual transfer experiments provide data for use in testing the transfer hypothesis.

The data presented in this section are from the transfer experiments harvested during the period from 1 October 1979 to 30 September 1980. For simplification of presentation, the experiments are grouped by seasons and as initial and residual transfer experiments.

The following is a largely descriptive account of the experiment results and their agronomic interpretation. A more complete statistical evaluation will be presented in the final project report.

2. Results of dry season experiments

a. Initial transfer experiments

During the 1979 dry season, maize grain yields increased sharply with phosphorus applications up to the +.40 or +.85 levels of P in initial transfer trials on all three sites at Jaiba, MG, Brazil. Tables 2, 3 and 4* show mean grain yield for these experiments.

When P levels were increased from -.85 to +.85 at the primary (Paraná), secondary #1 (Ceará) and secondary #2 (Bahía) sites, mean grain yields (at the highest N level) rose from 3578 to 8656, 5207 to 8181 and 5533 to 8891 kg/ha, respectively. Similar yield increases with applied P were observed at all levels of N. Conversely, there was only weak or no yield response to applied N on the three Brazil sites. These results reaffirm those from previous transfer experiments at Jaiba.

During the dry season in Puerto Rico initial transfer experiment treatment effects were mild to strong. But contrary to the Brazil experiments, the strongest yield responses were to the applied N, not to P levels. Mean grain yield data are presented in tables 5, 6 and 7 for the Isabela, Puerto Rico primary (Ramal), secondary #1 (Cerro) and secondary #2 (Calero) sites, respectively. Increasing applied N from 29 to 186 kg/ha gave grain yield increases from 5081 to 7378, 6249 to 7891 and 5238 to 6942 kg/ha for the Ramal, Cerro and Calero sites, respectively, at the highest level of P. A similar N effect occurred at intermediate and lower P treatment levels as well.

In general, the three Brazil sites have responded strongly to P but not to N. Apparently, at these BSP sites, sufficient soil N is available for at least one or more cropping seasons, as the sites are all on essentially virgin land. In Puerto Rico all BSP sites have been cropped for many decades and available soil N depends largely on recent cropping history including all aspects of management, especially fertilizer application. For these reasons the effects of N treatments have been quite variable in Puerto Rico.

* Tables 2 to 32 appear in Appendix B.

Although earlier transfer experiments at Puerto Rico sites have demonstrated positive yield responses to P indicating a limited soil P reserve, previous fertilizer applications at adjacent BSP sites have left residual P adequate for one or more crops of maize or have been nonuniform applications causing variability and hence blurring possible P treatment effects.

b. Residual transfer experiments

Residual transfer experiments conducted during the dry season i Brazil showed responses to P that ranged from strong at the primary site, table 8, to possibly a very mild and inconsistent response at the secondary site #2, table 9. There was a mild but consistently positive P treatment effect on grain produced at the secondary site #1, table 10. Maize grain yields, 949 to 5250, 2299 to 4456 and 2148 to 4363 kg/ha for the primary, secondary #1 and secondary #2 sites, respectively, were depressed for all residual transfer experiments in Brazil during the 1979 dry season. Grain yields for residual experiments were similarly low during the previous season.

At this time it is not clear whether during the residual experiment insufficient P was available or some other factor had become limiting. As in the case of initial transfer experiments, there was no N treatment effect for residual experiments in Brazil.

Only two residual trials were completed in Puerto Rico during the dry season of 1979-80. These were at the primary and secondary #1 sites, the experiment planted at secondary site #2 was damaged by a heavy rain shortly after planting. Nitrogen treatments gave mild to fairly strong yield increases on the Ramal (6744 kg/ha) and Cerro (7980 kg/ha) sites, respectively (tables 11 and 12), while the residual P effects were nil.

3. Results of wet season experiments

a. Initial transfer experiments

During the wet seasons in Brazil and Puerto Rico P and N treatment effects resulted in yield trends similar to those of the

preceding dry periods. The degree of response, however, was more moderate and maximum yields were slightly lower, though still reasonably good.

At the primary, secondary #1 and secondary #2 sites in Brazil raising P applications (from -.85 to +.85 levels) boosted grain yields from 4525 to 7039, 6018 to 7680 and 4203 to 7975 kg/ha, respectively, as indicated in tables 13, 14 and 15. Conversely, except for a moderate response to N up to the +.85 level at the Bahía site, there was only slight or no response to N for the Brazil wet-season experiments.

Puerto Rico wet-season maize grain yields appear in tables 16, 17 and 18 for primary, secondary #1 and secondary #2 sites, respectively. Production was relatively good at all three sites but there were only weak to moderate yield responses to applied N and no consistent responses to P levels. Mean yields overall P treatments at the highest N level, +.85, were 7041, 6632 and 6262 kg/ha for Ramal, Cerro and Calero sites, respectively.

b. Residual transfer experiments

Contrary to the previous year, FY 79, wet-season residual transfer experiments during FY 80 at Jaiba, MG, Brazil were more productive than were the preceding dry season residual transfer trials. Mean grain yields at the +.85 P level over all N levels were 7059, 6626 and 7318 kg/ha for primary, secondary #1 and secondary #2 sites, respectively (tables 19, 20 and 21). These were somewhat less than FY 80 dry season initial transfer trial yields but only slightly to moderately below wet season initial transfer trials. The improvement noted over last year's wet-season residual trial yields is partly attributed to earlier planting, December rather than January. Further experimentation would seem desirable regarding time of planting maize, especially during the wet season, in Brazil.

Average wet-season maize yields during 1980 for the Puerto Rico Ramal, Cerro and Calero sites are shown in tables 22, 23 and 24, respectively. Increasing N levels from -.85 to +.85 gave strong

yield responses from 2433 to 7132, 3461 to 9020 and 3157 to 6219 kg/ha at the primary and secondary #1 and #2 sites, respectively. Grain yields were high relative to previous seasons and again N treatments were very effective but increased P levels gave little or no response at Isabela.

Planting time for both so-called wet and dry seasons in Puerto Rico is probably no less crucial than for Brazil. However, because of the much less distinct seasonality of climate, especially rainfall and temperature, it will be more difficult to pinpoint appropriate planting schedules for Puerto Rico. Season-to-season fluctuations in crop production are likewise less readily attributable to "early" or "late" plantings in Puerto Rico.

III. Management Experiments

A. General

Aside from available phosphorus and nitrogen, limited soil moisture is probably the most severe constraint inherent in the soil family under study. For this reason, moisture utilization studies have been emphasized in BSP management experiments in Puerto Rico and Brazil. Irrigation rate experiments have been conducted in both Puerto Rico and Brazil by the BSP. The effect of imposed moisture stress at various growth stages has been studied in a Brazil experiment. Other types of experiments less directly related to soil water management included plant population density and planting date trials. The use of maize and stover mulch was tried. Multi-cropping begun in FY 78 and still underway is also indirectly related to soil moisture utilization, being an attempt to maximize the use of all natural resources available in a given space and time period.

Phosphorus rate and placement, and liming experiments were also carried out. Three tillage experiments were conducted previously and another was completed in FY 80.

B. Puerto Rico

1. Irrigation rate x nitrogen level

In Puerto Rico four irrigation x nitrogen level experiments have been completed, one during the wet season and three during dry seasons. The objectives of this study are (1) to compare the performance of maize when grown without irrigation during the dry and wet seasons in an area with an ustic soil moisture regime, (2) to determine the effect of supplemental irrigation on crop yield in both seasons, and (3) to study nitrogen-water interactions relative to maize production on a Eutrustox.

The Puerto Rico irrigation x nitrogen experiments were modeled after the line-source continuous variable method described by Hanks et al. (1976) but utilizing a trickle irrigation system instead of sprinklers. The first experiment had 24 levels of nitrogen from 0 to 230 kg/ha in 10-kg increments and 12 levels of water applied from 0 to approximately 20 mm of water per application. Irrigations were applied when tensiometer readings in the center plots showed 20 centibars or more tension. The irrigation treatments were likewise applied not randomly but in a stepwise fashion across the nitrogen treatments. There were four replications. The second experiment was laid out in a similar manner, but only half as many treatment levels were utilized and there was no replication. The plot size was very small in the first trial, being only two plants. Since treatment gradients were almost continuous, there were no border effects between plots and large plots were, therefore, unnecessary. For subsequent experiments, plot size was increased to four rows 4 m long (3 x 4m) and only the center two rows were harvested for yield measurements. Treatments were not replicated in the later trials.

The maize yield data from this study for FY 80 are presented in table 25. This year, as well as during the 1979 dry season, there was a strong response to water applications and a mild to moderately strong response to nitrogen. The highest grain yield, 9201 kg/ha, was obtained with 320 kg/ha of N and the

next to highest irrigation rate applied. Lowest yields were harvested from the plots receiving no water; these ranged only from 2985 to 4092 kg/ha, N showing no effect without applied water.

Tentative conclusions drawn from current and previous BSP wet season and dry season experiments are (1) that a reasonably high yielding crop of maize may be grown without supplementary water at Isabela during at least some dry seasons, (2) that during other dry seasons, however, maize yields may be improved considerably with appropriate supplemental irrigation and (3) that nitrogen deficiency can be a limiting factor moderately to severely restricting grain yields depending on cropping history, previous fertilizer applications and available soil moisture. Experimentation with supplemental water must be repeated over a number of seasons to provide reliable information as to crop requirements for irrigation in this area.

2. Normal tillage vs. minimum tillage

In a tillage experiment repeated for the third time at Isabela in FY 80 standard complete tillage was compared with a minimum tillage method of maize culture at various in-row plant spacings. The objectives of these experiments were (1) to evaluate the suitability of minimum tillage for maize production in Tropeptic Eutrustox in order to minimize soil erosion and compaction, (2) to evaluate three different plant population densities -- the standard used in transfer experiments, one lower and one higher -- and (3) to obtain a basis for evaluating the effect on maize yields of minimum tillage as practiced in the residual transfer experiments.

The experiment was established in a split-plot design with three replications. Tillage treatments, assigned to whole-plots, consisted of (1) complete tillage, plowing and discing twice followed by rotovating just before planting by hand, and (2) minimum tillage, weed control with paraquat and planting by hand with no other tillage. Later in the season weeds were controlled on all plots by shallow hoeing.

Plant spacings, sub-plot treatments, were 20, 23 and 27 cm between plants within the row or 66,666, 57,971 and 49,383 plants/ha, respectively. Maize, Pioneer hybrid 304C, was used as the test crop.

The results of this study are presented in table 26. Yield differences among tillage methods in this experiment were not significant. Plant spacing within the row had no significant effect on yields in the FY 79 experiment but favored 20 and 23 cm spacing over 27 cm in the more recent FY 80 trial.

Two conclusions can be drawn from these experiments. First, for maize production on Eutrustox sites such as at Isabela, complete tillage preparation for each season is not necessary. And, second, the plant spacing pattern of 23 cm between plants in rows 75 cm apart (approximately 58,000 plants/ha) is near optimum for the site environment.

3. Phosphorus placement x rate

A phosphorus level and placement study was completed in Puerto Rico in 1980 with maize, Pioneer brand hybrid X304C, as a test crop.

The objective of this experiment was to determine whether the effectiveness of given amounts of applied phosphorus can be optimized by placement in bands or rills rather than broadcast.

Four placement treatments were studied -- rill (beneath seed row), 15 cm band, 45 cm band and broadcast -- at three levels of phosphorus each. Rows were spaced 75 cm apart. The amounts of P applied at each level correspond to the treated portion of the total area; thus, the 15 cm band and 45 cm band treatments received 1/5 and 3/5, respectively, as much P as did the broadcast (75 cm) treatment. For rill treatments the same amounts of P were applied as to the 15 cm bands.

Grain yield data appear in table 27. All plots produced high yields, 7378 to 8523 kg/ha, and differences were not significant. Therefore the lowest rate of applied P, 6 kg/ha applied in 15 cm bands or rills, was as effective as the highest rates

and obviously more economical in this experiment. A previous experiment (during FY 78) showed some yield advantage with broadcast applications, though band applications were more conservative of P. Repeated experimentation is essential to provide adequate evidence for final conclusions. Tentatively it could be assumed that band applications are more economical with little or no sacrifice in yield.

Early growth of maize as evidenced by 30-day plant heights in table 28, showed more response to P levels and placement than did mature plants and grain yields. Plants were tallest at 30 days where the highest levels of P were applied and there was slightly more growth when the phosphorus was broadcast. The previous experiment reflected stronger responses but similar trends to placement and levels of P.

4. Lime x phosphorus

As a follow-up to earlier pot trials with soil from the Calero site (pH 4.2-4.5) a field experiment was conducted in FY 79 with lime and P variables on that site. The objective of this experiment was to verify pot study maize responses to lime and lime-phosphorus combinations under field conditions and with plants grown to maturity. Early, during the silking stage, treatment effects on plant size and ear development were visible, but final grain yields showed no consistent treatment effects (table 29). Hurricane David and tropical storm Federick passed near and over Puerto Rico, respectively, as this experiment was approaching maturity and damages from these storms could easily have obliterated treatment effects on grain yields.

To test for residual effect of lime and P this experiment was planted to maize again the following season, FY 80. The yield data from the residual trial also appear in table 29. Residual trial yields were higher and response to lime showed more consistent trends, the highest grain yield being 6,260 kg/ha at the highest lime level and 50 kg P/ha. Mean yields were generally low, however, for both the initial and residual experiments and treatment effects were not as strong as would

be expected.

C. Brazil

1. Maize and sorghum line-source irrigation

In cooperation with EMBRAPA, the national agency for agricultural research in Brazil, a line-source, sprinkler-irrigated maize and sorghum experiment was carried out from June through October 1979 at the Jaiba BSP primary site. The experiment was designed to study plant moisture requirements over the growth period and its effect on yields among varieties. This was similar to a previous line-source study completed the year before at this site, but improvements were incorporated and four varieties each of sorghum and maize were planted. A single line of sprinklers were installed to produce a pyramid-like gradient of moisture availability for the maize and sorghum. Tensiometer and gypsum block moisture data were collected on a daily basis and irrigations were scheduled accordingly. Growth and yield data were collected and forwarded to EMBRAPA for further analysis, interpretation and dissemination.

2. Moisture stress x P x plant density maize

This experiment, planted with Cargill 111C hybrid seed, was carried out from August to December 1979 at the BSP primary site in Jaiba. The study was designed to observe the possible interactions of levels of phosphorus applied (as SSP), different moisture regimes, and planting density. A split-plot randomized complete block design, with three replications, was used. Phosphorus levels (4) and densities (3) were assigned to sub-plots and moisture treatments to whole-plots.

The moisture stress periods were of 30 days duration. These periods were initiated at one week after germination, i.e. (1) 7 to 37 days after germination, (2) 37 to 67 days after germination, (3) 67 to 97 days after germination, and (4) no period of moisture stress as the control. The amount of moisture each plot received was controlled using drip irrigation lines and soil moisture status was monitored with soil tensiometers. As this period is the dry season in Jaiba, rainfall

was not a problem, although some rainfall occurred in mid-October which may have influenced the results of the third moisture stress period. As presented in table 30a, the four P treatment levels were 60, 40, 20, and 0 kg elemental P/ha. The three plant densities studied, as shown in table 30b, were 30,000, 55,000, and 85,000 plants/ha., all fertilized at 60 kg P/ha. All plots received the same application of 80 kg K/ha. and split applications of 100 kg N/ha. (25 kg at planting and 75 kg at 30 days).

3. Phosphorus placement

A phosphorus placement study, using X304C(Pioneer) hybrid maize, was conducted at the primary site in Jaiba from February to June 1980. The purpose of this experiment was to study the possible effects of different rates and placement methods of phosphorus (as SSP) on maize growth and yield. The levels of phosphorus used were 20, 40, 58, and 81 kg P/ha. which corresponded to the amounts of P needed to achieve 0.01, 0.02, 0.03, and 0.05 ppm of P in the soil solution. The methods of applying phosphorus were a) 15 cm band at 20% of full rate, b) 45 cm band at 60% of full rate, c) broadcast, or total plot area at full rate, and d) rill, or under the seed at 20% of full rate.

The experiment consisted of 16 treatments plus two controls in a randomized complete block design with three replications. Blanket applications of micronutrients plus K and N were applied to all plots except the complete control. Supplemental irrigations were supplied by a sprinkler system. A heavy windstorm in April caused extensive and persistent problems with lodged plants despite later efforts to hill these plants upright. The raw yield data plus treatment means are presented in table 31. The data as well as other plant growth data are being statistically analyzed. No conclusions as to treatment effects can be drawn at this time.

4. Multicropping

A multicropping study was initiated in August 1978 and continued to December 1980. Four cycles of planting and harvest were

accomplished during this period. These experiments were designed to furnish yield data and explore methods of maximizing food production on a small land area, in this case a 20m x 20m plot, through intensive management, close row spacing, and supplemental irrigation. A number of row crop species comprised each cycle. To insure total utilization of the 400 square meter space and full canopy use, while avoiding extreme plant competition, crop species used needed to be complementary.

Results of the four cycles, along with estimated economic returns, are presented in table 32. Approximate values are used as commodity prices vary throughout the year in Brazil. Certain assumptions may be discerned from the data. Vegetable crops such as onions and carrots appear to be fairly steady income-earners in these studies. Dry beans are also valuable, as they would most likely be used to contribute to the diet of the family involved.

While maize showed potential for acceptable yields in multicropping, maize competed too strongly for solar radiation, thus depressing yields of companion, higher-value row crops. Cassava produced high yields, but even at 2 meter row spacings only a first dry bean crop was possible in intercropping before the cassava became too competitive (as seen by the failure of the peanut crop). A second problem with cassava is the long period of time from planting to harvest (9 months), too long when other, faster maturing crops could be used for such a small, intensive farming system. Squash, if it can be prevented from becoming too dominant through trellising or late planting, also appears very productive.

In terms of potential economic benefits, the total estimated economic return for the four plantings was $1,159.88 (table 32). Total expenses, which excluded costs for water transport, labor, and seed, came to $374.70. If a small farmer substituted furrow irrigation for the sprinkler set-up used here, overall costs would drop to $99.47. Sprinkler irrigation was preferred to furrow irrigation as the system was simple to operate and more water efficient.

IV. Variety trials

No further variety testing has been done by BSP in Puerto Rico in FY 80. However, some maize and soybean variety trials were continued in Brazil for in-country purposes.

A maize composite population improvement experiment was initiated in 1979 to produce through mass selection a variety of maize specifically suited for the conditions found in Jaiba and northern Minas Gerais. The first planting (cycle 0) comprised 88 varieties of maize from a world germplasm collection composited of equal representation and recombined for the next cycle. During the October 1979 to September 1980 period, two additional cycles of this composite were planted and harvested. While selection pressure was kept at a minimum in the early cycles to prevent too great a loss of genetic variation (inbreeding coefficient <5%), the effects of selection for desirable plant type plus natural environment selection pressures produced pronounced changes in the observed characteristics of this population. Along with more plant height uniformity in general, changes occurring included plants less susceptible to lodging, somewhat lower in height, healthier, with a tendency towards prolificacy (more than one ear). This is a continuing experiment with a new planting following the harvest and selection of each cycle.

Two Brazil national maize variety trials were planted in November of 1979 at Jaiba. Trials such as these are planted in much of Brazil, with seed supplied by EMBRAPA. One of these trials consisted of 42 hybrids and varieties of normal maturing material, while the other was composed of 25 varieties and hybrids selected for early maturity (precocious). The two experiments were planted adjacent in completely randomized block designs with four repetitions. Copies of all of the data from these trials has been forwarded to EMBRAPA and as with earlier national maize trials which the BSP has carried out in Jaiba, the results will be published in a national report on maize trials conducted throughout Brazil.

A small soybean observational trial was planted in January 1980 and harvested in April. Fertilizer was broadcast at the rate of 25, 30 and 25 kg of N, P and K, respectively, per hectare. 28 varieties, from common ones such as Davis and Lancer, to specific IPB lines, were planted at a density of 500,000 plants/ha. Soybean yield for these varieties ranged from 2925 kg/ha for IPB selection 242-77 to 5171 kg/ha for Lancer and 5613 kg/ha for IPB 616-76. The average yield over all varieties was 3969 kg/ha. These data, in line with previous IPB experimental data on soybeans from Jaiba, indicate the high potential this area possesses for irrigated soybean production.

DISSEMINATION AND UTILIZATION OF PROJECT CONCEPTS AND RESULTS

I. Strategy Planning Meeting

In an effort to pave the way for an effective utilization of the principles underlying the Benchmark Soils Project and concepts related to it, a Panel Consultation on the Strategy for Land Evaluation and Agrotechnology Transfer in the Tropics and Subtropics was held at the headquarters of the Food and Agriculture Organization (FAO) of the United Nations in Rome, Italy, from 10 to 12 March 1980. The meeting was initiated by the Puerto Rico project, organized jointly by the BSP and FAO, and hosted by FAO.

In attendance were twenty-two distinguished soil scientists and administrators of national and international programs. They represented ACSAD, Syria (1); AID (1); Cornell University (1); EMBRAPA, Brazil (1); EPAMIG, Brazil (1); FAO (8); FIGNR, Federal Republic of Germany, (1); ISM, The Netherlands (1); ORSTOM, France (1); University of Ghent, Belgium (2); USDA-SCS (1); and the Hawaii and Puerto Rico BSP (3).

The intent of the meeting was to develop a strategy for land evaluation research and soil-based transfers of agroproduction technology at an international level in the tropics and subtropics. The specific objectives were:

1. To devise a framework for the effective utilization tranference research that combines national and international efforts and promotes the application of its results in development work,
2. To determine what needs to be done by whom, when, where and how to establish the relationships between soil characteristics and crop requirements in order to obtain a sound basis for soil survey interpretation and land evaluation, and
3. To assist the Benchmark Soils Project in developing a modus operandi for the utilization phase of the Project within the context of more comprehensive international efforts.

The format of the program emphasized discussion and dialogue rather than the formal presentation of papers. There were six technical sessions; one devoted to the presentation of background information and five to the various aspects of the general theme of the meeting.

The outcome of the meeting is summarized in the recommendations of the Panel Consultation that were published as BSP Leaflet 03-E in October 1980. These recommendations will enable the BSP to develop a scientifically sound utilization phase of the project that has been tentatively named "International Benchmark Soils Network for Agrotechnology Transfer" (IBSNAT). The goal of this program would be to accelerate the flow of agrotechnology from research centers to farmer fields. Its objectives include (i) to establish a network of collaborating national and international agricultural research centers in the tropics and subtropics, (ii) to develop an appropriate methodology for horizontal and vertical transfers of agrotechnology, (iii) to coordinate transfer-specific research conducted

at the participating centers and centrally analyze the results of this research, and (iv) to establish a scientific infrastructure conducive to effective knowledge transfers.

To the extent realistically possible, the Panel Consultation achieved its objectives as stated above. The success must be attributed to the high professional caliber of the participants, the congenial atmosphere of the discussions, and to a well-conceived program that provided a specific framework for the deliberations.

II. Field Day at Jaiba, Brazil

To familiarize a larger in-country audience with the philosophy, research and implications of the Benchmark Soils Project in Brazil, a BSP field day was held at Jaiba and Janauba in October 1980.

The meeting was convened by EPAMIG, UPR's collaborating agency in Minas Gerais, and its president extended personal invitations to all relevant organizations and individuals in Minas Gerais and to EMBRAPA, the national research agency.

Forty-seven professionals representing universities, national and state agencies, private companies, and various research, development and extension agencies mainly from Minas Gerais participated in the field day. They included 6 agronomists, 7 soil scientists, 1 horticulturist, 1 climatologist, 10 irrigation specialists, 3 veterinarians, 10 extension specialists, 2 professors of soil science, 1 forage specialist, 1 forester, and 5 other professionals. The diverse professional concerns of the participants illustrate the wide interest in the BSP concept of agrotechnology transfer.

The 3-day event included a first-evening orientation session, followed by a full day of on-site inspection. Huge soil pits had been excavated to allow the participants to study the soil profile. The final morning was spent summing up the previous days' experiences, which was followed by a lively discussion period. At the conclusion of the field day, each participant

was given a prepared set of brochures and general information about the BSP along with an official certificate of participation. For all concerned, the field day achieved its objective of creating a keener awareness of the Benchmark Soils Project in Minas Gerais and demonstrating our sizeable research efforts in the field.

III. Soil Classification Workshop

The Third International Soil Classification Workshop --centrally related to the BSP but funded under a separate grant from AID to UPR-- was held in Syria and Lebanon in April 1980 with a follow-up meeting held in Athens, Greece, in May 1980. The local sponsors of the workshop were the Arab Center for the Studies of Arid Zones and Dry Lands (ACSAD) in Syria and the Soil Science Institute of Greece. It was the third in a series of AID-supported workshops organized by UPR in cooperation with host country agencies with the objective to adapt Soil Taxonomy relative to the soils of the lower latitudes. The Syria/Lebanon workshop focused on the taxonomy of soils of dry areas and the redefinition of soil moisture regimes.

IV. Publications

Dr. Nyle C. Brady, editor of Advances in Agronomy, invited Drs. F. H. Beinroth and G. Uehara to prepare an article on the benchmark soils concept for the 1980 issue of this prestigious journal. To ensure a complete and authoritative coverage of the subject and a paper of high professional standards, Drs. R. W. Arnold, F. B. Cady and J. A. Silva were included as co-authors. A 60-page manuscript entitled "Agrotechnology Transfer in the Tropics based on Soil Taxonomy" was prepared. After editing by the UH/BSP publications specialist, Cynthia L. Garver, it was submitted to Dr. Brady in November 1979. The paper has subsequently been published in Advances in Agronomy, Vol. 33, pp. 303-339. It is anticipated that the paper will create a wide awareness of the rationales underlying the Benchmark Soils Project in the scientific community.

S. P. Nightengale, J. Badillo and G. L. Spain completed a paper that summarizes the results of the maize variety trials conducted in Puerto Rico. The manuscript was submitted for publication in UPR's Journal of Agriculture.

Four technical articles on the Benchmark Soils Project and its work in Brazil, together with an interview with UPR's Principal Investigator, were published in Portuguese in the "Informe Agropecuário," a Brazilian journal of agriculture (no. 61, pp. 69-79 and 83-84).

F. H. Beinroth prepared a paper on the stratification of the agroenvironment by Soil Taxonomy which he delivered at the Workshop on Agrotechnology Transfer held at the College of Tropical Agriculture and Human Resources of the University of Hawaii in August 1980. The paper will be published in the proceedings of that workshop.

Laboratory data and descriptions of the soils of Puerto Rico project were compiled and published as BSP Technical Report 5 in November 1979.

"Benchmark Soils News", a newsletter with a feature story, research highlights and related miscellanea combining contributions from personnel of the two projects was again published quarterly by the University of Hawaii for worldwide circulation.

WORKPLAN FOR COMING YEAR

I. General

The first extension of the UPR/BSP, contract AID/ta-C-1158, ended in December 1980. A one-year time extension without additional funds was requested in October 1980 and was subsequently approved under amendment no. 9 to the contract. Applying stringent measures of austerity, the as yet unused project funds should be marginally sufficient to conclude the activities detailed below in an adequate manner.

II. Agronomic Field Work

As of 1 October 1980 there were nine experiments in progress at the BSP sites at Jaiba in Minas Gerais, Brazil. These experiments include six transfer experiments and three management experiments, (mulching, polyculture and maize composite formation). All experiments will be harvested by December 1980.

III. Laboratory Studies

An approximate total of 600 more soil samples will be analyzed for P, N, bases, and pH. The analytical data are needed for the statistical test of the transfer hypothesis. Laboratory work is expected to be concluded by May 1981.

IV. Data Processing and Statistics

The raw data of the last set of experiments and the corresponding analytical data will be compiled and processed for statistical treatment. Weather data from all sites will be tabulated and summarized.

Dr. Larry A. Nelson of North Carolina State University, statistics consultant to the project, will statistically analyze the results of the various experiments conducted in Puerto Rico and Brazil using standard multiple regression and analysis of variance techniques. Transferability will be studied using models currently being used by the Hawaii project, and attempts will be made to study this aspect with other techniques. The study of transferability will be made mainly for the Eutrustox of Puerto Rico and Brazil but Hawaii Eutrustox data will be brought into a combined analysis.

Dr. Nelson plans to spend some days in Puerto Rico in late April 1981 to discuss his work with project staff.

V. Dissemination

UPR project staff will prepare papers on the rationale, concepts, results and implications of the Benchmark Soils Project to be delivered at the following meetings:

- Primera Conferencia sobre Transferencia de Tecnología de Fertilizentes en Puerto Rico, to be held in Mayaguez, Puerto Rico from 9 to 11 December 1980 under the sponsorship of the University of Puerto Rico and the Tennessee Valley Authority,
- International Conference on Soils with Variable Charge, to be held in Palmerston North, New Zealand from 11 to 18 February 1981 under the auspices of the New Zealand Society of Soil Science and the International Society of Soil Science,
- National Work Planning Conference of the USDA Soil Conservation Service, to be held in Washington, DC from 6 to 10 April 1981,
- Fourth International Soil Classification Workshop, to be held in Rwanda from 2 to 12 June 1981, and tentatively
- Inter-American Symposium on Agro-Climatic Modeling and Information Systems: Their value and adaptation in developing countries, to be held in Caracas, Venezuela from 21 to 26 September 1981 under the sponsorship of the Aspen Institute's Food and Climate Forum.

The preparation of technical manuscripts for publication in professional journals will continue in 1981 and beyond project termination. The intent of these papers is to document the agronomic work of the BSP and make the wealth of data and information generated by more than 130 field experiments, and laboratory and statistical studies accessible to the scientific community.

VI. Administration

Upon the conclusion of project activities in Brazil the custody and control of equipment purchased with contracts funds will be turned over to EPAMIG, pursuant to Clause 15(c) of the Additional General Provisions. Similar action will be taken later regarding the BSP equipment located in Puerto Rico.

Prior to contract termination all other pending administrative matters, and financial and personnel aspects will be resolved in an orderly fashion and in accordance with university and AID regulations.

VII Final Report

A comprehensive summary report of appealing form and substance will be prepared, published and widely distributed in 1981. The report will summarize the work conducted by the UPR/BSP over a period of six years in Puerto Rico and Brazil with particular emphasis on a critical analysis of the transfer hypothesis underlying the project. It will also highlight the salient findings of the twenty-two variety trials and thirty-three management experiments conducted during this time. Although these were of peripheral importance to the central objective of the project, they yielded results believed to be of consequence to the proper utilization of Eutrustox by small farmers in LDCs.

APPENDIX A

I. Experiments conducted at Isabela Agricultural Experiment Station

Exp. No. & Crop	Type of Expt.	Site	Season	Begun	Terminated
1. Soybean	Uniformity	Primary	Wet	7-24-75	10-20-75
2. Soybean	Transfer[1/] (PxK)	Primary	Int.	3-05-76	8-03-76
3. Maize	Transfer (PxK)	Primary	Wet	4-02-76	8-06-76
4. Maize	Variety x P	Primary	Wet	5-14-76	8-30-76
5. Maize	Variety x P	Primary	Wet	7-12-76	11-05-76
6. Soybean	Transfer (PxK)	Secondary #1	Wet	7-30-76	11-29-76
7. Maize	Transfer (PxK)	Secondary #1	Wet	8-02-76	11-16-76
8. Soybean	P x Density x Var.	Primary	Wet	9-05-76	1-03-77
9. Soybean	Transfer (PxK)	Secondary #1	Dry	12-09-76	3-28-77
10. Maize	Transfer (PxK)	Secondary #1	Dry	12-12-76	4-18-77
11. Soybean	Seedbed Preparation	Substation	Dry	12-13-76	5-31-77
12. Soybean	Transfer (PxK)	Primary	Dry	12-21-76	4-14-77
13. Maize	Transfer (PxK)	Primary	Dry	12-22-76	4-26-77
14. Maize	P-placement x levels	Primary	Wet	4-04-77	8-02-77
15. Maize	Water (irrig) x N	Primary	Wet	5-05-77	8-25-77
16. Maize	Transfer (PxK)	Primary	Wet	5-20-77	9-20-77
17. Maize	Transfer (PxK)	Secondary #1	Wet	6-02-77	9-27-77
18. Maize	Variety x P	Primary	Wet	6-17-77	10-04-77
19. Maize	Transfer (P x N)[2/]	Primary	Wet	6-23-77	10-17-77
20. Maize	Transfer	Secondary #1	Dry	11-15-77	3-27-78
21. Maize	Transfer	Primary	Dry	12-12-77	4-20-78
22. Maize	Variety	Primary	Dry	12-13-77	4-18-78

1/ Unless designated as residual, all transfer experiments listed were initial transfer experiments.

2/ Experiment PR-19 and all maize transfer experiments thereafter were with P and N as variables.

Experiments conducted at Isabela Agricultural Experiment Station (cont'd)

23.	Maize	Residual transfer	Primary	Dry	1-12-78	5-22-78
24.	Maize	Water (irrig) x N	Primary	Dry	1-18-78	5-31-78
25.	Soybean	Residual transfer (PxK)	Secondary #1	Dry	2-17-78	7-24-78
26.	Maize	Residual transfer	Secondary #1	Wet	4-10-78	8-02-78
27.	Maize	Transfer	Primary	Wet	4-25-78	8-08-78
28.	Maize	Variety x P x N	Primary	Wet	4-25-78	8-10-78
29.	Maize	Water (irrig) x N	Primary	Wet	4-26-78	rain damag abandoned
30.	Maize	Transfer	Secondary #1	Wet	5-08-78	8-30-78
31.	Maize	Residual transfer	Primary	Wet	5-10-78	8-28-78
32.	Maize	Tillage (Min. vs. Plow) x Density	Primary	Wet	5-16-78	9-11-78
33.	Maize	Transfer	Secondary #2	Wet	6-08-78	9-26-78
34.	Maize	Residual transfer	Primary	Dry	11-17-78	3-21-79
35.	Maize	Residual transfer	Secondary #1	Dry	11-17-78	3-19-78
36.	Maize	Residual transfer	Secondary #2	Dry	11-21-78	3-27-79
37.	Maize	Transfer	Primary	Dry	12-06-78	4-19-79
38.	Maize	Transfer	Secondary #1	Dry	12-06-78	4-17-79
39.	Maize	Transfer	Secondary #2	Dry	12-12-78	4-24-79
40.	Maize	Water (irrig) x N	Secondary #1	Dry	12-14-78	4-30-79
41	Maize	Residual transfer	Secondary #1	Wet	5-02-79	8-27-79
42.	Maize	Residual transfer (2nd residual)	Secondary #1	Wet	5-02-79	8-27-79
43.	Maize	Residual transfer	Primary	Wet	5-3-79	8-29-79
44.	Maize	Transfer	Secondary #1	Wet	5-17-79	9-06-79
45.	Maize	Transfer	Primary	Wet	5-18-79	9-07-79
46.	Maize	Residual transfer	Secondary #2	Wet	5-23-79	9-11-79
47.	Maize	Lime x P	Secondary #2	Wet	5-25-79	9-12-79
48.	Maize	Transfer	Secondary #2	Wet	5-30-79	9-10-79
49	Maize	Tillage x population	Primary	Wet	6-04-79	9-13-79

Experiments conducted at Isabela Agricultural Experiment Station (cont'd)

50.	Maize	Residual transfer	Primary	Dry	11-14-79	3-19-80
51	Maize	Residual transfer	Secondary #1	Dry	11-14-79	3-24-80
52.	Maize	REsidual Lime x P	Secondary #2	Dry	11-16-79	3-17-80
53.	Maize	Transfer	Primary	Dry	12-1-79	4- 7-80
54.	Maize	Transfer	Secondary #1	Dry	12-1-79	4-9-80
55.	Maize	Transfer	Secondary #2	Dry	12-5-79	4-10 ~~3-31~~-80
56.	Maize	Tillage x population	Primary	Dry	12-7-79	4-17-80
57.	Maize	Water (irrig.) x N	Secondary #1	Dry	12-18-79	5-1-80
58.	Maize	Residual Transfer	Primary	Wet	4-22-80	8-11-80
59.	Maize	Residual Transfer	Secondary #1	Wet	4-22-80	8-12-80
60.	Maize	Residual Transfer	Secondary #2	Wet	4-24-80	8-15-80
61.	Maize	Transfer	Secondary #2	Wet	4-25-80	8-19-80
62.	Maize	Transfer	Primary	Wet	4-29-80	8-22-80
63.	Maize	Transfer	Secondary #1	Wet	4-30-80	8-25-80
64.	Maize	P-placement x levels	Primary	Wet	5-8-80	8-28-80

APPENDIX A

II. Experiments conducted or assisted by BSP at Jaiba, MG, Brazil

Expt. No. & Crop	Type of Expt.	Site	Season	Begun	Terminated
1. Maize	Transfer[1/] (PxK)	Primary	Wet	10-21-76	3-11-77
2. Maize	Variety x P	Primary	Wet	10-26-76	3-15-77
3. Maize	Variety x Density	Primary	Wet	10-28-76	3-16-77
4. Maize	Variety, Nat'l.	Primary	Wet	10-30-76	3-22-77
5. Maize	Variety Annex	Primary	Wet	10-30-76	3-22-77
6. Soybean	Transfer (PxK)	Primary	Wet	11-24-76	4-29-77
7. Soybean	Variety, INTSOY	Primary	Wet	11-25-76	2-03-77
8. Maize	Transfer (PxK)	Primary	Dry	6-07-77	12-15-77
9. Maize	Transfer (PxN)[2/]	Primary	Dry	6 08-77	12-16-77
10. Maize	Irrigation, EMBRAPA	Primary	Dry	6-11-77	11-23-77
11. Sorghum	Irrigation, EMBRAPA	Primary	Dry	6-12-77	10-05-77
12. Soybean	Variety, INTSOY	Primary	Dry	6-23-77	10-07-77
13. Soybean	Variety x P	Primary	Dry	7-11-77	11-10-77
14. Maize	Variety x P	Primary	Dry	7-25-77	1-26-78
15. Maize	Density	Primary	Wet	11-06-77	4-17-78
16. Soybean	Density	Primary	Wet	11-08-77	3-15-78
17. Maize	Variety, Nat'l.	Primary	Wet	11-09-77	4-10-78
18. Maize	Variety	Primary	Wet	11-10-77	3-31-78
19. Maize	Transfer	Primary	Wet	11-10-77	3-31-78
20. Maize	Transfer	Secondary #1	Wet	11-20 77	4-26-78
21. Maize	Transfer	Secondary #2	Wet	11-21-77	5-05-78
22. Maize	Transfer	Primary	Dry	6-20-78	12-15-78
23. Maize	Residual Transfer	Primary	Dry	6-16-78	12-14-78

1/ Unless designated as residual, all transfer experiments listed were initial transfer experiments.

2/ Experiment B-9 and all transfer experiments thereafter were with P and N as variables.

Experiments conducted or assisted by BSP at Jaiba, MG, Brazil (cont'd)

24.	Maize	Transfer	Secondary #1	Dry	6-20-78	11-29-78
25.	Maize	Residual Transfer	Secondary #1	Dry	6-17-78	11-22-78
26.	Maize	Transfer	Secondary #2	Dry	6-19-78	12-05-78
27.	Maize	Residual Transfer	Secondary #2	Dry	6-19-78	12-02-78
28.	Maize	Irrigation, EMBRAPA	Primary	Dry	7-20-78	11-28-78
29.	Sorghum	Irrigation, EMBRAPA	Primary	Dry	7-20-78	11-28-78
30.	Soybean	Variety INTSOY	Primary	Dry	7-27-78	11-(6-30)-78
31.	Multicrop	Intensive Mgmt.	Primary	Dry/Wet	9-10-78	Continuing
32.	Maize/Sorghum	Planting Schedule EPAMIG	Primary	Wet	10-15-78	5-21-79
33.	Maize	Varieties, normal EMBRAPA	Secondary #2	Wet	11-13-78	5-10-79
34.	Maize	Varieties, precocious EMBRAPA	Secondary #2	Wet	11-13-78	5-14-79
35.	Soybean	Varieties, IPB	Primary	Wet	1-15-79	5-30-79
36.	Maize	Transfer	Primary	Wet	1-09-79	6-16-79
37.	Maize	Residual Transfer	Primary	Wet	1-16-79	7-10-79
38.	Maize	Transfer	Secondary #1	Wet	1-12-79	6-12-79
39.	Maize	Residual Transfer	Secondary #1	Wet	1-15-79	7-06-79
40.	Maize	Transfer	Secondary #2	Wet	1-10-79	6-12-79
41.	Maize	Residual Transfer	Secondary #2	Wet	1-12-79	7-06-79
42.	Maize	Composite	Primary	Dry	4-11-79	9-20-79
43.	Maize	Transfer	Primary	Dry	6-06-79	11-22-79
44.	Maize	Residual Transfer	Primary	Dry	6-28-79	1-03-80
45.	Maize	Transfer	Secondary #1	Dry	6-09-79	11-21-79
46.	Maize	Residual Transfer	Secondary #1	Dry	6-28-79	1-03-80
47.	Maize	Transfer	Secondary #2	Dry	6-08-79	11-20-79
48.	Maize	Residual Transfer	Secondary #2	Dry	7-04-79	1-03-80
49	Maize/Sorgum	Irrig., line-source (EMBRAPA)	Primary	Dry	6-05-79	10-26-79
50.	Maize	Density X P X Irrig.	Primary	Dry	7-25-79	1-05-80

Experiments conducted by BSP at Jaiba, MG, Brasil (cont'd)

51.	Multicrop	Intensive Mgmt.	Primary	Dry/Wet	9-20-79	7-3-80
52.	Maize	Transfer	Primary	Wet	11-26-79	5-8-80
53.	Maize	Residual Transfer	Primary	Wet	12-19-79	5-30-80
54.	Maize	Transfer	Secondary #1	Wet	11-28-79	5-7-80
55.	Maize	Residual Transfer	Secondary #1	Wet	12-19-79	5-29-80
56.	Maize	Transfer	Secondary #2	Wet	11-28-79	5-7-80
57.	Maize	Residual Transfer	Secondary #2	Wet	12-19-79	5-29-80
58.	Maize	Composite, Cycle 1	Primary	Wet	10-30-79	3-12-80
59.	Maize	Variety, Normal EMBRAPA	Secondary #2	Wet	11-9-79	5-22-80
60.	Maize	Variety, Precocious EMBRAPA	Secondary #2	Wet	11-9-79	5-23-80
61.	Soybean	Variety, IPB	Primary	Wet	1-8-80	5-6-80
62.	Maize	P-placement x levels	Primary	Wet/Dry	2-8-80	6-30-80
63.	Maize	Composite, Cycle 2	Primary	Dry	4-2-80	9-4-80
64.	Maize	Transfer	Primary	Dry	4-26-80	10-14-80
65.	Maize	Residual Transfer	Primary	Dry	5-17-80	11-5-80
66.	Maize	Transfer	Secondary #1	Dry	4-26-80	10-14-80
67.	Maize	Residual Transfer	Secondary #1	Dry	5-23-80	10-27-80
68.	Maize	Transfer	Secondary #2	Dry	4-26-80	10-15-80
69.	Maize	Residual Transfer	Secondary #2	Dry	5-23-80	11-5-80
70.	Maize	Mulching	Primary	Dry	6-29-80	12-17-80
71.	Multicrop	Intensive Mgmt.	Primary	Dry/Wet	7-11-80	12-24-80
72.	Maize	Composite, Cycle 3	Primary	Wet	9-19-80	3-2-81

APPENDIX B

Table 2

Maize, Pioneer brand hybrid X304C, dry-season yields from initial transfer experiment (BSP B-43) planted June 6 and harvested November 22, 1979 at Jaiba, MG, Brazil, primary (Paraná) site.

P kg/ha	Coded P Treatment Level	Grain Yield, kg/ha[1/]					
53.3	+.85		8112		8920		8656
40.3	+.40			9192		9187	
28.8	"0"	6233	8227		7503		7649
17.3	-.40			5670		5905	
4.3	-.85		3819		3705		3578
0	-1	2354			2185		
	Coded N Treatment Level	-1	-.85	-.40	"0"	+.40	+.85
	N kg/ha	0	14	54	90	126	166

1/ Adjusted to 15.5% moisture, means of 3 replicates.

Table 3

Maize, X304C, dry-season yields from initial transfer experiment (BSP B-45) planted June 9, and harvested November 21, 1979 at Jaiba, MG, Brazil, secondary site #1 (Ceará).

P kg/ha	Coded P Treatment Level	Grain Yield, kg/ha[1/]					
26.6	+.85		8357		8553		8181
20.2	+.40			7134		7583	
14.4	"0"	6446	7663		7106		7740
8.6	-.40			7376		7420	
2.2	-.85		4492		5682		5207
0	-1	4243			3675		
		Coded N Treatment Level					
		-1	-.85	-.40	"0"	+.40	+.85
		N kg/ha					
		0	14	54	90	126	166

1/ Adjusted to 15.5% moisture, means of 3 replicates.

Table 4

Maize, X304C, dry-season yields from initial transfer experiment (BSP B-47) planted June 8 and harvested November 20, 1979 at Jaiba, MG, Brazil, secondary site #2 (Bahia).

P kg/ha	Coded P Treatment Level	Grain Yield, kg/ha[1/]					
53.3	+.85		8278		7651		3891
40.3	+.40			7516		7794	
28.8	"O"	7172	7749		7358		7355
17.3	-.40			5411		5916	
4.3	-.85		3357		4161		5533
0	-1	3899			4838		
	Coded N Treatment Level	-1	-.85	-.40	"O"	+.40	+.85
	N kg/ha	0	14	54	90	126	166

1/ Adjusted to 15.5% moisture, means of 3 replicates.

Table 5

Maize variety X304C dry-season yields from initial transfer experiment (BSP PR-53) planted December 1, 1979 and harvested April 7, 1980 at Isabela, Puerto Rico, primary site (Ramal).

P, kg/ha	Coded P treatment Level	Grain Yiel kg/ha[1/]					
95.2	+.85		5081		6489		7378
72.1	+.40			5921		6953	
51.5	"O"	3329	4414		6268		7280
30.9	-.40			5758		7007	
7.7	-.85		5396		6915		7561
0	- 1	4136			6386		
		Coded N Treatment Level					
		- 1	-.85	-.40	"O"	+.40	+.85
		N, kg/ha					
		0	29	71	108	144	186

1/ Adjusted to 15.5% moisture, means of 3 replicates.

Table 6

Maize variety X304C dry-season yields from initial transfer experiment (BSP PR-54) planted December 1, 1979 and harvested April 9, 1980 at Isabela, Puerto Rico secondary site (Cerro).

P, kg/ha	Coded P Treatment Level	Grain Yield, kg/ha 1/					
57.7	+.85		6249		7375		7891
43.7	+.40			7235		8127	
31.2	"O"	6346	6248		7165		8237
18.7	-.40			7278		7873	
4.7	-.85		6489		7163		8513
0	- 1	6338			7616		
	Coded N Treatment Level	- 1	-.85	-.40	"O"	+.40	+.85
	N, kg/ha	0	29	71	108	144	186

1/ Adjusted to 15.5% moisture, means of 3 replicates.

Table 7

Maize variety X304C dry-season yields from initial transfer experiment (BSP PR-55) planted December 5, 1979 and harvested April 10, 1980 at Isabela, Puerto Rico, secondary site (Calero).

P, kg/ha	Coded P Treatment Level	Grain Yield, kg/ha 1/					
48.3	+.85		5238		6416		6942
36.6	+.40			5708		6938	
26.1	"O"	4553	4582		6311		6878
15.7	-.40			6745		6917	
3.9	-.85		5032		6763		6932
0	- 1	5195			5843		
	Coded N Treatment Level	- 1	-.85	-.40	"O"	+.40	+.85
	N, kg/ha	0	29	71	108	144	186

1/ Adjusted to 15.5% moisture, means of 3 replicates.

Table 8

Maize, X304C, dry-season yields from residual transfer experiment (BSP B-44 following B-36) planted June 28, 1979 and harvested January 3, 1980 at Jaiba, MG, Brazil, primary (Paraná) site.

P kg/ha 2/	Coded P Treatment Level	Grain Yield, kg/ha 1/					
53.3	+.85		5250		5059		4692
40.3	+.40			5054		3906	
28.8	"O"	3393	2895		2963		2969
17.3	-.40			2368		2082	
4.3	-.85		1107		1112		1663
0	-1	949			1262		
		Coded N Treatment Level					
		-1	-.85	-.40	"O"	+.40	+.85
		N kg/ha					
		0	14	54	90	126	166

1/ Adjusted to 15.5% moisture, means of 3 replicates.

2/ Phosphorus was applied only to the initial transfer experiment; N was applied to both initial and residual trials.

Table 9

Maize, X304C, dry-season yields from residual transfer experiment (DSP B-46 following B-38) planted June 28, 1979 and harvested January 3, 1980) at Jaiba, MG, Brazil, secondary site #1 (Ceará).

P kg/ha 2/	Coded P Treatment Level	Grain Yield, kg/ha 1/					
26.6	+.85		4454		4451		4122
20.2	+.40			3797		4456	
14.4	"O"	4273	4141		3775		3729
8.6	-.40			3193		3161	
2.2	-.85		3039		3302		2299
0	-1	2670			2354		
	Coded N Treatment Level	-1	-.85	-.40	"O"	+.40	+.85
	N kg/ha	0	14	54	90	126	166

1/ Adjusted to 15.5% moisture, means of 3 replicates.

2/ Phosphorus was applied only to the initial transfer experiment; N was applied to both initial and residual trials.

Table 10

Maize, X304C, dry-season yields from residual transfer experiment (BSP B-48 following B-40) planted July 4, 1979 and harvested January 3, 1980 at Jaiba, MG, Brazil, secondary site #2 (Bahia).

P kg/ha 2/	Coded P Treatment Level	Grain Yield, kg/ha 1/					
53.3	+.85		3218		3748		4363
40.3	+.40			4203		4203	
28.8	"O"	3641	2493		3142		4186
17.3	-.40			3191		3927	
4.3	-.85		2148		3271		3659
0	-1	2235			3874		
	Coded N Treatment Level	-1	-.85	-.40	"O"	+.40	+.85
	N kg/ha	0	14	54	90	126	166

1/ Adjusted to 15.5% moisture, means of 3 replicates.

2/ Phosphorus was applied only to the initial transfer experiment; N was applied to both initial and residual trials.

Table 11

Maize variety X304C dry-season yields from residual transfer experiment (BSP PR-50 following PR-45) planted November 14, 1979 and harvested March 19, 1980 at Isabela, Puerto Rico, primary site (Ramal).

P, kg/ha[2/]	Coded P Treatment Level	Grain Yields, kg/ha[1/]					
83.1	+.85		4038		6051		5502
62.8	+.40			5032		6402	
44.8	"O"	4182	4686		5835		5692
26.9	-.40			5222		6394	
6.8	-.85		4091		5019		6744
0	- 1	3769			6164		
	Coded N Treatment Level	- 1	-.85	-.40	"O"	+.40	+.85
	N, kg/ha	0	29	71	108	144	186

1/ Adjusted to 15.5% moisture, means of 3 replicates.

2/ Phosphorus was applied only to the initial transfer experiment; N was applied to both initial and residual trials.

Table 12

Maize variety X304C dry-season yields from residual transfer experiment (BSP PR-51 following PR-44) planted November 14, 1979 and harvested March 24, 1980 at Isabela, Puerto Rico, secondary site (Cerro).

P, kg/ha 2/	Coded P Treatment Level	Grain Yield, kg/ha 1/					
41.9	+.85		6175		7980		7387
32.4	+.40			7160		7299	
22.6	"O"	4477	5073		7603		8229
13.7	-.40			7142		7652	
3.3	-.85		6644		7372		7969
0	- 1	4699			6964		
	Coded N Treatment Level	- 1	-.85	-.40	"O"	+.40	+.85
	N, kg/ha	0	29	71	108	144	186

1/ Adjusted to 15.5% moisture, means of 3 replicates.

2/ Phosphorus was applied only to the initial transfer experiment; N was applied to both initial and residual trials.

Table 13

Maize, Pioneer brand hybrid X304C, wet-season yields from initial transfer experiment (BSP B-52) planted November 26, 1979 and harvested May 8, 1980 at Jaiba, MG, Brazil, primary site (Paraná).

P kg/ha	Coded P Treatment Level	Grain Yield, kg/ha[1/]					
26.6	+.85		7078		7307		7039
20.2	+.40			6002		6942	
14.4	"O"	5327	6702		6361		6101
8.6	-.40			5118		6104	
2.2	-.85		3188		2794		4525
0	-1	4094			2868		
		Coded N Treatment Level					
		-1	-.85	-.40	"O"	+.40	+.85
		N kg/ha					
		0	29	71	108	144	186

1/ Adjusted to 15.5% moisture, means of 3 replicates.

Table 14

Maize, X304C, wet-season yields from initial transfer experiment (BSP B-54) planted November 28, 1979 and harvested May 7, 1980 at Jaiba, MG, Brazil, secondary site #1 (Ceará).

P kg/ha	Coded P Treatment Level	Grain Yield, kg/ha[1/]					
20.2	+.85		7197		7625		7680
15.3	+.40			7597		6830	
10.9	"O"	6175	6496		6876		8251
6.6	-.40			5753		5929	
1.6	-.85		5814		6286		6018
0	-1	4372			6578		
		Coded N Treatment Level					
		-1	-.85	-.40	"O"	+.40	+.85
		N kg/ha					
		0	29	71	108	144	186

1/ Adjusted to 15.5% moisture, means of 3 replicates.

Table 15

Maize, X304C, wet-season yields from initial transfer experiment (BSP B-56) planted November 28, 1979 and harvested May 7, 1980 at Jaiba, MG, Brazil, secondary site #2 (Bahía).

P kg/ha	Coded P Treatment Level	Grain Yield kg/ha[1/]					
38.9	+.85		6884		7439		7975
29.4	+.40			6045		6635	
21.0	"O"	5504	6000		6270		6826
12.6	-.40			5644		6222	
3.2	-.85		4534		3966		4203
0	-1	3418			4513		
		Coded N Treatment Level					
		-1	-.85	-.40	"O"	+.40	+.85
		N kg/ha					
		0	29	71	108	144	186

1/ Adjusted to 15.5% moisture, means of 3 replicates.

Table 16

Maize variety X304C wet season yields from initial transfer experiment (BSP PR-62) planted April 29 and harvested August 22, 1980 at Isabela, Puerto Rico, primary site (Ramal).

P, kg/ha	Coded P Treatment Level	Grain Yields, kg/ha[1/]					
77.9	+.85		6900		6860		6652
59.0	+.40			7877		7039	
42.1	"O"	6264	6599		7083		7482
25.3	-.40			7884		7832	
6.3	-.85		7461		6882		6990
0	- 1	6164			7473		
	Coded N Treatment Levels	- 1	-.85	-.40	"O"	+.40	+.85
	N, kg/ha	0	29	71	108	144	186

1/ Adjusted to 15.5% moisture, means of 3 replicates.

Table 17

Maize variety X304C wet-season yields from initial transfer experiment (BSP PR-63) planted April 30, and harvested August 25, 1980 at Isabela, Puerto Rico, secondary site (Cerro).

P, kg/ha	Coded P Treatment Levels	Grain Yields, kg/ha[1/]					
59.2	+.85		5475		6783		7304
44.8	+.40			6924		7011	
32.0	"O"	6284	6464		6905		6333
19.2	-.40			6151		6870	
4.8	-.85		6638		7055		6258
0	- 1	4903			6858		
	Coded N Treatment Levels	- 1	-.85	-.40	"O"	+.40	+.85
	N, kg/ha	0	29	71	108	144	186

1/ Adjusted to 15.5% moisture, means of 3 replicates.

Table 18

Maize variety X304C wet-season yields from initial transfer experiment (BSP PR-61) planted April 25 and harvested August 19, 1980 at Isabela, Puerto Rico, secondary site (Calero).

P, kg/ha	Coded P Treatment Level	Grain Yield, kg/ha[1/]					
51.9	+.85		5853		6938		7745
39.3	+.40			5819		6416	
28.1	"O"	3494	5187		6867		5160
16.8	-.40			6614		6033	
4.2	-.85		4706		6238		5882
0	- 1	4477			5989		
		Coded N Treatment Levels					
		- 1	-.85	-.40	"O"	+.40	+.85
		N, kg/ha					
		0	29	71	108	144	186

1/ Adjusted to 15.5% moisture, means of 3 replicates.

Table 19

Maize, X304C, wet-season yields from residual transfer experiment (BSP B-53 following B-43) planted December 19, 1979 and harvested May 30, 1980 at Jaiba, MG, Brazil primary site (Paraná).

P kg/ha[2/]	Coded P Treatment Level	Grain Yield, kg/ha[1/]					
53.3	+.85		6473		7625		7078
40.3	+.40			6804		7701	
28.8	"O"	4148	6757		5618		6483
17.3	-.40			4017		5705	
4.3	-.85		3839		3951		4807
0	-1	3604			3545		
		Coded N Treatment Level					
		-1	-.85	-.40	"O"	+.40	+.85
		N kg/ha					
		0	29	71	108	144	186

1/ Adjusted to 15.5% moisture, means of 3 replicates.

2/ Phosphorus was applied only to the initial transfer experiment; N was applied to both initial and residual trials.

Table 20

Maize, X304C, wet-season yields from residual transfer experiment (BSP B-55 following B-45) planted December 19, 1979 and harvested May 29, 1980 at Jaiba, MG, Brazil, secondary site #1 (Ceará).

Grain Yield, kg/ha[1/]

P kg/ha[2/]	Coded P Treatment Level					
26.6	+.85		6921		6963	5995
20.2	+.40			6022		6924
14.4	"O"	5388	6367		5907	6022
8.6	-.40			6269		6186
2.2	-.85		3997		5568	5473
0	-1	3811			5324	
	Coded N Treatment Level	-1	-.85	-.40	"O"	+.40	+.85
	N kg/ha	0	29	71	108	144	186

1/ Adjusted to 15.5% moisture, means of 3 replicates.

2/ Phosphorus was applied only to the initial transfer experiment; N was applied to both initial and residual trials.

Table 21

Maize, X304C, wet-season yields from residual transfer experiment (BSP B-57 following B-47) planted December 19, 1979 and harvested May 29, 1980 at Jaiba, MG, Brazil, secondary site #2 (Bahía).

P kg/ha 2/	Coded P Treatment Level	Grain Yield, kg/ha 1/				
53.3	+.85		7568		7090	7296
40.3	+.40			7168		6636
28.8	"O"	5650	5314		6396	6652
17.3	-.40			4889		5850
4.3	-.85		3268		4560	6211
0	-1	5021			5152	

	Coded N Treatment Level					
	-1	-.85	-.40	"O"	+.40	+.85
	N kg/ha					
	0	29	71	108	144	186

1/ Adjusted to 15.5% moisture, means of 3 replicates.

2/ Phosphorus was applied only to the initial transfer experiment; N was applied to both initial and residual trials.

Table 22

Maize variety X304C wet-season yields from residual transfer experiment (BSP PR-58 following PR-53) planted April 22 and harvested August 11, 1980 at Isabela, Puerto Rico, primary site (Ramal).

P, kg/ha 2/	Coded P Treatment Level	Grain Yields, kg/ha 1/					
95.2	+.85		2433		5684		7132
72.1	+.40			3906		6796	
51.5	"O"	1108	2268		5737		6876
30.9	-.40			4488		6211	
7.7	-.85		2765		5373		7577
0	- 1	1649			5761		
		Coded N Treatments					
		- 1	-.85	-.40	"O"	+.40	+.85
		N, kg/ha					
		0	29	71	108	144	186

1/ Adjusted to 15.5% moisture, means of 3 replicates.

2/ Phosphorus was applied only to the initial transfer experiment; N was applied to both initial and residual experiments.

Table 23

Maize variety, X304C wet-season yields from residual transfer experiment (BSP PR-59 following PR-54) planted April 22 and harvested August 12, 1980 at Isabela, Puerto Rico, secondary site (Cerro).

P, kg/ha 2/	Coded P Treatment Level	Grain Yield, kg/ha 1/					
57.7	+.85		3461		7315		9020
43.7	+.40			5763		8008	
31.2	"O"	2879	4372		6754		9054
18.7	-.40			6228		8004	
4.7	-.85		4974		6618		8285
0	- 1	2582			7021		
	Coded N Treatment Level	- 1	-.85	-.40	"O"	+.40	+.85
	N, kg/ha	0	29	71	108	144	186

1/ Adjusted to 15.5% moisture, means of 3 replicates.

2/ Phosphorus was applied to the initial transfer experiment; N was applied to both initial and residual trials.

Table 24

Maize variety X304C wet-season yields from residual transfer experiment (BSP PR-60 following PR-55) planted April 24 and harvested August 15, 1980 at Isabela, Puerto Rico, secondary site (Calero).

P, kg/ha 2/	Coded P Treatment Levels	Grain Yield, kg/ha 1/					
48.3	+.85		3157		5677		6219
36.6	+.40			5272		6400	
26.1	"O"	2272	3013		5517		5061
15.7	-.40			4948		5670	
3.9	-.85		3174		5927		6985
0	- 1	2705			4807		
	Coded N Treatment Levels	- 1	-.85	-.40	"O"	+.40	+.85
	N, kg/ha	0	29	71	108	144	186

1/ Adjusted to 15.5% moisture, means of 3 replicates.

2/ Phosphorus was applied only to the initial transfer experiment; N was applied to both initial and residual trials.

Table 25

Maize variety X304C dry season yields from nitrogen x irrigation experiment (BSP PR-57) planted December 18, 1979 and harvested May 1, 1980 at Isabela, Puerto Rico, secondary site #1 (Cerro)

Applied N kg/ha	Grain Yield, kg/ha 1/					
320	5236	6961	8394	8750	9201	8794
160	4894	6553	7569	7843	9160	7541
80	4244	5916	6097	5742	5983	6173
40	3981	5136	4623	4940	4315	4338
20	3607	4406	3737	4213	3548	3638
0	3106	3499	3636	4092	2985	3330
	0	30	60	90	120	150
	Irrigation time, minutes 2/					

1/ Adjusted to 15.5% moisture.

2/ Water was applied through twin-wall trickle irrigation tubing with 8" x 40" hole spacings; treatment levels were determined by timing each application to deliver from 0 to approximately 20 mm of water per application.

Table 26

Maize, X304C, grain yields from a tillage X plant spacing experiment (BSP PR-56) planted December 12, 1979 and harvested April 17, 1980 at the Isabela, Puerto Rico BSP primary site (Ramal).

In-row Spacing	Tillage Treatment Conventional	No Tillage	Mean
cm	Grain Yield, kg/ha 1/		
20	9273	9446	9360 2/ a
23	8623	9142	8883 a
27	7770	8174	7972 b
Mean	8555 a	8921 a	8738

1/ Adjusted to 15.5% moisture, means of 3 replicates.

2/ Means in the same column or line followed by the same letters are not significantly different at the .05 level of probability.

Table 27

Maize, X304C, wet-season yields from phosphorus placement experiment (BSP PR-64) planted May 8 and harvested August 28, 1980 at Isabela, Puerto Rico, primary site (Ramal).

P kg/ha[2/]	Coded P Treatment Level	Grain Yields, kg/ha[1/]			
78	+85	8183[3/] a	8346 a	7937 a	8422 a
42	"O"	7378 a	8131 a	7848 a	8523 a
6	-85	7431 a	7860 a	8166 a	7456 a
		Band width (cm)			
		Rill	15	45	75

1/ Adjusted to 15.5% moisture, means of three replicates.

2/ Phosphorus levels indicated represent rates applied to the treated area only - 15 cm, 45 cm and 75 cm (broadcast) bands.

3/ Values followed by the same letter are not significantly different at the .05 level of probability.

Table 28

Maize, X304C, 30-day plant heights for phosphorus placement experiment (BSP PR-64) planted May 8 and harvested August 28, 1980 at Isabela, Puerto Rico, primary site (Ramal).

P kg/ha[2/]	Coded P treatment Level	Height at 30 days, cm[1/]			
78	+85	127 abc	130 ab	124 abc	133 a
42	"0"	118 cde	120 bcd	107 f	127 abc
6	-85	117 cdef	109 ef	117 cde	112 def
		Band width, cm			
		Rill[2/]	15	45	75

1/ Means of ten plants per plot in each of three replicates.

2/ Phosphorus levels indicated represent rates applied to the treated area only - 15 cm, 45 cm and 75 cm (broadcast) bands. For the rill treatment the same amount of P as was applied to the 15 cm band was drilled below the seed.

3/ Values followed by the same letters are not significantly different at the .05 level of probability.

Table 29

Maize, Pioneer brand hybrid X304C, yields from lime x phosphorus initial and residual experiments (BSP PR-47 followed by PR-52) conducted May 25 to September 12, 1979 and November 16, 1979 to March 17, 1980 near Isabela, Puerto Rico, secondary site #2 (Calero).

P, kg/ha		Grain Yields, kg/ha[1/]			
100	Initial			4594	4597
	Residual			5154	5139
50	Initial	4142	4159	4862	4868
	Residual	4245	5208	5831	6260
20	Initial	4450	4261	3971	4067
	Residual	4946	4978	5181	5127
0	Initial	4601	4249	3893	4930
	Residual	4144	5119	5025	5047
		0	3	6	9
		$CaCO_3$, meq Ca^{++}/100 gm soil			

1/ Adjusted to 15.5% moisture, means of 3 replicates.

Table 30

Mean yields of maize Cargill 111C, for P x water x density study over. 3 replications at Jaiba, MG, Brazil.

a) Phosphorus Levels x Periods of Moisture Stress

Applied P	Stress Period1/ 1st 30 days	2nd 30 days	3rd 30 days	No Stress
kg/ha	Grain Yield, kg/ha2/			
60	7228	3223	6617	7485
40	5983	2442	6847	6100
20	5234	2662	6066	6708
0	4447	2857	6137	4176

b) Plant density x periods of moisture stress (at 60 kg P/ha)

Plants/ha	Stress Period1/ 1st 30 days	2nd 30 days	3rd 30 days	No Stress
	Grain Yield, kg/ha2/			
30,000	5223	3192	4818	5401
55,000	7229	3223	6617	7485
85,000	8233	2374	7235	7756

1/ Stress periods were 30-day units beginning 7 days after emergence; "1st 30 days" refers to treatment with no water 1 week after emergence to 30 days hence, "2nd 30 days" refers to treatment with no water 37 to 67 days after emergence, etc.

2/ Adjusted to 15.5% moisture.

Table 31

Maize, x 304C, yields from P-placement experiment (BSP B-62) at Jaiba MG, Brazil, February 8 to June 30, 1980.

P-treatment No.	Placement	ppm	Grain Yield, kg/ha[1/] Replicate I	II	III	Mean
1	15cm band	.01	6412	5417	5806	5878
2	15cm	.01	5037	5920	3780	4912
3	broadcast	.01	6745	6216	6769	6577
4	rill	.01	5986	4725	5180	5297
5	15cm	.02	7369	7003	6043	6805
6	45cm	.02	6961	7206	7388	7185
7	broadcast	.02	4647	6715	6707	6023
8	rill	.02	7267	5938	5027	6077
9	15cm	.03	6512	5935	5413	5953
10	45cm	.03	4434	6987	5212	5544
11	broadcast	.03	6640	5989	6495	6375
12	rill	.03	6645	6419	4621	5895
13	15cm	.05	6444	5333	5141	5639
14	45cm	.05	6116	6663	4878	5886
15	broadcast	.05	6719	6955	5376	6350
16	rill	.05	6931	5147	6068	6049
17	control #1[2/]		4730	6632	2882	4748
18	control #2[2/]		6559	5956	4643	5719

1/ Adjusted to 15.5% moisture.

2/ Control #1 received a blanket application of nutrients but no applied P. Control #2 received no applied fertilizer.

Table 12

Crop yield and economic data for 4 planting cycles of an irrigated, intensive management multicrop experiment (400 m^2) at Jaiba, M. G. Brazil, primary site.

Crop/Variety	No. 20M Rows	Planting/Harvest Dates	Yield plot yield	Yield kg/ha	Unit Value $ US	Total Value $ US
First Planting Cycle: Aug. 78 - Feb. 1979						
Radish, Redondo Verm. Precoce	2	Aug 18/78 - Sept-Oct./78	237 dz	--	0.125/dz	29.62
Onion, Red Creole	12	Aug 18/78 - Jan 4/79	29.2 kg	1622	0.83/kg	24.24
Carrots, Nantes Superior	7	Aug 18/78 - Jan 10/79	124.0 kg	11,857	0.42/kg	51.67
Garlic, local cultivar	6	Aug 21/78 - None harvested	(poor germination)		--	--
Dry Bean, Campesino	26	Sept 11/78 - Dec 28/78	20.6 kg	515	0.63 kg	12.88
Maize, 111C (Cargill)	27	Sept 18/78 - Feb 24/79	230.6 kg	5765	6.25/60 kg	23.95
Total Value, 1st cycle						142.36
Second Planting Cycle: Apr-Sept. 1979						
Dry Bean, Carioca	26	Apr 10/79 - July 25/79	60.0 kg	1500	0.82/kg	49.20
Maize, 111C (Cargill)	14	Apr 25/79 - Sept 18/79	24.7 kg	617	0.19/kg	4.70
Squash, Abobora Menina	5	Apr 25/79 - Aug-Sept/79	186.6 kg	12440	0.42/kg	78.37
Cucumber	5	Apr 25/79 - none harvested	--	--	--	--
Squash, Zuchini	3	Apr 25/79 - none harvested	--	--	--	--
Total Value, 2nd cycle						132.27

Table 32 cont'd.

Crop/Variety	No. 20M Rows	Planting/Harvest Dates	Yield plot yield	Yield kg/ha	Unit Value $ US	Total Value $ US
Third Planting Cycle: Sept 79 - July 1980						
Cassava	13	Sept 20/79 - July 3/80	954.3 kg	23,857.5	0.16/kg	152.69
Dry Beans, Carioca	26	Sept 22/79 - Dec 28/79	37.4 kg	935.0	0.95/kg	35.53
Peanut, Tatu	12	Jan 4/80 - None harvested	--	--	--	--
Total Value, 3rd Cycle						188.22
Fourth Planting Cycle: July 80 - Dec 1980						
Onion, Early Yellow Globe	26	July 11/80 - Nov 19/80	466.3 kg	11,657.5	0.65/kg	303.10
Dry Bean, Black Rico 23	26	July 15/80 - Oct 25/80	49.3 kg	1,232.5	1.20/kg	59.16
Carrot, Nantes Superior	13	Aug 25/80 - Dec 29/80	458.6 kg	11,465.0	0.73/kg	334.78
Total Value, 4th Cycle						697.04
Total Value of all 4 cycles						$1,159.88
Mean Value per planting cycle						289.97

APPENDIX C

PROJECT PERSONNEL

Puerto Rico

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Brazil

EPAMIG Liaison:	Fernando Zinho Antunes
Agronomists:	Mervyn L. Olson
Research Aides:	Narbal de Sá Marcos A. C. Torres
Field Foreman:	Delcino C. Jorge
Driver/Mechanic:	Ivandir Pereira Miranda
Typist:	Ademar Fernandes dos Anjos