Report on Trip to Costa Rica
July 13 - 19, 1997
USAID Grant No. LAG-G-00-97-00002-00
SM-CRSP Project *Decision Aids for Integrated Nutrient Management*

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Objectives:

As one of six projects in the revised SM-CRSP, our project involves a multi-disciplinary team of investigators from four U.S. universities - Cornell, Hawaii, North Carolina State and Texas A&M. The goal of our project is to develop decision aid tools which will improve the process of diagnosing location-specific soil nutrient constraints and selecting appropriate remedial management practices. In order to make these tools globally relevant, we plan to work closely with International and National Agricultural Research and Extension Systems that have recognized expertise in the diagnosis and correction of soil nutrient problems.

The “Centro de Investigaciones Agronomicas” of the University of Costa Rica (CIA-UCR) has an extensive and renown information base on soil nutrient problems and improved management strategies for Central American ecosystems. The Center for Agronomic Investigations provides research, teaching and extension services targeting agriculture and forestry development in Costa Rica. Through joint appointments of their faculty, CIA has close linkages with UCR’s programs in the Agronomy Department and the Undergraduate and Graduate Schools. Fifteen of the CIA faculty have training at the M.Sc. level and five at the Ph.D. level. CIA’s research and extension programs in soil science, biotechnology, and post-harvest technology include collaboration with private enterprises and national/international institutions. Their laboratory facilities provide support for investigations in plant nutrition, soil management and conservation, soil classification, soil microbiology and biochemistry, soil and plant analysis, biotechnology and post-harvest physiology.

With CIA-UCR collaboration we intend to assemble this knowledge into our decision aid tools, making it available to decision makers facing similar natural resource and food production problems throughout the world. CIA-UCR is one of several national collaborating institutions which we are visiting in Africa, Asia and Latin America during the start-up phase of our project.

Specific objectives of our visit to CIA-UCR in Costa Rica were to:

- become fully acquainted with their existing knowledge base,
- identify gaps in their information base which we can help resolve; and
- explore potential field sites where the decision aid tools could be tested and refined.

Itinerary:

July 12-13	Arrival of U.S. team in San Jose; Osmond and Smyth miss connection in Miami and their arrival is delayed to July 14.
July 14	Tour of CIA-UCR facilities and preliminary discussions with Dr. Alfredo Alvarado, center director.
July 15	Tour of DEMASA heart-of-palm production from peach palm in the Sarapiqui region
July 16	Tour of vegetable and coffee production systems in the Cartago-Guayabo-Turrialba region
July 17	Tour of coffee production systems in the Naranjo and Barva regions
July 18	Meetings with CIA-UCR faculty in San Jose
July 19	Departure for U.S.

Sarapiqui Region:

The Sarapiqui region is located on the Carribean coastal area, north of the road between San Jose and Limon. Mean annual rainfall is 3962mm and mean annual temperature is 24 °C. Elevation is approximately 25 m. Soils form on ancient eroded terraces from alluvial deposits of volcanic materials with gently undulating topography. Dominant soils are Allic Hapludands with gibbsite as the dominant clay mineral. Significant areas of Ultisols also are present within the region. Selected chemical and physical properties are shown in Table 1 for a Hapludand profile which we observed on the DEMASA farm. These are acid Andisols with most of the KCl-extractable acidity comprised by Al. High Modified Olsen-extractable P values in the plow layer reflect previous fertilizer inputs. Single-point P sorption tests indicate high P retention throughout the profile.

The DEMASA farm has been growing peach palm (*Bactris gasipaes*) for heart-of-palm (‘palmito’) production for almost 20 years. Currently, they have 1,300 ha of peach palm and a canning plant that is operating at about 80% of capacity. Their current management practices are based on experiences they gained over the years as to how palmito quantity and quality are affected by different plant populations and spacings, harvest frequencies, crop residue and groundcover maintenance, and nutrient inputs. When grown solely for palmito production, management entails frequent thinning of sprouts to maintain a specific number/plant and harvesting the meristems when they reach a specific height and base diameter. Due to germplasm heterogeneity, plants in each parcel are harvested several times/year. DEMASA appears to maintain good records of productivity over time for each land parcel and their associated adjustments in management practices. Soil samples are routinely collected from these parcels and analyzed in the UCR-CIA laboratories.

Palmito production has expanded over time to farmers adjacent to DEMASA. Farmers selling harvested palmito to the DEMASA cannery have an average of 5 ha in peach palm. Throughout the Carribean coastal region of Costa Rica there are approximately 6,000 ha of peach palm grown for palmito which is processed by 3-4 canneries. Peach palm is also grown in the Turrialba region for purposes of fruit production.

UCR-CIA has a good history of collaboration with peach palm producers in Costa Rica. They have conducted extensive research in vegetative propagation of peach palm and this technology is now in the process of being patented. In recent years UCR-CIA faculty have assisted DEMASA with on-site trials on crop residues/groundcover management and fertilization practices. Routine applications of N, P and K fertilizers at DEMASA are now complemented, periodically, with lime and micronutrients (namely B and Zn). We were also shown ongoing trials to correct Mg deficiencies which have begun to appear in some parcels.

We identified several aspects of the ongoing nutrient management practices for palmito which merited further investigation:

- responses to lime (which is surface-applied without incorporation) may stem from the correction of a Ca deficiency and improved subsoil rooting depth rather than a correction of Al toxicity *per se*;
- criteria used for diagnosing and recommending lime, N, P and Mg fertilizer needs are not yet clearly defined; there is a good probability that these nutrients are being both over- and under-applied in selected land parcels;
- given the pronounced response in meristem growth to N fertilization and the amounts applied, the potential for N pollution appears to be high in palmito production systems; and
- existing soil and plant data could be explored to develop some preliminary soil nutrient-yield relationships and nutrient input-output balances

Cartago-Guayabo-Turrialba Region:

This region includes the northeastern portion of the Central Valley and the Carribean side of the central mountain range in Costa Rica. Soil moisture regime is udic with 3000-5000 mm annual rainfall and mean annual temperatures between 17 and 24 °C. Elevation ranges from 700 to 1500 m. Over half of the area has slopes >16% and slopes for one-third exceeds 30%. Alluvial terraces are mixed in with colluvial deposits, lava flows from Turrialba volcano and ash. Depositions of ash are more pronounce above 1000 m elevation. Andisols are associated with Ultisols according to slope position.

Land use at the higher elevations and primarily on the Central Valley side consisted of pasture and vegetables. At lower elevations in the Guayabo and Turrialba areas the dominant crop was coffee followed by macadamia, sugar cane and plantains. Soils in this region include Typic and Lithic Melanudands, Typic Tropohumults and Typic Humitropepts. Selected chemical properties for Andisols in the Guayabo region are shown in Table 2. It is common practice to surface-apply lime to coffee grown in soils with these acid pH values. Exchangeable Ca and Mg levels for the surface horizons may in part reflect prior applications of lime and Mg fertilizers. UCR-CIA is assisting farm cooperatives in the Guayabo region to adjust lime and fertilizer recommendations for coffee to the different types of soils.

In visits to this region and the Naranjo-Barva area we gained appreciation and understanding for the role of coffee production in the Costa Rican agriculture and economy. Annual national green coffee bean production has ranged from 156000 to 168000 metric tons

Table 1. Selected chemical and physical properties of an Allic Hapludand in Sarapiqui, Costa Rica.

		pH		Exchangeable					Eff.	Acid	P	Amorph.		Org.	Extractable						
Horizon	**Depth**	**H_2O**	**NaF**	**Ca**	**Mg**	**K**	**Acid.**	**Al**	**CEC**	**Sat.**	**Retent.**	**Fe**	**Al**	**Mat.**	**P**	**Cu**	**Fe**	**Mn**	**Zn**	**Sand**	**Clay**
	cm			--------------------cmol$_c$ L^{-1}--------------------						--------------------%--------------------					---------------mg L^{-1}---------------					-----%-----	
Ap	0-5	4.9	10.4	1.20	0.50	0.04	4.30	4.33	6.04	71	92	2.7	2.4	7.98	26	19	742	18	4.1	49	38
Ad	5-20	4.8	10.6	0.60	0.20	0.11	3.90	3.80	4.81	81	96	2.4	2.2	5.21	13	17	528	22	3.8	46	41
Bw1	20-46	4.8	9.7	0.70	0.20	0.08	2.30	2.27	3.28	70	97	2.4	2.2	2.25	13	13	337	20	3.8	39	48
Bw2	46-67	4.8	9.6	0.60	0.20	0.09	1.90	1.94	2.79	68	96	--	--	1.24	16	10	183	15	3.0	32	58
C	67-90	4.8	10.6	0.80	0.30	0.08	2.30	2.26	3.48	66	96	--	--	0.93	21	10	185	13	2.8	29	58
Ab	90-113	4.9	10.8	0.90	0.40	0.03	0.70	0.73	2.03	35	99	--	--	1.12	29	15	96	9	3.5	52	33

Ca, Mg, acidity and Al extracted with 1N KCl; K, P, Cu, Fe, Mn and Zn extracted with the Modified Olsen; P retention by the Blakemore test; and amorphous Fe and Al by the ammonium oxalate method.

Source: Centro de Investigaciones Agronomicas, University of Costa Rica between 1991 and 1996. Between 1991 and 1995 coffee's contribution to Costa Rican gross agricultural product has increased from 14 to 23%. Coffee exports generate about 15% of the nation's foreign currency and 25% of employment in the agricultural sector. Coffee fields in both regions were well managed. Intensive pruning of shade trees and old coffee growth, weed management, fertilizer and lime inputs and replacement of unproductive fields with seedlings of improved varieties were readily apparent. We were informed this reflected farmer anticipation of good prices during the coming years. When prices are forecast to drop, farmers cut back on fertilizer and lime inputs, allow shade-tree regrowth, and reduce labor-intensive prunning of coffee growth from previous years.

Table 2. Selected chemical properties for Andisols cropped to coffee in the Guayabo area of Costa Rica.

Soil	**Hori-**	**pH**	**Exchangeable**				**Org.**	**Extractable**				
Depth	**zon**	**H_2O**	**Ca**	**Mg**	**K**	**Acid.**	**Mat.**	**P**	**Cu**	**Fe**	**Mn**	**Zn**
cm			-------------cmol$_c$ L^{-1}-----------				%	-----------------mg L^{-1}---------------				
A:0-5	A1	4.2	4.6	0.7	0.33	nd	21	nd	nd	nd	nd	nd
5-43	A2	4.3	0.8	0.3	0.28	"	15	"	"	"	"	"
43-48	Bw1	4.2	0.3	0.1	0.17	"	4	"	"	"	"	"
48-125	Bw2	4.5	0.4	0.2	0.12	"	3	"	"	"	"	"
125+	BC	4.5	0.5	0.4	0.13	"	3	"	"	"	"	"
B:0-18	A	4.7	2.3	1.7	0.54	"	17	"	"	"	"	"
18-50	Bw	5.0	0.5	0.2	0.35	"	9	"	"	"	"	"
B: productive site		4.8	2.5	0.6	0.17	1.5	nd	19	17	284	21	4
B: unproductive site		4.4	1.0	0.3	0.22	3.1	"	20	19	379	26	5

nd= not determined; Ca, Mg, acidity and Al extracted with 1N KCl; K, P, Cu, Fe, Mn and Zn extracted with the Modified Olsen.
Source: Centro de Investigaciones Agronomicas, University of Costa Rica

Naranjo-Barva Region:

This area is located in the northwestern section of the Central Valley. Mean annual rainfall, at elevations of about 1200 m and under an ustic soil moisture regime, ranges from 2410 mm in Naranjo to 2656 mm in Barva. Soils are Typic Dystrandepts associated with Andic Humitropepts. Selected chemical and physical properties of an Andic Humitropepts at San Jeronimo farm in Naranjo are shown in Table 3. Bulk density ranges from 0.81 g/ml in the Bw2 horizon to 1.02 g/ml in the Bw1 horizon. Total porosity ranges from 53% in the Bw1 horizon to 60% in the Bw2 horizon. Near this profile we observed a field trial evaluating several approaches to minimize runoff during coffee establishment on steep slopes. This farm adopted new technologies for prunning old coffee growth, wherein alternating rows are pruned over a

Table 3. Selected chemical and physical properties of an Andic Humitropepts at San Jeronimo farm in Naranjo, Costa Rica.

		pH		**Exchangeable**					**Eff.**	**Acid**	**P**	**Amorph.**		**Org.**	**Extractable**						
Horizon	**Depth**	**H_2O**	**NaF**	**Ca**	**Mg**	**K**	**Acid.**	**Al**	**CEC**	**Sat.**	**Retent.**	**Fe**	**Al**	**Mat.**	**P**	**Cu**	**Fe**	**Mn**	**Zn**	**Sand**	**Clay**
	cm			--------------------cmol$_c$ L^{-1}--------------------						--------------------%--------------------					---------------mg L^{-1}---------------					-----%-----	
Ap	0-22	6.7	10.7	12.3	3.5	0.6	0.2	0.0	16.6	1	81	1.5	1.5	8.5	24	25	32	2	4	44	30
A2	22-45	5.5	10.2	6.7	1.4	1.0	0.2	0.1	6.2	3	85	1.7	1.8	5.6	10	14	56	1	1	47	32
Bw1	45-88	4.5	10.1	2.0	0.4	2.5	1.0	0.9	5.9	17	86	2.3	1.5	1.6	10	30	100	4	4	29	52
Bw2	88-107	4.9	9.5	3.5	0.5	1.0	0.2	0.1	5.2	4	89	1.9	1.6	2.0	10	29	74	1	3	39	49
Bw3	107-142	4.8	9.8	3.2	0.3	0.9	0.1	0.0	4.5	2	98	2.9	4.1	1.1	8	20	66	1	3	69	19

Ca, Mg, acidity and Al extracted with 1N KCl; K, P, Cu, Fe, Mn and Zn extracted with the Modified Olsen; P retention by the Blakemore test; and amorphous Fe and Al by the ammonium oxalate method.
Source: Centro de Investigaciones Agronomicas, University of Costa Rica

sequence of three to four years. The standard practice was to prune the entire field in the same year.

In Barva we visited the Center for Coffee Research (CICAFE), a division of the Costa Rican Coffee Institute (ICAFE). This center concentrates on research and extension on agronomic and bean processing practices. Their 1995 annual report (ICAFE, 1996) indicates considerable progress in germplasm selection, crop management and phytosanitary practices. The most recent experiments indicate a renewed focus by the center on plant nutrition and fertilizer management. However, many of the fertilizer trials involve single rates of various nutrients and it is not readily apparent what was the basis for selecting these rates.

Although acidity is not a major limitation in soils of this region (compare Table 3 with Tables 1 and 2), UCR-CIA expressed concern about acid depositions in this area which are associated with continued activity from the Poas volcano. This was illustrated by all the rust on tin roofs of houses in this region, relative to others areas which we visited.

Project Site Selection:

The palmito production area of Sarapiqui was selected as the site in Costa Rica where the project's decision aid tools could be tested and refined. This was based on both group discussion held every night following field tours and concurrence by UCR-CIA. We consider this to be a good site for investigations of decision aids for tree-based systems. Peach palm is a food commodity that has a limited information base, although its popularity as a viable crop alternative is growing throughout Latin America. We are familiar with research and developmental efforts on palmito in Panama, Colombia, Ecuador, Peru, Bolivia and Brazil. Therefore, potential for transferability of knowledge between the Sarapiqui site and other regions is good. Additional favorable traits for this site include the involvement of both private and commercial sectors, existence and accessibility to agronomic data, and presence of acidity, N and P constraints.

Schedules for baseline assessment activities was also discussed. It was agreed that the assessment would contribute in several ways to the project: (a) it would elicit critical information useful to decision support system development and testing; (b) produce baseline data on current decision making processes and practices that can serve as a reference point from which to access future system behavior; and (c) identify quantitative indicators for periodic monitoring of social, economic and environmental impact. The baseline study will use rapid appraisal field methods and focused discussion with stakeholders, including policy-makers, extension agents, educators, NGO's and farmers. Alfredo Alvarado will take the lead in compiling an inventory of existing information on soils, resources, environment and agricultural practices for the targeted region. This information will be presented at a project workshop scheduled for December in Hawaii. Follow-up assessment activities on-site are planned for January of next year with assistance of Frank Smith.

Other Aspects of the Project:

Team discussions, held every evening, also provided the opportunity to develop plans for other project tasks. These meetings were the first opportunity for face-to-face interaction among project coordinators since the CRSP's inaugural meeting in 1996 in Raleigh. Discussion topics included schedules for travels to sites in Mali and Philippines, contacts with participants in the extensive evaluation network, preferred methods of communication within the project, and integration of the decision support systems. Discussions on the later topic established the foundation and guidelines for initiation of programming activities at the respective institutions for the task of developing an integrated prototype of the system by the end of year one.

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