Report on Trip to Costa Rica
September 9-24, 2000
USAID Grant No. LAG-G-0097-00002-00
SM-CRSP Project *Decision Aids for Integrated Nutrient Management*

Traveler:
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Objectives:
1. Assist Costa Rica collaborators with alternative approaches for diagnosing P status in soils (organic and microbial P analysis) and plant tissues in peach palm stands.
2. Discuss and conduct verifications of allometric relationships for peach palm generated previously. Discuss biomass and nutrient accumulation of belowground tissues ("spider"), and its possible role in the P plant internal cycle of peach palm. Lead field work to obtain data on belowground biomass and nutrients in peach palm stands of different age.
3. Visit and discuss the field experiments at Los Diamantes and Altamira. Record symptoms of deficiency and differences in biomass accumulation and plant morphology between treatments.

Itinerary:

September 9	Travel from Honolulu to San José, Costa Rica
September 10,11	At San José
September 12,13	Field work in Guapiles area
September 14 to 18	At San José
September 19	Field work at Guapiles area
September 20	At San José
September 21	To Altamira
September 22	At San José
September 23	Travel from San José to Honolulu
September 24	Arrival to Honolulu

Report:
On arrival in Costa Rica, I met with Rafael Salas, Eloy Molina and Jimmy Boniche to discuss: (i) incoming field work to determine belowground biomass in peach palm stands for heart-of-palm, (ii) ongoing work on the P fertilization experiment in Altamira, and (iii) future on-farms experiments to compare predictions of NuMass against field data.

In the subsequent days, most of the time was devoted to field work consisting in excavating and towing out the belowground biomass component in four peach palm stands ranging in age from 2 to 21 years (Figure 2). The initial density of the stands was 5000 plants/ha. The belowground section of the plant (locally called 'spider') consists of a stem-like tissue and coarse roots which spread radially from the tree vertical axis (Figure 3). Most of the spiders extended no more than 40-50 cm in depth, and, laterally, seemed to cover most of the available space among plants. The spiders were taken to San José, washed, and separated into coarse roots and stem-like tissue. For the latter, a white-colored tissue called ‘interface’ was evident but it comprised a relatively small volume. The washing and separation operation of the spider was very time-consuming and it took several hours for one person to cut the coarse roots with a clipper and remove the soil intermingled with the belowground tissues. Subsamples were taken to the lab for dry weight determination and nutrient analysis.

The amount of belowground biomass in peach palm stands for heart-of-palm is quite large and, to a certain extent, the belowground:aboveground ratio appears to increase with age from about 1 in young stands to more than 2 in mature stands (Figure 1). According to previous data on aboveground biomass (Molina *et al.*, 2000), there would be as much as 12 Mg/ha of belowground biomass in a mature peach palm stand. Phosphorus concentrations in belowground tissues is remarkably high, and P contents may be as high as 30 kg/ha in mature stands. It does not seem possible to determine a simple allometric relationship between aboveground and belowground biomass for individual plants because the development of the aboveground parts is controlled by management (harvest and control of shoot number) while the growth of the belowground biomass appeared mainly restrained by competition among contiguous plants. Aboveground biomass can be estimated, however, from allometric equations generated previously for peach palm stands for heart-of-palm (Ares *et al.*, 2000b). Then, belowground: aboveground ratios could be used to estimate belowground biomass from aboveground biomass data at a given age.

On September 18, I met with R. Salas, E. Molina, and J. Boniche from CIA, and Fred Cox from North Carolina State University to discuss details of the greenhouse P fertilization study at La Leona farm (See comments on the design of the experiment in F. Cox’s *Report on trip to Costa Rica and Ecuador-September 17-18*). There was a discussion on potential benefits (good correlation of solution P with P uptake) and problems (high variability, low measurable amounts) of using soil solution P (extracted with 0.01 M $CaCl_2$ for instance) as an ancillary diagnostic measure of P deficiency. The use of soil solution P in tree crops is being advocated in Australia for nursery and field plants (Smethurst, 2000). In an experiment with peach palm in the Amazon region, however, solution P collected with suction cups in the topsoil was too low and variable to be a reliable indicator of soil P dynamics (Schroth *et al.*, 2000). After the meeting, we examined some “spiders” with F. Cox and discussed the amounts of nutrients sequestered in the belowground biomass. These nutrients would have a low turnover rate and be an important component of the nutrient budget in peach palm stands.

On September 21, J. Boniche, D. Alpizar, F. Cox and I visited the P experiment at Altamira. The trial consists in six P doses from 0 to 47 kg P/ha yr. In general, there are no responses so far in yield to P additions, and P concentrations in foliage (3rd and 5th leaf) and soil (at 0-5 and 5-20 cm depth extracted by the Modified Olsen and Mehlich-3 methods) did not correlate with P additions (Ares *et al*, 2000a). A visual inspection of the plants under the different treatments revealed that most of them looked similar. Photographs were taken on one representative plot for each treatment and plant morphology was discussed.

During the first year of the experiment in Altamira, the P doses were split into two applications. For the second year, the annual P doses were applied in full in August 2000. Recent results indicated that a relative ample range in soil P at 0-5 cm was established after the fertilizer application but the range is relatively small for foliage P (Table 1). Also, soil sampling is being conducted in the alley in addition to the standard sampling at about 30-40 cm from the plant row. Future work will include determination of different soil organic P pools and microbial P, and sampling of other tissues in addition of foliage (i.e., petiole, stem and coarse roots). An increment borer will be used to sample stem and coarse roots. Some exploratory work in the four peach palm stand where spiders were excavated suggested that P concentration in petioles and coarse roots would be more related to available soil P than foliage P (Figure 4). Petiole is a standard sampling tissue for nutrient diagnosis in several annual crops such as potato (Meyer and Marcum, 1998), and also for tree crops such as papaya (Awada, 1976). In a field experiment on a Typical Histosol, petiole P concentration of papaya plants in a treatment receiving 1121 kg P/ha was three times the concentration in the control. Petiole P was also correlated to stem growth (Awada, 1976). Other research suggested that the ratio of petiole P concentration to leaf blade P concentration is a good index of P status in grapevines (Janat *et al.*, 1990). The proposed rationale is that under deficient conditions, P moves from older to younger tissues thought the petioles. When sufficient P is available, P accumulates in the petioles and the petiole:blade P ratio is usually equal or higher than 1. Under P stress, P would move from the petioles into the blades and the ratio would decrease.

Table 1. Soil and tissue P concentrations two months after fertilization (October 2000) in the Altamira experiment.

	Soil P at 0-5 cm		Soil P at 5-20 cm		Tissue P concentration	
P doses	Row	Alley	Row	Alley	Leaf 3	Leaf 5
ka ha^{-1} yr^{-1}	-------------------- mg kg^{-1}	--------------------			---------- %	----------
0	10.5	4.7	7.7	5.8	0.19	0.18
3.9	7.4	5.6	6.2	4.5	0.22	0.18
7.8	7.6	6.2	6.4	6.0	0.22	0.20
14.4	11.3	5.9	10.5	4.8	0.21	0.19
21.0	17.5	5.9	12.6	4.8	0.22	0.19
47.0	31.3	7.8	16.8	5.6	0.23	0.19

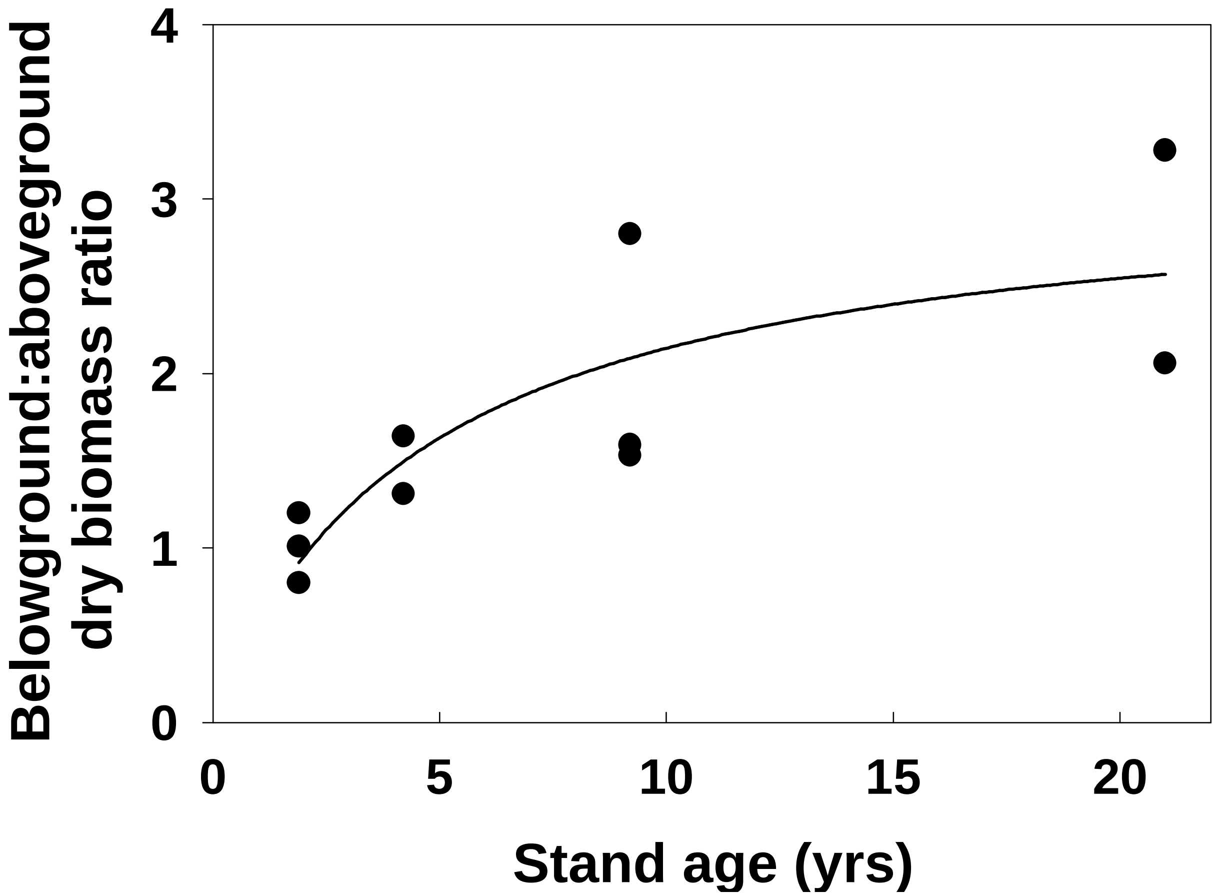

Figure 1. Belowground (‘spider):aboveground ratio in peach palm stands in the Atlantic Region of Costa Rica.

Figure 2. Towing to remove belowground biomass (‘spider’) in a mature peach palm stand in the Atlantic Region of Costa Rica.

Figure 3. View of belowground biomass (‘spider’) in a 21-year old peach palm stand in the Atlantic Region of Costa Rica

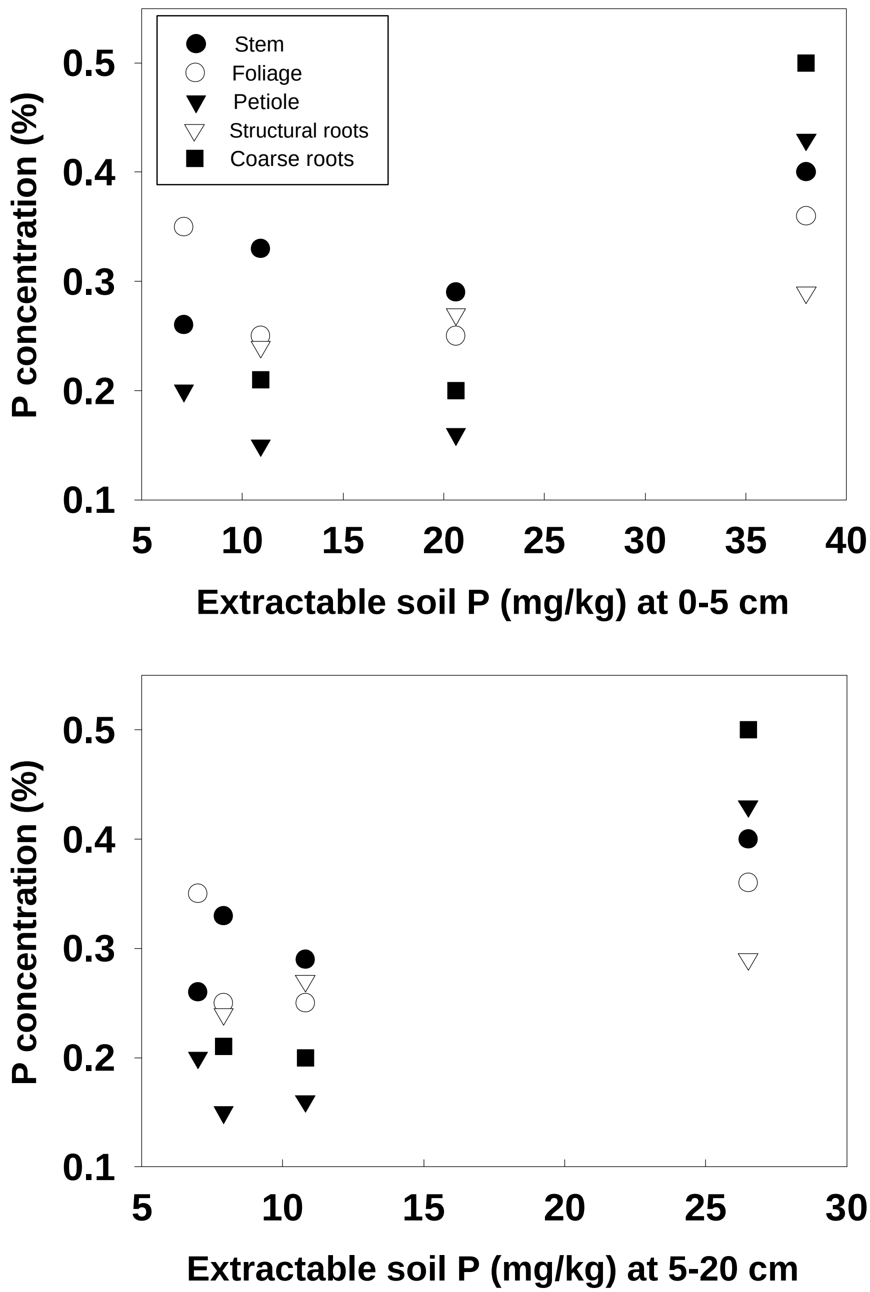

Figure 4. Relation between extractable soil P (by the Modified Olsen method) and P concentration in different tissues.

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