Report on Trip to Guatemala, Honduras and Costa Rica
April 13 - 22, 1999
USAID Grant No. LAG-G-00-97-00002-00
SM-CRSP Project Decision Aids for Integrated Nutrient Management

Traveler: T. Jot Smyth - North Carolina State University

Objectives:
In order to ensure that decision support system software for integrated soil nutrient management is user-friendly and has user-value, the software must be piloted under a variety of location-specific conditions. Our project attempts to ensure that the decision support system software is user-friendly and has user-value through frequent interactions with an extensive network of evaluators in tropical Africa, Asia and Latin America. Network evaluators also have soil nutrient management knowledge, and field-laboratory data sets that need to be explored and incorporated into the decision support system software whenever deemed appropriate. Travel to Guatemala and Honduras focuses on initiating interactions with evaluators in the extensive network. A stopover in Costa Rica, during the traveler’s return to Raleigh, is a cost-effective approach for providing technical backstopping assistance to ongoing project activities at the intensive testing site in that country. A series of greenhouse and field trials with peach palm are at various stages of progress, and this visit intends to ensure suitable continuation of activities based on a joint review, assessment and discussion of existing data with collaborators at the University of Costa Rica.

Specific travel objectives are to:
1. attend the PCCMCA annual meeting in Guatemala and present an invited paper on the Integrated Soil Nutrient Management DSS;
2. work with Mr. Elio Duron in Honduras on interpretation of soil and crop field data for P fertilization trials conducted in Panama, Costa Rica and Honduras on soils derived from volcanic materials; and
3. provide technical backstopping support to Univ. Costa Rica collaborators conducting ongoing project activities at the intensive testing site in Costa Rica.

Itinerary:

Tuesday, April 13
Travel from Raleigh to Guatemala City

Wednesday, April 14
Attended the PCCMCA meetings; presented invited paper on IntDSS software at a plenary session; demonstrated IntDSS software prototype to Dr. I. Rao; discussions with several meeting participants.

Thursday, April 15
Travel from Guatemala City to Tegucigalpa

Friday - Saturday, April 16 - 17
Worked in Tegucigalpa with Mr. Elio Duron on field, greenhouse and laboratory data for P fertilization and management in soils of Central America.

Sunday, April 18
Travel from Tegucigalpa to San José
Monday, April 19  Meetings, review of data and discussions in San José with Alfredo Alvarado, Rafael Salas, Lidieth Uribe, Eloy Molina, Jose Quesada and Larry Szott

Tuesday, April 20  Travel to Altamira to visit site for P fertilizer experiment on peach palm

Wednesday, April 21  Travel to Min. Agriculture’s “Los Diamantes” Exp. Stn. in Guapiles to assess potential sites for peach palm experiments on nutrient and biomass accumulation and N fertilization

Thursday, April 22  Wrap-up discussions in San José with Alfredo Alvarado, Lidieth Uribe and Eloy Molina; departure for the U.S.

Guatemala:

My visit to Guatemala was in response to an invitation to participate in the annual meetings of the Central American Crop and Animal Improvement Program (PCCMCA) - equivalent in the region to the American Society of Agronomy meetings in the U.S. The theme for this year’s meeting was “Knowledge integration as a basis for agricultural development in MesoAmerica and the Carribean”. I presented a paper on “Decision support systems for integrated soil nutrient management” as part of a plenary session panel on “Management and use of soils in the tropics”. Dr. Miguel Ayarza, leader of CIAT’s Steepland Project in Honduras and alumni of the Soil Management CRSP’s graduate research programs at N.C. State University, presented a paper on “Integrated soil nutrient management” in the same panel.

The focus of my presentation was to (a) describe and illustrate the fundamental rule sets we are developing in the IntDSS software to diagnose constraints and recommend corrective management strategies for soil acidity, N and P limitations, and (b) emphasize the need for analysis and interpretation of site-specific research such that results are transferrable, whenever possible, to a variety of site conditions. The transferability issue was a major topic of discussion during panelist’s replies to plenary questions after the presentations.

Ing. Roman Gordon, of IDIAP in Azuero - Panama, described field trials on fertilizer N split-applications for corn that were conducted over multiple years and locations within Panama as part of CIMMYT’s Regional Agronomic Trials program. The inclusion of multiple N rates and availability of rainfall data at each field site, makes this data particularly relevant to our project’s efforts on the N component of the decision support system. Roman is willing to assist us with information on these studies via e-mail correspondence with our project’s investigators who are focusing on N.

I also had a productive meeting with Dr. Idupulapati Rao, CIAT soil scientist based in Cali, Colombia. Dr. Rao was present at the meeting in Cali which Russ Yost and Keith Cassel attended, circa 1995, to discuss potential collaboration with U.S. universities on soil management issues. He was interested in an update on the SM-CRSP’s efforts in soil nutrient management decision support systems. I demonstrated a working prototype of the IntDSS software and the PDSS2 module. Dr. Rao is interested in testing the IntDSS software prototype under their field
conditons in Colombia. Since my return to Raleigh, he has re-iterated CIAT’s interest via e-mail correspondence.

**Honduras:**

My visit to Tegucigalpa was to meet with Ing. Elio Duron and obtain greenhouse, laboratory and field data for his research on P management in Central American soils. Delays in publication of this data make it necessary that we proceed with analysis/interpretation so the information can be added to the IntDSS P module database for Central American soils. Elio has two years of results for field trials with a factorial combination of P rates, sources (TSP and North Carolina PR) and placement (band and broadcast) at three locations in Central America: an Andisol in El Pericon, Honduras with continuous corn; a Typic Plinthudult at Calabacito, Panama, and a Tropudult at La Selva, Costa Rica. An annual crop cycle of rice and cowpea were grown in experiments in Panama and Costa Rica. Data for each crop includes stover and grain yields, crop P uptake, diagnostic foliar P analysis and soil extractable P by the Mehlich-1 and Modified Olsen procedures.

Elio also has data for laboratory soil P incubations and greenhouse P response trials with sorghum for 11 soils (Alfisols, Andisols, Inceptisols and Ultisols) collected from both the field trial sites described above and other locations in Costa Rica, Guatemala, Honduras and Panama. The P incubation studies compared two methods for estimating soil P buffer coefficients: the Hunter technique with progressive air-drying after P is added to soil in an equal volume of solution; and repeated cycles of wetting-drying wherein the soil moisture content never exceeds field capacity. Soil P in these studies was measured with the Modified Olsen and both the Mehlich-1 and -3 extractants. We were able to find files or hardcopies for most of the data, but Elio needs to check for some information on the hard drive of a computer he has at La Ceiba.

Elio has been busy for the last three months serving as DICTA’s bilingual technical guide for numerous international technical missions who have been visiting Honduras to assess hurricane damage. Their hope is that some technical assistance programs will eventually materialize from all these visits.

**Costa Rica:**

This was a good time for a visit to Costa Rica as several laboratory and field investigations were at a point where critical decisions were being made. The first day entailed visits with UCR-CIA staff in San José. Subsequent days involved travels to field trial sites in Altamira and Guapiles. Activities described in the following are grouped according to their primary relation to the project’s acidity, N or P modules.

**Acidity**

Lidieth Uribe was approaching completion of the laboratory and greenhouse activities to assess how soil chemical properties in an Andisol might be affected by peach palm prunnings which are left as a surface mulch during bi-weekly harvests of heart-of-palm. Soil in 45-cm long PVC columns (10.1-cm internal diameter) received the following surface treatments:

1. CaCO$_3$ at 2 t ha$^{-1}$;
2. peach palm prunnings at 10 t ha$^{-1}$;
3. a mixture of treatments 1 and 2; and
4. control with no lime or plant material added.

Columns received the equivalent of 40cm of water, applied at a constant rate over 5 days (see apparatus in Figure 1). Thereafter the central 40cm of each column were divided into 10-cm
segments. Soil in each segment is currently in the lab for chemical analyses. Preliminary interpretations of water-soluble C determinations are that differences among treatments for this variable are negligible. Soil from each segment is also being subjected to a root length bioassay for 6 days of growth by an acid sensitive bean cultivar. Upon harvesting the current bioassay, Lidieth plans to repeat the test with another bean cultivar.

Figure 1. Setup for column leaching study with lime and peach palm residues added to an acid Andisol.

Upon completion of this study Lidieth will begin a second greenhouse study to assess the CaCO₃-equivalence of peach palm prunnings in an Andisol and Ultisol of the ‘Huertar Norte’ region. Prunnings at rates of 0, 2.5, 5 and 10 t ha⁻¹ air dried material will be super-imposed to variable lime treatments and planted to one of the acid-sensitive bean cultivars used in the previous study. Response variables, after four weeks of growth, include aboveground biomass, and weight and length of roots.

Rafael Salas has the greenhouse peach palm pot trial to assess root growth response to lime, Ca and Mg underway, but there were some changes in the original protocol. The experiment consists of six replicates for the following lime, Ca and Mg treatments applied to an Andisol and Ultisol:
1. CaCO₃ at 1X the exchangeable Al;
2. MgCO₃ at 1X the exchangeable Al;
3. CaSO₄ to supply an equal amount of Ca as treatment 1;
4. MgSO₄ to supply an equal amount of Mg as treatment 2;
5. a 50:50% mixture of CaCO₃ and MgCO₃ on a lime equivalence basis to total 1X the exchangeable Al;
6. a 50:50% mix of Ca(NO₃)₂ and CaCl₂ to supply an equal amount of Ca as treatment 1; and
7. control with no lime, Ca or Mg salts added.
Initial chemical properties for the soils used in the experiment are shown in Table 1. The same bulk sample for the Andisol is also being used in Lidieth Uribe’s column leaching experiment.

Table 1. Chemical soil properties for bulk samples of the Andisol and Ultisol surface samples collected at the DEMASA farm in Pococi for use in the pot trials to assess peach palm root growth response to lime, Ca and Mg.

<table>
<thead>
<tr>
<th>SOIL</th>
<th>pH in</th>
<th>Org.</th>
<th>Exchangeable</th>
<th>Olsen Extractable</th>
</tr>
</thead>
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<td></td>
<td>H₂O</td>
<td>C</td>
<td>Ca</td>
<td>Mg</td>
</tr>
<tr>
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<td>4.8</td>
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Pre-germinated peach palm seedlings were grown in the pots for 2.5 months. At that time (and just prior to my visit) lime, Ca and Mg treatments were added to each pot as a solution. Root elongation response to the treatments will then be evaluated after 2.5 months of additional growth. Additions of Ca and Mg salts via an aqueous suspension may work fine for treatments 3, 4, and 6 because they are relatively soluble and should redistribute throughout the soil with successive waterings to maintain pots near their water holding capacity. However, the aqueous suspension of CaCO₃ and MgCO₃ in treatments 1, 2 and 5 will maintain these liming materials near the pot surface. This localized lime placement could raise the surface soil pH, increase the ECEC and prevent Ca and Mg redistribution in soils with subsequent waterings. Furthermore, loss of HCO₃⁻ as CO₂ in surface applied lime would diminish its Al neutralization potential throughout the remainder of the pot volume. The net result is that we cannot ensure that surface applied lime enhances root growth conditions by reducing toxic Al concentrations or increasing Ca and Mg availability throughout the potting medium. Rafael will continue the currently installed experiment for another 2 months before harvesting to measure root length. The experiment will then be repeated, with lime and salt treatments thoroughly mixed into the soil prior to planting. Results from the ongoing experiment may enable us to further refine treatment composition for the following study.

Eloy Molina provided a corrected table for initial soil sampling after the lime and gypsum treatments were applied to the field experiment at the DEMASA farm (see Table 2). This replicated field trial was initiated by UCR in a 15-year-old peach palm plantation at the request of and on the DEMASA farm prior to our project’s planning visit by Hue, Smyth and Wagger in 1998. DEMASA is measuring cumulative heart-of-palm yields and UCR is monitoring changes in soil chemical properties among treatments with samples collected on an annual basis. Comparisons of soil Ca, Mg and Al values among rates of lime and gypsum (Table 2) show some expected trends at both sampling depths, but there also appears to be considerable variation. Statistical analysis of the data should help clarify some of this variation. Lime quality
Table 2. Chemical soil properties of an Allic Hapludand at two sampling depths for the lime and gypsum field trial at the DEMASA farm in Pococi. Samples were collected in 1998 shortly after the treatments were applied to the 15-year-old peach palm plantation. Mean values for 3 treatment replicates.

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TREATMENT pH in Org. Exchangeable Olsen Extractable

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ᵃ Treatments consisting of a mixture of calcitic and dolomitic lime.
information also needs to be assembled so that lime rates can be expressed in terms of CaCO₃-equivalence as well as total Ca and Mg applied in the treatments. Eloy plans to take a second set of soil samples on these lime treatments before August of this year. It will be interesting to review the yield data for the first year, once Eloy receives it from DEMASA.

**Phosphorus**

UCR-CIA staff have been searching for a suitable site within the ‘Huertar Norte’ region for a P fertilization study in an established peach palm plantation. More than 20 potential sites were surveyed, but none of them had sufficiently low soil P availability. A suitable site was recently identified on a farm near Altamira, Alajuela. Soil data and experiment protocol for the P experiment are described in Adrian Are’s recent report on travels to Brazil and Costa Rica (download from [http://intdss.soil.ncsu.edu/sm-crsp/Download/Trip_Reports/Adrian_Brazil_CRica_99Rept.pdf](http://intdss.soil.ncsu.edu/sm-crsp/Download/Trip_Reports/Adrian_Brazil_CRica_99Rept.pdf)). I visited the P experiment site with Alfredo Alvarado, Eloy Molina and Jose Quesada. Altamira is on the eastern side of the mountains and about 30 from the border with Nicaragua. Elevation is several hundred meters above the Sarapiqui area. The site is on a farm with about 30 ha of peach palm with plantation ages ranging from 1 to 2.5 years. Prior land use was pastures for extensive beef-cattle production. Alfredo tentatively classifies the soil at the P study site as an Aquic Dystrudept. Replicates for the P treatments have been delineated, soil samples were collected and analyzed, and Eloy is awaiting feedback from Russ and Adrian on the rates of P fertilizer that should be applied to the treatments. Other parts of the peach palm plantations are on Typic Paleudults and Humic Hapludults (Alvarado’s tentative field classification), and are potential sites for a N fertilization trial (see N section for more about this).

Soil extractable P for the laboratory P incubation studies on 70 samples from Ecuador, Central America and Hawaii are still in progress. Eloy provided data to give Fred Cox on Modified Olsen and Mehlich-3 extractable P for most of the soils. Once the incubation studies are completed, soils with be analyzed for other variables that might serve as corrolaries to improve prediction of soil P buffer coefficients. Selected samples will also be prepared and shipped to N.C. State University for mineralogical analyses.

The selection and collection of soil samples along various transects in Costa Rica for greenhouse studies on P response by peach palm has not yet begun. Hopefully, this activity will begin in the near future to avoid delays in implementation of the greenhouse pot trials. Timing of Cox’s trip to Central America, to delineate protocols for the pot trials, should coincide with completion of soil sampling and laboratory characterization analysis.

**Peach palm nutrient and biomass accumulation, and litter decomposition**

These activities relate to all nutrient modules in IntDSS. In order to predict peach palm nutrient requirements for plantations at different ages, a trial was outlined to monitor biomass and nutrient accumulation for 12 consecutive months in existing plantations of different ages (1 to 15 years). A major criteria for selection of plantations to be sampled was uniformity in soils and management practices among plantations - to avoid confounding differences among plantations. Changes in owner policies (and, thus, collaborative support for new activities) at the DEMASA farms, eliminated primary candidate sites. UCR staff have been searching for alternative sites throughout the ‘Huertar Norte’ region. Several on-farm sites were rejected because they did not feel there would be sufficient control of experimental protocols to avoid the risk of loss of data or compromise results.
Eloy, J. Quesada and I visited suitable sites for plots in a 4- and 8-year-old peach palm plantation at the ‘Los Diamantes’ Experiment Station of the Ministry of Agriculture and Cattle Production (MAG) which is located at Guapiles. Soils for both plantations are Hapludands. The plantation with 4 years age was used for prior plant population trials. The plantation with 8 years of age has a fixed population and was used to evaluate heart-of-palm production among different peach palm assessions. The same fertilization and management practices were used in both plantations. There is sufficient area among replicated plots in both plantations where we could install the biomass and nutrient accumulation trials with a common peach palm assession and plant density (2x1m spacing among plants). Before initiating actual monitoring of plant yields and nutrient accumulation, Eloy proposes to undertake 1-2 months of standard fertilization, heart-of-palm harvesting and thinning of plant shoots to ensure greater uniformity in the plots. Arrangements have been worked out between UCR and ‘Los Diamantes/MAG’ to conduct collaborative peach palm experiments at the station. Ing. Antonio Bogantes will be the primary contact at the station. Antonio played a key role during the project’s baseline survey for the Sarapiqui peach palm growing region by identifying local technicians to help with questionnaires and facilitating initial contacts with farmers. In addition to on-station research with peach palm, a considerable part of Antonio’s time involves on-farm technical assistance to peach palm growers.

While at ‘Los Diamantes’ Antonio gave us a tour of several field trials with peach palm. ‘Los Diamantes’ is one of three sites in Latin America which maintains peach palm assessions collected from Central America and the Amazon during a multi-national project in the ‘80s. The other repository sites are INPA in Manaus, Brazil and INIAA in Yurimaguas, Peru. There are assessions both with and without spines. Antonio recently reported on mean heart-of-palm yield data for two five-year trials conducted at the station: (a) evaluation of plant population densities (Bogantes et al., 1997a), and (b) evaluation of different peach palm assessions (Bogantes et al., 1997b). He agreed to send me, via Eloy, yield data by year for each treatment so that we can look at yield trends with plantation age. Preliminary inspection of the data indicates that 5-year average yields increased from 10,540 palmitos ha$^{-1}$ to 18,503 palmitos ha$^{-1}$ when the conventional peach palm population of 5,000 plants ha$^{-1}$ (2x1-m spacing) was increased to 13,333 plants ha$^{-1}$ (1.5x0.5-m spacing). Average yields (over 5 years) at 5,000 plants ha$^{-1}$ for the peach palm assession traditionally used in Costa Rica (‘Tucurrique’) was 10,140 palmitos ha$^{-1}$, compared with 14,080 palmitos ha$^{-1}$ for the ‘Yurimaguas’ assession. Bogantes pointed out that the Yurimaguas assession has no spines and heart-of-palm (palmito) harvest begins at an earlier stage than other assessions with spines. He suggests that peach palm productivity could possibly be increased in the region through a combination of the Yurimaguas assession and greater plant population densities. Current constraints to increased population densities are injuries to laborers by the peach palm spines, but the spineless Yurimaguas assession would avoid this.

Gabriela Soto was traveling at the time of my visit, but left a series of data tables summarizing current results on the field litterbag decomposition trials of peach palm residues from heart-of-palm harvests which are ongoing at the DEMASA farm at Guapiles. Gabriela now has three replicated series of litterbag decomposition trials in the field, each one initiated at different dates to evaluate potential interactions with annual rainfall distribution. Starting dates are 31 July 1998 for series 1, 24 September 1998 for series 2, and 11 March 1999 for series 3. In each series litterbag replicates are harvested at 1, 2, 4, 8, 16, 24, 32, 40 and 48 weeks. Upon
harvest plant dry weight is determined, subsamples are ashed to determine a correction for soil contamination, and N, P, Ca, Mg and K are determined in the plant residues.

Data for the initial 16 weeks in series 1 were included in projects’s annual report for Year 2 (pp. 18-21 of document http://intdss.soil.ncsu.edu/sm-crs/p/Download/Documents/IntDSS_YR2_Report.pdf), indicating a rapid rate of decomposition between weeks 2 and 4 (about 35% loss of initial dry weight) followed by a slower rate of decomposition between weeks 4 and 16 (about 35% loss of initial dry weight in 12 weeks). Preliminary inspection of data between weeks 16 and 32 (the last available set of data) for series 1 indicates an additional loss of 20% initial dry weight between weeks 16 and 24, but only a 4% loss between weeks 24 and 32. Initial dry weight loss percent up to 16 weeks in series 2 is consistent with the trends observed in series 1. The current data suggest that decomposition begins in the 2nd week and about 20% of the initial plant material remains at 32 weeks with little subsequent decomposition. Since palmitos are harvested every 1-2 weeks there is a continual addition of prunnings throughout the year, each at different stages of decomposition. Collectively, this adds up to a continual release of nutrients for plant uptake.

Current plans are for Gabriela to travel to Raleigh at a yet-to-be-determined time this year, to work with Michael Wagger on statistical modeling and interpretation of these data. There are several questions which need clarifications from Gabriela, and may require additional lab determinations on samples prior to her travel to the U.S.

Nitrogen

During the past year, prices and demand for heart-of-palm at Costa Rican processing plants have softened. Buyers are attributing this to new production reaching international markets in other Latin American countries. Peach palm growers have compensated by reducing their fertilizer inputs, and foliar N deficiency symptoms, exemplified in Figure 2, were evident in most regions where we traveled. We explored several potential sites and selected two locations for initiating N fertilization experiments.

One site is on the farm near Altamira in a 1.5 year old plantation near the P fertilization trial. Soils are tentatively classified as Typic Paleudults. Nitrogen deficiency symptoms were particularly strong at this location. We suspect that prior long-term land use for unfertilized pastures may have contributed to depletion of native soil N reserves.

The second site is located on Hapludands at the ‘Los Diamantes’ station near Guapiles. The field is 4 years old, but due to prior poor management of plant shoots among plants (spaced at the traditional 2x1 m), the entire field was cut with a powersaw at soil surface level in November 1998. Eloy and Antonio note that above ground plant regrowth during the past 5 months at this site (Figure 3) is significantly greater than in a new 5-month-old plantation; they attribute this rapid regrowth to an established root system in the 4-year-old plantation. Antonio noted that this radical plantation treatment is often practiced in the region, and that above ground biomass tends to reach equilibrium in about 1 to 1.5 years of regrowth. Eloy and Antonio propose running a N fertilization study for two years at this site to evaluate peach palm response to N during both regrowth and the subsequent year. During the 2nd year of this study it is intended that one would be evaluating N response similar to that of a 6-year-old plantation.

Suggested annual N rates by Eloy and Antonio are 0, 75, 150, 225, 300 and 500 kg N ha⁻¹ applied in 6 equal split applications every 2 months. Most farmers are split-applying 300 kg N ha⁻¹ year⁻¹, but there is unconfirmed suspicion that this rate may be too high. Other nutrient inputs would be similar to those described in the protocol for the P fertilization study. Biomass for
pruned and harvested materials will be weighed and subsampled for moisture determination and nutrient uptake. Selected leaf numbers targeted for diagnostic foliar analysis in the P experiment will also be sampled and analyzed for N in these experiments. Each experiment will have 4 replications. The field at ‘Los Diamantes’ is large enough that we could possibly include additional plots to destructively sample total above ground biomass and nutrient content at selected time intervals during the N experiment. During subsequent discussions with Alfredo and Eloy at UCR it was also suggested that Rafael could install and monitor series of variable depth suction lysimeters in selected N treatments at both Altamira and ‘Los Diamantes’.

Alfredo and Eloy requested that I discuss plans for the N experiments with U.S.-team members and, eventually, submit a consensus outline of experiment design and protocol. They would like to initiate these N trials soon after the studies on P and biomass-nutrient accumulation have been started.

Midterm Socio-Economic Survey

While in San José, we also discussed areas which we would like for Frank Smith to investigate during the project’s midterm survey. Frank is scheduled to be in Costa Rica during the latter part of May. Three major topics were identified which reflected changes or potential
impacts on peach palm production systems in Costa Rica since the baseline survey in project year 1. These are described in the following.

- The role of peach palm grower associations - they have increased both in size and numbers during the past 3 years, and we would like to explore their roles, functions, and priority needs within the peach palm production systems.

- Adjustments in policy, support services and farmer practices to the softening of heart of palm export market - what measures or strategies have the different sectors taken to adjust to the change in the commodity market? How will this impact nutrient management practices? We should gain some useful information on peach palm system “resilience” through studies on this topic.

- Project impacts - has the project’s collaborative involvement contributed towards an improved understanding and identification of information gaps and/or the process by which knowledge is collected and synthesized to fill such gaps?

The mid-term assessment will involve less farmer surveys than in the baseline study and more interviews and contacts with personnel in farmer associations and government agencies involved in policy, finance, marketing, research, extension and education.

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**Pertinent Literature:**
