Report on Travel to Mali
February 22 - March 2, 1998
USAID Grant No. LAG-G-00-97-00002-00
SM-CRSP Project *Decision Aids for Integrated Nutrient Management*

Travel Team:

Lloyd R. Hossner - Texas A&M University
Frank M. Hons - Texas A&M University
Frank J. Smith - North Carolina State University

Objectives:

- Conclude a Memorandum of Understanding with the Institute d'Economie Rurale (IER) in Mali defining a collaborative research program on nutrient management;
- Conduct the baseline survey for the project site located near the Cinzana Research Station; and
- Clearly define the research program for the core experiment and trials to be conducted in farmer fields.

Itinerary:

Sunday, February 21	Arrival in Bamako - met by Mamadou Doumbia
Monday, February 22	Meetings and discussions with IER staff
Tuesday, February 23	Continue discussions with IER staff and travel to Segou
Wednesday, February 24	Initiated baseline survey; discussions with IER - Cinzana Station staff
Thursday, February 25	Continued baseline survey data collection; visit to Cinzana Station and farmer fields
Friday, February 26	Continued baseline survey data collection; continued meetings with Cinzana staff; returned to Bamako
Saturday, February 27	Baseline data coding; tour of Bamako; Hossner and Hons depart Mali
Sunday, February 28	Baseline report preparation
Monday, March 1	Baseline report completed
Tuesday, March 2	Smith departs Mali

Memorandum of Understanding:

A memorandum of understanding and sub-grant between the Texas A&M Research Foundation and the Institute d'Economie Rurale was signed that outlines project responsibilities and data collection protocol to develop, refine and evaluate decision aid tools. Data collection will be in the Cinzana area about 200 km northeast of Bamako. The area is in the Sahelian region. The memorandum was approved by Dr. Alpha S. Maiga, Directeur General of IER. IER collaborators are enthusiastic about the project and we expect an excellent collaborative research association with them. Members of the Mali team include Dr. Mamadou Doumbia (Coordinator), Mr. Adama Coulibaly, Mr. Zoumana Kouyate and Ms. Aminata Sidibe.

Baseline Survey:

Dr. Frank J. Smith, Professor of Psychology at North Carolina State University, coordinated the baseline survey of farmers in the study area. He worked with Mr. Oumar Coulibaly of the Cinzana Station and other Cinzana staff to develop the survey instrument. Data on farmer practices and traditions were gathered from five villages, coded, and evaluated. In addition, individuals involved in policy and marketing of fertilizers and farmer commodities were interviewed to provide background information. Dr. Smith's report will be submitted as a separate paper.

Research Program in the Cinzana Region:

Malian scientists, led by Dr. Mamadou Doumbia, will collect data that will develop, refine and test the decision aid tools. Their primary efforts will relate to the diagnosis, recommendations and fertilizer guidelines on soil N, P, Ca, Mg and acidity problems in the area. Interrelations between soil acidity, soil Ca/Mg depletion and N source (fertilizer, biological N fixation, organic waste) are primary ingredients of the ADSS, NDSS and PDSS models.

Malian scientists will work in three area:

1. The core experiment (attached) will be conducted as outlined. Cowpea will be the legume included in the experiment rather than peanut. Cowpea is the major legume grown in rotation with millet in the Cinzana region. Peanut is grown but the Cinzana area is a secondary peanut production region.
2. A separate study will be conducted by Mr. Adama Coulibaly to evaluate Ca and Mg relationships and movement as influenced by source and rate. Calcium (and Mg) will be applied as limestone and as gypsum in combination with organic compost and Tilemsi rock phosphate. Soil and plant parameters will be monitored for a two year period; and
3. On-farm nutrient budgets will be developed in two or three villages. The budgets will be developed on a field level rather than a farm level. Inputs of nutrient in compost and removal of nutrients in vegetative materials will be carefully monitored. Supportive soil data and biomass productivity and composition will be developed. In addition, the influence of composting on nutrient loss and the potential for nitrate contamination of household well water from composting pits will be evaluated. Copies of the core experiment, as negotiated with IER scientists, and the On-Farm research protocol are attached to this report. A research technician (Mrs. Sherry Blanton) will be stationed at the Cinzana Center in mid-May to develop analytical methods, assist in the analytical procedures, and collaborate with Malian scientists on soil and plant analyses.

Lists of Contacts:

Bamako

USAID -

Dr. Roger Bloom, ADO, Mali

Institute d'Economie Rurale (IER) -

Dr. Alpha S. Maiga, Director General

Dr. Oumar Niangado, Former Director General
Dr. Bino Teme, Research Director
Dr. Mamadou Doumbia, Director, LaboSEP, Sotuba Station
Mr. Yacouhe Doumbia, Sotuba Station, Director
Dr. Lassine Diarra, Sotuba Station, Head of Farming Systems and INTERCRSP
Ms. Aminata Sidibe, Sotuba Station, LaboSEP

Cinzana Research Station (IER)

Mr. M'Pe' Diarra, Cinzana Station Director
Mr. Zoumana Kouyate, Cowpea Program Leader
Mr. Adama Coulibaly, Millet Program Leader
Mr. Oumar Coulibaly, Extension Social Scientist
Mr. Saouti Toure, Cooperating Farmer

Core Experiment at the Cinzana Experiment Station

Recommendations of U.S. Team-Members of the IntDSS Project

Rationale:

The Cinzana Experiment Station is one of three intensive testing sites for our project, and the only one with conditions representative of acid, sandy soils of the African Sahel. Whenever possible, the project intends to conduct most of its developmental research at the testing sites through a collaborative effort of the scientists from the host-country institution and the U.S. team. Discussions at the project planning workshop held in Honolulu, Hawaii, wherein IER was represented by Mr. Adama Coulibaly and Dr. Mamadou Doumbia, identified the need for core experiments at each testing site. These core experiments would allow testing and identification of refinements needed for the decision support systems, while also providing soil, yield and plant nutrient data which are needed to calibrate and enhance performance of the software at the regional level. The objectives, hypotheses, procedures and design of the core experiment for Cinzana are described in the following. The experimental design and treatment combinations seek to maximize use of the trials to provide information for a number of different tasks related to the diagnosis, recommendation and fertilizer guidance on soil N, P, Ca, Mg and acidity problems in the region. Interrelations between soil acidification, soil Ca/Mg depletion and N source (fertilizer, BNF) are a major topic of the InterCRSP project which includes IER and members of the IntDSS project.

Objectives:

1. Compare ADSS, NDSS, and PDSS predictions of yield with observed yields at DSS recommended levels of N, P and lime requirements for cowpea and millet in an acid, sandy soil.
2. Acquire cowpea and millet yield response data on interactions among N, P and lime application rates that are suboptimal to the rates recommended by ADSS, NDSS and PDSS.
3. Evaluate effectiveness of BNF in cowpea with ubiquitous Rhizobia.
4. Evaluate carry over of biologically fixed N in cowpea to a succeeding millet crop via the maintenance of post-harvest cowpea stover in the field.
5. Compare soil P coefficients derived from laboratory P incubations with coefficients derived from laboratory analysis of field-applied P.
6. Assess the residual (carry over) effect of P and lime on soil chemical properties between crops.
7. Compare the rate of soil acidification, and Ca and Mg depletion between crops dependent on fertilizer N and BNF as their primary N sources.
8. Monitor downward movement through the soil profile of lime-derived Ca and Mg, and investigate its potential benefit towards deeper crop root proliferation.

Hypotheses:

1. The diagnostic accuracy of PDSS and ADSS can be improved upon acquisition of local information; all three DSS modules can be improved upon inclusion of local experience.
2. Phosphorus and lime recommendations by PDSS and ADSS are within 50% of the field-determined levels for optimum yield under traditional farmer practices in the region.

There is sufficient information in the literature on crop N requirements, fertilizer efficiency and soil N coefficients to obtain the same accuracy on N predictions by NDSS. Accuracy of all DSS modules can be improved upon local determination of factors used in the prediction algorithms.

3. Because of widespread cowpea cultivation in the region, BNF effectiveness on cowpea by ubiquitous soil Rhizobia is not less than 75% of that for Rhizobia in commercially available inoculum.
4. In these poorly-buffered, sandy soils acidity generated by fertilizer N will be greater than that produced by BNF.
5. Downward movement of basic cations will improve deep crop rooting and reduce drought stress with time after liming. But this effect is short-lived unless lime is applied on a frequent basis.
6. There is a significant yield advantage for millet in N carried over from cowpea stover in the preceding crop, but stover value as fodder and compost and millet prices do not make this practice economically feasible. Quantification of this N carry-over to millet will be useful for the DSS fertilizer guidance module.

Procedures:

1. Two field experiments will be conducted simultaneous over two years. For clarity they are identified by the first crop to be planted in each as the 'Cowpea' and 'Millet' experiments. In the second year the crop species will be switched between experiments. Both experiments contain incomplete factorials of N, P and lime applications. The optimum levels of N, P and lime (level 2) are the amounts recommended by NDSS, PDSS and ADSS for each crop, based on local knowledge about yields levels and soil analysis data prior to planting each crop. For the second crop in each experiment, this means that NDSS, PDSS and ADSS recommendations would be generated based on soil analysis from each treatment after harvesting the first crop.
   In all but one treatment for the 'Cowpea' experiment (treatment 10) it is expected that crop residues will be removed after grain harvest of each crop, as is the traditional farmer practices for the region. Prior local experience will serve as the guide for determining whether other nutrients such as Mg, K, S and minor elements need to be applied, in a uniform manner to all treatments, to ensure that they are not limiting crop yield response to N, P and lime. Likewise for number of replications - it depends largely on variability in soil properties and cropping history within the experiment station field (or fields) where the experiments will be located. Lime and P should be broadcast-incorporated to allow meaningful interpretation of soil test analyses.
2. <u>Cowpea Experiment</u>- N is not applied to most of the treatments, and the crop is dependent on native soil N and BNF supply. Treatments 4, 8 and 9 compare the effectiveness of native and introduced Rhizobia on N supply with that from fertilizer N. Treatments 1 - 8 allow evaluations of different combinations of P and lime rates on nodulation, BNF and yield outcome. Potential benefits to N nutrition of millet in year 2, as N carried over from cowpea stover can be estimated by comparing millet yields and N in aboveground biomass between treatments 10 and the treatments with different fertilizer N rates at constant levels of P and lime (treatment 10 vs. treatments 4, 8 and 9).

3. Millet Experiment - without a legume for the first crop, there is no need for treatment 10 in the 'Cowpea' experiment. Thus, this experiment has one less treatment. Otherwise, the same comparisons can be made among N, P and lime treatments. The net result of both experiments is 4 crops over 2 years with comparisons between cowpea and millet in each year.

Cowpea Experiment - cropped to cowpea in year 1 followed by millet in year 2

YEAR	TREATMENT	CROP	INOCULUM	N	P	LIME
1	1	Cowpea	No	N0	P0	L0
	2		No	N0	P0	L2
	3		No	N0	P1	L2
	4		No	N0	P2	L2
	5		No	N0	P2	L0
	6		No	N0	P2	L1
	7		No	N0	P1	L1
	8		No	N2	P2	L2
	9		Yes	N0	P2	L2
	10[a]		Yes	N0	P2	L2
	11		No	N1	P1	L1
2	1	Millet	--	N0	P0	L0
	2		--	N2	P0	L2
	3		--	N2	P1	L2
	4		--	N2	P2	L2
	5		--	N2	P2	L0
	6		--	N2	P2	L1
	7		--	N2	P1	L1
	8		--	N0	P2	L2
	9		--	N1	P2	L2
	10[a]			N0	P2	L2
	11		--	N1	P1	L1

N0, P0, L0 = no N & P fertilizer or lime;
Levels 1 = 50% of the predicted N, P and lime by NDSS, PDSS and ADSS for optimum yield;
Levels 2 = 100% of the predicted N, P and lime by NDSS, PDSS and ADSS for optimum yield;
[a] This would be the only inoculated cowpea treatment wherein stover was maintained in the field, in contrast to farmer practices of removing all stover from the field.

Millet Experiment - cropped to millet in year 1 followed by peanut in year 2

YEAR	TREATMENT	CROP	INOCULUM	N	P	LIME
1	1	Millet	--	N0	P0	L0
	2		--	N2	P0	L2
	3		--	N2	P1	L2
	4		--	N2	P2	L2
	5		--	N2	P2	L0
	6		--	N2	P2	L1
	7		--	N2	P1	L1
	8		--	N0	P2	L2
	9		--	N1	P2	L2
	10		--	N1	P1	L1
2	1	Cowpea	No	N0	P0	L0
	2		No	N0	P0	L2
	3		No	N0	P1	L2
	4		No	N0	P2	L2
	5		No	N0	P2	L0
	6		No	N0	P2	L1
	7		No	N0	P1	L1
	8		No	N2	P2	L2
	9		Yes	N0	P2	L2
	10		No	N1	P1	L1

Definition of fertilizer and lime levels the same as in the “Cowpea Experiment”
Stover removed from all treatments; since cowpea follows millet the treatment for effect of stover on subsequent crop is not relevant.

Measurements:

1. <u>Plant</u>
   a. Plant population and height at a recognized stage of growth as insurance data against crop failure;
   b. Nutrient content of diagnostic leaf tissue at the appropriate growth stage;
   c. Destructive sampling of a limited number of cowpea plants at mid-flowering stage for nodule number and mass, and aboveground plant mass and N content;
   d. Grain and stover yields at harvest;
   e. Nutrient content of harvested grain and stover.
2. <u>Soil</u>
   a. Sampling depths for each treatment and rep: 0-15, 15-30, 30-60 and 60-90 cm;
   b. Frequency: prior to planting first crop and after harvest of each crop;
   c. Chemical determinations: pH (H_2O), KCl-extractable Ca, Mg and acidity; exchangeable K, and "available" P; P is only needed on 0-15 and 15-30 cm samples, but may need to be measured in special samples taken about 30 days after planting (*purpose - relations between freshly-applied fertilizer P and soil test P*); NO_3 and NH_4; organic C on the first set of soil samples taken from plots.
   d. Collect enough soil at all depths in post-harvest sampling to have 250 g in reserve after all chemical analyses; after review of soil analyses and upon evidence of Ca & Mg movement into subsoil, profile samples from all reps for selected treatments would be used for root growth bioassay with millet and cowpea seedlings under screen-house conditions; in conjunction with soil chemical data, root bioassay would be used to interpret potential benefits to crop rooting depth by basic cation movement into subsoil.
3. <u>Weather</u> - daily rainfall, temperature, solar radiation and relative humidity
4. <u>Lime</u> - particle fineness and CaO and MgO content of each mesh size

Items to be Learned from Mali Farmers

Via Ongoing IER On-Farm Trials in the Cinzana Region

1. **Nutrient Budgets**

We would like to support ongoing efforts to develop nutrient budgets for selected farms. This includes the measure of yields and nutrient accumulation in grain & stover at the field level on the farm; analyses of post nutrient content, estimates of compost distribution among fields; calculation of nutrient input-output balance at both the field and farm level. Soil analyses of the fields would be good complementary information to help interpret consequences of the nutrient budget data. Our perception is that there can be considerable nutrient redistribution among fields within the farm and this might be influenced by farmer's definition of "good" and "bad" fields. We are developing a nutrient budget software program. It needs this kind of data for its database in order to become a useful tool in the African Sahel.

2. **Nutrient Losses in Composting**

How much nutrients are lost during the open-pit composting process? Monitor nutrient content of selected compost pits over time.

3. **Managing Nutrient Losses in Composting**

Can nutrient loss from compost pits be reduced by covering the pits? This would be a suggested paired-comparison treatment that could be combined with item 2. Measurements of soil NO_3, K and other mobile nutrients, under the compost pits, would be useful information. If covering pits significantly improves nutrient content, is it enough to impact productivity at the field level? A follow up field test of the two composts would help determine if the bottleneck is at the composting process or in the compost application.

4. **Nitrate Contamination of Groundwater**

How close are household wells to the compost pits? If the pits are at the home compound and nitrate is leaching, there could be potential nitrate contamination of groundwater. How about monitoring nitrate content of well water for wells with variable proximities to compost pits? Has this already been done?