Report on Trip to Senegal and Mali
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SM-CRSP Project *Decision Aids for Integrated Nutrient Management*

Travel Team:
Shaw Reid - Cornell University
Frank Smith - North Carolina State University
Jot Smyth - North Carolina State University
Russell Yost - University of Hawaii

Objectives:

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 tools that are useful under a variety of conditions the team of U.S. scientists and overseas collaborators will develop, refine and evaluate decision aid products in three testing areas representative of major ecosystems in the tropics. The region surrounding the Cinzana Experiment Station of the 'Institute d'Economie Rurale' (IER) in Mali will serve as the project's testing area for the Sahel. Project members at Texas A&M University have collaborated with IER personnel at Cinzana in developmental research since 1986, but this will be the first opportunity for an on-site visit by project team-members from the other U.S. universities. Members of this SM-CRSP project also participate in the West African InterCRSP project. A visit to InterCRSP collaborators at the 'Institute Senegalese de Recherche Agricole' (ISRA), during travel to Mali, was deemed useful for strengthening and coordinating linkages between CRSP projects.

Specific objectives of the trip were to:

- become familiar with ISRA concerns on soil and acidity and nutrient problems in Senegal, and explore their potential interests of our project's developmental research and outreach activities;
- become fully acquainted with regional farming practices and the existing knowledge base for the Cinzana region; and
- explore potential field sites where the decision aid tools could be tested and refined.

Itinerary:

September 25	Arrival in Dakar
September 26	Meetings and discussions with ISRA staff
September 27	Travel to Bamako
September 28	Tour of city and U.S. team meeting with Dr. Mamadou Doumbia

September 29	Meetings with Dr. Bino Témé (IER), Adama Dembele (USAID/ADO) and Dr. Oumar Niangado (IER); travel to Cinzana Experiment Station and meeting with station staff
September 30	Visit to farms in Dogouba (Mr. Laxima Djire) and Cinzana-Gare (Mr. Saouti Toure); tour of Cinzana station
October 1	Return to Bamako; wrap-up meeting with Dr. Bino Témé; tour of soil-water-plant laboratory; meeting with Dr. Yacouba Doumbia (Sotuba Station); departure for U.S.; Russ Yost remained in Bamako to initiate InterCRSP project activities with collaborators from Mali, Gambia, Senegal, Cape Verde and Burkina Faso

Senegal:

Our meeting with ISRA scientists began with a brief presentation about our project's goals, objectives, and developmental strategy for producing decision aid tools for soil nutrient management. Questions were raised about transferring soils information among different classification systems, addressing interactions between soil nutrient and water constraints, and potential types of auxiliary tools we might produce to augment local use of the computerized decision support system. The latter question reinforced our perception for the need to provide agriculturalists with practical guides on nutrient management alternatives based on regional knowledge synthesized from the decision support system. ISRA scientists were interested in our project and identified several areas of soil acidity and nutrient management experience in Senegal which could be incorporated into the decision support system knowledge base. Given their interest in our planned activities, ISRA scientists could provide valuable collaboration in our extensive evaluation network which seeks to evaluate decision aid tools under a variety of location-specific conditions.

ISRA estimates there are about 430,000 ha of soils in Senegal with $pH<5.5$ and believes this number is increasing. A peanut-millet rotation is practiced in about 90% of this area. Many of these soils have a low clay content. Upon cultivation surface-layer soil organic matter drops to 0.3-0.5% within three years, Ca is leached and Al toxicity is suspected to become a major problem for peanut. Little tillage is practiced, the potential for runnoff is significant during frequent high rainfall events. Farmers are recommended to apply 150 kg ha^{-1} of a 6-20-10 NPK formula to peanut followed by a combination of 150 kg ha^{-1} of a 14-7-7 NPK formula and 100 kg ha^{-1} of urea to millet in the subsequent year. Fertilizer distribution in the country often occurs after the planting season. Nutrient balance estimates, based on inputs versus exports in crops, frequently indicate deficits for Ca and P.

Some experiments suggest that an application of 400 kg ha^{-1} of local phosphate rock (PR) will resolve soil P deficiencies for about four years. Considerations are being made to recommend the use of 1 t ha^{-1} of a 50-50 mixture of PR and phosphogypsum by-product. The intent is to increase the Ca supplement, especially to peanut, but there could be adverse effects on the dissolution and plant-availability of P from the PR.

Farmers collect organic materials from harvests, household debris, manures, etc. and apply these mixtures to fields adjacent to their compounds (locally know as 'chan-de-case').

From the nutrient management standpoint this suggests frequent redistribution of soil nutrient stocks among land parcels within a farm. Successful adoption of legume fallows is contingent on the farmer's perception of a meaningful return for the labor invested. Factors such as the legume's value as a forage encourages adoption, whereas improved soil N supply for subsequent crops does not. In regions surrounding Dakar, peanut residues have a higher cash value as forage than harvested peanuts and this exacerbates soil nutrient deficits.

Although time did not allow visits to their field activities, we were impressed with the ISRA staff's knowledge of soil acidity and nutrient management problems in Senegal and their strategies to address these constraints. There are considerable similarities between their strategies and our project's developmental research activities in the areas of (1) sustaining adequate soil Ca and Mg supply, (2) legume management and (3) P management. Both Ms. Badiane and Mr. Sene participate in the West Africa InterCRSP project. One of them will be participating in a baseline assessment tour of the InterCRSP project's member-countries with Russ Yost and other collaborators in the week after our trip. Upon completion of that tour, Russ will be able to identify specific linkages between planned activities of our project and the InterCRSP project which would be mutually beneficial to all parties involved.

Mali:

Cinzana Station

To reach the Cinzana Experiment Station we traveled about 200 km from Bamako to Segou on the road to Tombouctou, then drove southeast on another road for 30 km. This is one of 16 experiment stations which IER maintains throughout Mali. The area encompassed by the Cinzana station includes Sahelian, Sudanan and sub-Sudan ecosystems. The primary goals of the station are to improve food security and increase productivity. The station has ongoing programs in breeding, cropping system improvements, striga control, entomology and nutrient management for millet, cowpea and groundnut. Annual work plans for the station are based on farmer input during field days and meetings with farmer associations. Primary requests are for improved seed, fertilizers, improved pest and weed management practices, and planting date studies. There are good facilities on-site to process and prepare soil and plant materials for subsequent analyses at the Soil-Water-Plant Laboratory at the Sotuba Experiment Station near Bamako.

The Cinzana Station staff comes across as an efficient multi-disciplinary unit. Most have received training at the M.S. level, including two members who recently returned from U.S. universities. The field experiments we visited were properly designed, maintained and monitored. These included several studies which Texas A&M faculty helped implement several years ago to investigate fertilizer and legume management interactions in crop rotations for sorghum and millet.

We were pleased to learn that, prior to our arrival, the Cinzana Station staff had analyzed and discussed the document describing our SM-CRSP project. Their questions about the project focused primarily on how the decision support system considered different plant factors and local farming practices. They welcomed development of any tools which would improve their abilities to diagnose soil nutrient constraints and transfer improved nutrient management technologies to the region's farmers.

Soil Properties in the Cinzana Region

Selected soil properties are shown in Table 1-3 for three pedons in a toposequence progressing from high to low elevation in the Cinzana region. Slopes are in the 1-2% range in level or undulating uplands. Soils in the uppermost landscape position contain eolian sand deposits over fluvial sediments. Drainage decreases with increasing clay content at the lower landscape positions. The soils have acid pH values but exchangeable Al never exceeded 0.8 $cmol_c\ kg^{-1}$ in any sampling depth (0.3 $cmol_c\ kg^{-1}$ in the Aridic Palesustalf). As with other regions of the Sahel, farmers prefer the sandy soils (Tables 1 and 2) for sorghum and millet production.

Collaborative investigations with Texas A&M University at the Cinzana Station have documented a marked spatial variability in sorghum establishment, growth and yield within single fields with Grossarenic and Plinthic Paleustalfs. Greenhouse experiments on problem soils indicated that P deficiency was a major factor limiting sorghum growth followed by acidity. Optimum sorghum growth was achieved with the application of 15 mg P kg^{-1} soil (Doumbia et al., 1991ab). Field trials have also compared sorghum, millet and cowpea yield responses to fertilization (N and P) and/or tillage. Fertilization was more effective in increasing yields in wet years, and tillage was more effective in dry years (Wendt et al., 1991b). Plowing increased infiltration during the dry season, but the effect did not last through the rainy season when compared to a no-till treatment (Wendt et al., 1991a).

Visits to Farmers in the Cinzana Region

Farms we visited are two in a series of farms throughout Mali which Mamadou monitors through monthly visits. In conjunction with local experiment station staff he is logging farmer operations, measuring yields and sampling soils for routine analysis in each major farm parcel, and conducting field trials to evaluate improved technologies. Mr. Toure had the largest land holdings (36 ha) among the two farms visited. He is the president of the Cinzana-Gare farmer's association and is known throughout the region for consistently using the earliest millet planting date at the onset of the rainy season. Both farms have animal-drawn carts and tillage equipment.

The head of the household makes most of the decisions about farming operations. Women have absolute control over small land allocations, wherein men provide some assistance in planting. The first priority at the onset of the rainy season is to establish millet and sorghum in sufficient land area to supply the household with these food staples for the entire year. Remaining farm land will then be planted to peanut, cowpea and bambara groundnut. Cowpea is frequently intercropped with millet and sorghum.

The sole source of nutrients is a composted mixture of crop residues, animal manures, ash and house wastes produced near the household compounds during the long dry season. Crop residues are collected after each harvest and either fed to animals or added directly to the compost pits. The compost is distributed to fields prior to the onset of the rainy season. Some farmers incorporate the compost, but others surface-apply it as small spots near the hills where seeds will be planted. Farmers will apply greater quantities (some estimates are 4 t ha^{-1} fresh weight) of compost on their "good lands" which they consider to be the sandy soils. Their less productive lands, the clayey soils may not receive any compost. This process constitutes a redistribution of nutrient stocks within their farms which favors the sandy soils.

The experiment station recommends farmers to delay compost applications to fields until the planting season, in an attempt to minimize nutrient losses by leaching and volatilization.

Table 1. Selected chemical and physical characteristics of a coarse-loamy, mixed, isohyperthermic Aridic Paleustalf at Cinzana, Mali.

SOIL		pH		Exchangeable					Eff.	Acid	P	Amorphous		Org.	Total	Extr.	H_2O Content (bars)				
HORIZON	DEPTH	H_2O	KCl	Ca	Mg	Na	K	Acid.	CEC	Sat.	Retent.	Fe	Al	C	N	P	1/10	1/3	15	Sand	Clay
	cm			--------------------cmol$_c$ kg^{-1}--------------------						------------------------------%------------------------------						mg kg^{-1}	--------------------%--------------------				
Ap	0-16	5.5	4.5	0.9	0.2	tr	--	1.3	2.4	54	6	0.03	0.02	0.24	0.02	18	4	4	1.5	89	3
Ba	16-40	4.7	3.8	1.0	0.2	0.1	0.1	2.6	4.0	65	13	0.05	0.04	0.20	0.02	7	10	7	3	84	8
Bt1	40-65	5.0	4.0	1.5	0.2	0.1	tr	1.9	3.7	51	6	0.05	0.04	0.17	0.02	7	12	12	3.7	83	9
Bt2	65-105	5.1	3.9	1.0	0.3	--	tr	2.0	3.3	61	6	0.06	0.04	0.10	0.01	7	5	7	3.9	83	10
Bt3	105-158	5.3	4.2	1.9	0.6	0.2	0.1	1.8	4.6	39	22	0.06	0.04			4	9	8	5.6	75	15
Bt4	158-172	5.9	4.7	2.4	0.6	tr	tr	1.1	4.1	27	6	0.03	0.04			3	13	8	5	74	14
Bt5	172-200	6.3	4.9	2.3	0.6	0.1	0.1	1.2	4.3	28	10	0.03	0.04			6	13	9	5	75	13

tr = trace; exchangeable bases extracted with NH_4OAc; exchangeable acidity extracted with KCl; P extracted with Bray 1; P retention by the Blakemore test; and amorphous Fe and Al by the acid oxalate method.
Source: Soil Survey Laboratory, NSSC/NRCS/USDA (http://vmhost.cdp.state.ne.us/~nslsoil/soil.html; pedon S90FN-585-006)

Table 2. Selected chemical and physical characteristics of a fine-loamy, mixed, isohyperthermic Plinthustalf at Cinzana, Mali.

SOIL		pH		Exchangeable					Eff.	Acid	P	Amorphous		Org.	Total	Extr.	H_2O Content (bars)				
HORIZON	**DEPTH**	**H_2O**	**KCl**	**Ca**	**Mg**	**Na**	**K**	**Acid.**	**CEC**	**Sat.**	**Retent.**	**Fe**	**Al**	**C**	**N**	**P**	**1/10**	**1/3**	**15**	**Sand**	**Clay**
				---cmol$_c$ kg^{-1}---						---%---						mg kg^{-1}	---%---				
Ap1	0-9	5.1	4.1	0.7	0.2	--	0.2	1.7	2.8	61	2	0.03	0.04	0.27	0.03	7		6	2	81	9
Ap2	9-19	4.7	3.8	0.8	0.2	--	0.1	2.7	3.8	71	6	0.03	0.03	0.29	0.02	5	9	6	3	80	12
Bt	19-41	5.0	3.8	1.4	0.7	--	tr	4.8	6.9	70	13	0.06	0.07	0.27	0.02	4		10	7	65	26
Btv	41-76	5.0	3.8	2.6	1.0	0.1	--	6.4	10.1	63	24	0.06	0.14	0.17		3		16	12	51	41
Btvg1	76-113	5.2	3.9	2.4	0.6	0.1	--	3.7	6.8	54	17	0.03	0.07	0.08		4		11	8	63	29
Btvg2	113-156	5.1	4.1	2.6	0.7	0.1	--	2.8	6.2	45	17	0.01	0.05	0.07		4		9	8	63	27
Btvg3	156-200	5.3	4.3	3.5	1.0	0.1	--	2.4	7.0	34	10	0.01	0.04	0.04		3		14	9	56	34

tr = trace; exchangeable bases extracted with NH_4OAc; exchangeable acidity extracted with KCl; P extracted with Bray 1; P retention by the Blakemore test; and amorphous Fe and Al by the acid oxalate method.
Source: Soil Survey Laboratory, NSSC/NRCS/USDA (http://vmhost.cdp.state.ne.us/~nslsoil/soil.html; pedon S90FN-585-004)

Table 3. Selected chemical and physical characteristics of a very-fine, kaolinitic, isohyperthermic Typic Haplustalf at Cinzana, Mali.

SOIL		pH		Exchangeable					Eff.	Acid	P	Amorphous		Org.	Total	Extr.	H_2O Content (bars)				
HORIZON	**DEPTH**	**H_2O**	**KCl**	**Ca**	**Mg**	**Na**	**K**	**Acid.**	**CEC**	**Sat.**	**Retent.**	**Fe**	**Al**	**C**	**N**	**P**	**1/10**	**1/3**	**15**	**Sand**	**Clay**
	cm			--------------------cmol$_c$ kg^{-1}--------------------						------------------------------%------------------------------						mg kg^{-1}	--------------------%--------------------				
Ap	0-15	5.5	4.3	5.6	2.1	0.1	0.1	8.6	16.5	52	29	0.17	0.18	0.98	0.07	5		21	13	36	44
AB	15-46	5.2	4.2	7.0	2.6	0.1	tr	13.0	22.7	57	51	0.09	0.47	0.50	0.04	3		28	24	8	80
Bv1	46-73	5.2	4.2	6.5	2.3	0.1	--	8.3	17.2	48	38	0.04	0.24	0.29	0.03	4		25	21	13	77
Bv2	73-100	5.2	4.2	5.0	1.4	tr	--	4.3	10.7	40	29	0.04	0.11	0.13		3		16	13	40	45
Bvg1	100-140	6.0	4.5	5.3	1.4	0.1	tr	2.8	9.6	29	17	0.03	0.09	0.07		4		14	12	45	42
Bvg2	140-173	5.7	4.9	5.2	1.4	0.1	--	2.3	9.0	26	13	0.02	0.06	0.06		1		14	11	47	39
BCvg	173-200	6.2	4.9	5.0	1.4	0.1	--	2.7	9.2	29	19	0.03	0.05	0.04		1		15	11	50	36

tr = trace; exchangeable bases extracted with NH_4OAc; exchangeable acidity extracted with KCl; P extracted with Bray 1; P retention by the Blakemore test; and amorphous Fe and Al by the acid oxalate method.
Source: Soil Survey Laboratory, NSSC/NRCS/USDA (http://vmhost.cdp.state.ne.us/~nslsoil/soil.html; pedon S90FN-585-005)

Farmers also are encouraged to add Tilemsi phosphate rock to the compost pits as a means of overcoming widespread soil P deficiencies. Thus far, farmers in this region have been reluctant to try direct applications of commercial fertilizers to their crops. As we traveled through the Cinzana region, however, most of the millet and sorghum fields appeared to have sub-optimal N supply.

When compared to our project's intensive testing sites in Costa Rica and the Philippines, a unique feature of the Cinzana site is the use of compost as the farmer's primary conduit for soil nutrient management. The on-farm activities which Mamadou and the station staff are conducting should provide useful baseline information on nutrient input-output balances, nutrient transfers within the farm, and specific farming activities which could be targeted to improve nutrient management practices.

Based on the apparent widespread deficiencies of N and P, we believe that it would be useful to establish a field trial to obtain sorghum and millet yield response curves to these nutrients. This type of experiment would provide useful information on yield potential in the region, and calibration of N and P coefficients for the decision support system. Treatments for correction of acidity and Ca and Mg supply could be added at a modest cost. IER staff will review existing research reports to determine if this information already exists for the Cinzana region.

Meetings in Bamako:

Both Drs. Niangado and Témé were receptive to our SM-CRSP project's collaboration with IER in the Cinzana region. They liked the project's focus on development of decision aid tools for diagnosing soil nutrient problems and recommending improved management alternatives. Current IER procedures require that annual work plans be submitted by December 31 of the preceding year. This fits well with the project planning workshop, scheduled for December 3-5, where next year's workplans will be developed jointly by U.S. scientists and representatives from each of the three testing sites.

A brief tour of the soil-plant-water laboratory at the Sotuba Station indicates that the lab can perform most routine determinations for soil and plant samples. The laboratory has a well-trained staff and we appreciate the difficulties of maintaining equipment and adequate supplies under conditions of limited local technical assistance.

Mr. Roger Bloom, ADO for USAID/Mali, was traveling and we met with Mr. Adama Dembele. We were informed that the mission was placing particular emphasis on strengthening the private sector, but this did not include any components related to fertilizer and lime production/distribution.

Other Project-Related Activities:

Team meetings during evening hours entailed discussions comparing traits between intensive testing sites, structure of the baseline assessment studies for each site, future project activities at each site, and improved linkages between SM-CRSP and InterCRSP projects. Based on these preliminary site visits we have also identified the need to develop a tool that will help users to calculate balances between nutrient inputs and outputs at single and multiple field levels. A paper prototype of a spreadsheet tools was developed. Shaw Reid will take the lead in assembling the initial spreadsheet for subsequent team input.

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List of Contacts:

Senegal- 'Institute Senegalese de Recherche Agricole' (ISRA)
Mr. Adama Faye, Animal Production System
Ms. Aminata Badianne, Natural Resources
Mr. Modou Sene, Soil Science
Dr. Richard Dick, Soil Science, OSU, Corvallis, OR
Mali-
'Institute d'Economie Rurale' (IER)
Bamako:
Dr. Oumar Niangado, Director General
Dr. Bino Témé, Research Director
Cinzana Experiment Station:
Mr. Zoumana Kouyaté, Cowpea Program
Mr. Adama Coulibali, Millet Program
Mr. Oumar Coulibali, Farming Systems
Mr. Soriba Katile, Entomology
Sotuba Experiment Station:
Dr. Yacouba Doumbia, Station Director
Dr. Mamadou Doumbia, Director, Soil-Plant-Water Laboratory
Farmers in the Cinzana Region
Dogouba village - Mr. Laxima Djire
Cinzana-Gare village - Mr. Saouti Toure
USAID/ADO
Mr. Adama Dembele