Report on Travel to Mali
September 13 - September 21, 1998
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SM-CRSP Project: *Decision Aids for Integrated Nutrient Management*

Traveler:
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Background:

The Cinzana Experiment Station, near Segou - Mali, is one of three intensive testing sites for the IntDSS Project with conditions representative of acid, sandy soils of the African Sahel. Discussions at the project planning workshop in Honolulu, Hawaii identified the need for core experiments at each intensive testing site. The purpose of these experiments is to allow testing and identification of refinements of the decision support systems while providing soil, yield, and plant nutrient data which are needed to calibrate and enhance performance of the software at the regional level. In addition to the specific objectives listed below, this trip provided an opportunity to evaluate the overall status of the core experiment during the first growing season.

Objectives:

- evaluate the influence of phosphorus and lime on symbiotic nitrogen fixation system of cowpea grown in the core experiment at the Cinzana Station;
- visually evaluate the overall crop growth response of millet and cowpea to treatments in the core experiment;
- share information about the developments of NDSS and IntDSS with collaborating scientists at the Soil and Plant Analysis Lab (LaboSEP) at the Sotuba and at the Cinzana Research Stations; and
- become familiar with the results from other long-term agronomic experiments at the Cinzana Station.

Itinerary:

Sunday, September 13	Arrival Bamako- Met by Dr. Abubacar and transported to hotel.
Monday, September 14	Attempted to locate acetylene with the help of Ms. Aminata Sidibe.
Tuesday, September 15	Briefly discussed development of NDSS with Ms. Aminata Sidibe at LaboSEP, Sotuba Station and traveled to the Cinzana Station.
Wednesday, September 16	Measured nodule number and mass in Reps I and II of the cowpea component of the core experiment.
Thursday, September 17	Completed measurements of nodule number and mass for Rep III of the cowpea test and discussed development of NDSS with Mr. Adama Coulibaly , Mr. Zoumana Kouyate, and Ms. Sherry Blanton-Knewtson.. Visited the manure test of Dr. Mamadou Doumbia on the farm of Mr. Saouti Toure near Cinzana Village.

Friday, September 18	Consulted with Ms. Sherry Blanton-Knewtson about problems with the N micro-diffusion system and visited with Mr. Kouyate about his long-term rotation experiments with millet-cowpea and sorghum-cowpea.
Saturday, September 19	Continued to trouble shoot problems with the N micro-diffusion system and visited Mr. Kouyate's rotation and green manure experiments on the Cinzana Station.
Sunday, September 20	Rested; made final visual assessments of crop growth in the core experiment; evaluated effectiveness of modifications to the N micro-diffusion system.
Monday, September 21	Traveled from Cinzana Station to LaboSEP at the Sotuba Station near Bamako. Discussed the capability of LaboSEP to perform Kjeldahl N analysis of plant material from the core experiment. Helped Sherry Blanton-Knewtson locate supplies needed for her work. Departed Bamako 10:15 PM.

Core Experiment at the Cinzana Station:

Experimental Information

- Both cowpea and millet tests were planted on August 7. The experiment was planted with the cowpea variety, Sutiva 2, and the millet variety, Sanioba 03.
- As of September 20, 780 mm of rain had fallen on the experiment during the wet season. Rainfall was low in June (43 mm) and the last half of July (36 mm) and very high in August (334 mm).
- Weeds were controlled manually. No herbicides were used.
- An insecticide was used to control ants, aphids and other soil borne insects.
- The experiment is planted on an oxic Haplustalf soil of loamy sand texture (refer to Reid et al. (1997) trip report on the project's web site [*http//intdss.soil.ncsu.edu/sm-crsp/Download/Download.htm*] for a detailed soil description). The field was ridge tilled before planting using animal (oxen) power.
- The phosphorus source was triple super phosphate broadcast and incorporated just before planting.
- The lime source was calcium carbonate that was applied and incorporated one week before planting.
- The planting pattern for cowpea was 0.75 m between rows and 0.5 m between hills within the row.
- The planting pattern for millet was 0.75 m between rows and 0.8 m between hills within the rows.
- Plots were 7.5 m wide by 10 m long and contained 10 rows with 0.75 m between rows.

Table 1. Treatment levels for phosphorus and lime applied to cowpea and millet crops in year 1 of the core experiment at Cinzana Station, Mali.

PHOSPHORUS/LIME	CROP	
TREATMENTS	COWPEA	MILLET
	---------- kg ha^{-1} ----------	
P1	36	28
P2	72	56
L1	813	813
L2	1626	1626

- Treatments in the cowpea test were modified from the original plans. The changes are noted in table 2 as bold lettering within parentheses. The N0P2L2 treatment with inoculation was not implemented because there was no inoculant available in Mali. The N2P2L2 and the N1P1L1 treatments were not implemented in the cowpea test because their value was apparently not perceived by the local scientists. The cowpea test now has a total of 12 plots of the N0P2L2 treatment. Three of these plots will be used as the cowpea residue incorporation treatment for the millet trial in year 2.
- Since the N2P2L2 treatment was not used, it will not be possible to determine whether the indigenous bradyrhizobial population limited the yield of cowpea in this environment. *It is important that this treatment (N2P2L2) be included in the cowpea test for year 2*. It is not necessary to base the N level for this treatment on any NDSS prediction. The N level used could be based on a realistic yield expectation for this environment and a N use efficiency of 0.5. As will be discussed later in this report the bradyrhizobia indigenous to this soil did effectively nodulate the cowpea crop but there is no way to determine whether N_2 fixation potential of the bradyrhizobial population limited the yield. As a collaborator, I am puzzled that Reid, Smyth, Israel, Wagger and Wollum were not consulted about the changes before they were made. A simple e-mail message to any one of these collaborators could have clarified what N rates to use in a very short period of time. I hope in the future that all collaborators will be consulted in a timely manner about any changes in the treatments for the core experiment.

General Observations

- The cowpea plants were not flowering on 9-17-98.
- There is considerable within plot variation for the cowpea but much more within plot variation was evident for the millet. In plots with sufficient nutrients, the height of millet varied from knee high to shoulder high. Since other millet on the station which was planted in June and early July did not show such within plot variation in plant size, this variation for millet in the core experiment may have been some type of photosensitivity response associated with the late planting date.

Table 2. Original plans for treatments and modifications made (labels shown in bold) upon installation of the core experiment for cowpea and millet at Cinzana Station, Mali.

TREATMENT	CROP	INOCULUM	N	P	LIME
1	Cowpea	No	N0[b]	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 **(N0)**	P2	L2
9		Yes **(No)**	N0	P2	L2
10[a]		Yes **(No)**	N0	P2	L2
11		No	N1 **(N0)**	P1	L1
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

[a] Inoculated cowpea treatment where the stover is maintained in the field in contrast to farmer practice of removing all stover from field. In all other treatments, stover is harvested.

[b] 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.

In year 2, millet will be planted in cowpea plots and cowpea will be planted in millet plots.

- Although within plot variation for the millet is high, treatment effects for millet are much more evident than for cowpea. This was related to a strong N response.
- Treatment effects on plant size were evident for cowpea. Plants in the P0L0 and P0L2 treatments were smaller than in other treatments. Plants in P2L2 treatments had almost lapped both within and between the rows. This was not the case for the P0L0 treatment.
- On 9-20-98 about 5% of the cowpea plants were flowering and the heads were emerging from a few millet plants. Even the smallest millet plants had heads almost ready to emerge.
- The experiment has been well managed since initiation. However, the late planting date may result in low yields if the rains end at the normal time as seed development would occur under water-stressed conditions. The rains have been reasonably good in September but the loamy sand soil can store only a limited amount of water.

Nodulation and Dry Weight Measurements for Cowpea

Procedure:

- At 40 days after seeding one hill each from row 2 and from row 9 of each plot was sampled. Shoots and roots after removal of nodules were dried at 60 to 65 °C for 72 hours.
- Nodules were removed from roots counted and fresh weight determined.

Observations and Comments:

- The acetylene reduction activity of the nodulated roots was not measured due to prohibitive cost of acetylene gas from Bamako or Segou. The nodulation measurements reported in Table 3 indicate how the treatments influenced the symbiotic system.
- In general, the plants were well nodulated so there must have been a favorable level of infective bradyrhizobia indigenous to the soil. The majority of the nodules were reddish brown to pink in the infected zone which indicated that they had some level of nitrogen fixation activity. As much as 10% of the nodules had multiple lobes. This attribute was noted in all treatments.
- Nodulation and dry weight data are reported in Table 3. The P0L0 and P0L2 treatments significantly decreased (P=0.05) nodule number and nodule mass relative to the P2L2 treatment. The P2L0 treatment numbers were similar to the P2L2 control treatment. These results indicate that at this location phosphorus availability is more limiting to the development of the symbiotic system than soil acidity. This conclusion must be considered tentative since the full impact of lime may not be realized in this cropping season because it was applied only one week before seeding. The P0L2 treatment decreased whole plant dry weight by 28% compared to the P2L2 control. This difference is significant at the 0.06 probability level. It is anticipated that differences in whole plant dry mass will become greater as plants progress into reproductive development.

Table 3. The influence of phosphorus and lime on nodulation and dry matter accumulation of cowpea grown in an oxic Haplustalf soil at the Cinzana Research Station, Mali.

	NODULE		WHOLE PLANT
TREATMENTS	**NUMBER**	**FRESH WEIGHT**	**DRY WEIGHT**
	/hill	g/hill	g/hill
P0L0	50	1.29	20.0
P0L2	56	1.78	23.3
P1L2	98	2.13	27.6
P2L2	107	3.48	32.3
P2L0	95	2.88	28.7
P2L1	84	2.80	28.1
P1L1	93	3.27	23.7
$LSD_{0.05}$	37	0.96	NS

Protocol for Sampling the Core Experiment at Maturity

- Remove the end hills from each of the 4 center rows (rows 4,5,6 and 7) of each plot.
- Harvest the heads and pods from the 4 center rows after removing the end hills and air dry.
- Then harvest stover (residue) and air dry.
- Thresh heads and pods saving chaff and pod walls as well as the grain.
- When plant material dries to a constant weight, weigh and record data.
- Take subsamples of air-dried material and dry at 60 C for 48 h so that moisture content can be determined. This will allow correction of yields to a dry mass basis.
- Chop material into small fragments, place in a large bag and mix by turning bag end over end. After mixing remove approximately 100 grams of material by compositing 5 subsamples from different parts of the total sample.
- Remove 100 gram subsamples of grain from the total sample of each plot.
- Place subsamples in ziplock bags for storage and transport to LaboSEP at the Sotuba Station where they will be ground and analyzed for N by a Kjeldahl procedure. At the present time the Technicon system at LaboSEP is not functional but I was assured that it can be repaired. I was also told that the Animal Nutrition Lab at Sotuba also has the capability to analyze for N by a Kjeldahl procedure.
- To meet the objectives of the core experiment P, K, Ca, and Mg content of the grain and stover will also need to be measured.
- Soil sampling for measurement of pH(H_2O), KCl-extractable Ca, Mg, and acidity; exchangeable K and available P at 0-15 ,15-30,30-60 and 60-90 cm depths will need to be done after harvest.
- This protocol, with the exception of soil sampling, was discussed with Mr Adama Coulibaly. The soil sampling is a part of the original protocol of the core experiment discussed with Dr.

Hossner's travel team in March of 1998 (Hossner, et al., 1998). If modifications to the protocol proves to be necessary, he has been asked to bring them to our attention.

Discussions with Mr. Zoumana, Kouyate Cowpea Program Leader:

Mr. Kouyate's experiments have consistently shown that yields of sorghum and millet grown in rotation with cowpea are increased when compared to continuous sorghum and millet even when the above ground residue is removed from the field. The following experimental treatments were suggested as a way to evaluate how the yield enhancements of these crops come about:

1) continuous sorghum or millet,
2) cowpea (residue and seed removed)/sorghum or millet,
3) cowpea (seed removed and residue incorporated)/sorghum or millet, and
4) cowpea as a green manure/sorghum or millet.

The amount of nitrogen added to the soil in different treatments will need to be determined so that nitrogen budgets for each treatment can be developed. These measurements would help determine whether the yield response is due to increased nitrogen availability or to a combination of factors.

Discussions about Development of NDSS:

The status of development of the NDSS was discussed with Mr. Adama Coulibaly (Millet Program Leader), Mr. Zoumana Kouyate (Cowpea Program Leader) and Ms. Sherry Blanton-Knewtson (graduate student from Texas A&M University). Major emphasis was place on the fact that the algorithm that drives the NDSS system is an expanded version of the Stanford equation and major components of the equation that need to be derived from published and unpublished N response experiments were described. Also, the spreadsheets that will be sent to cooperating scientists to assist in compiling research data on seed yield, above ground biomass and nitrogen accumulation in response to N application were described. I stressed that every cell in these spreadsheets does not have to be filled and emphasized that yield, and above ground biomass and N accumulation data would be the most useful kind of information for this exercise. Any additional information would help with the interpretation of yield and N accumulation data. Dr. N. Van Duivenbooden at ICRISAT Sahelian Center in Niamey, Niger was identified as a potential source of information on nutrient responses of millet and sorghum in the Sahel.

Consultations with Ms. Sherry Blanton-Knewtson:

Sherry was having problems obtaining consistent and complete recovery of N in the micro-diffusion system. Recoveries were variable and incomplete especially in the 1 to 10 ppm N range. After some experimentation, the system for holding the boric acid trap was modified to obtain a good seal of the lids to the rim of the jars and NaOH was substituted for MgO in Mulvaney's procedure to increase the pH of the sample solution from 10.8 to 12.8. Preliminary tests indicated good recovery of N (85 to 90%) from 10 ppm and 50 ppm standards after a diffusion time of only 24 hours. Sherry will determine the optimum diffusion time and evaluate the recovery of N in the 1 to 10 ppm range from standards prepared in the KCl extractant. If good recovery is achieved, the procedure will be applied to KCl extracts of soil samples from the long term rotation experiments at the Cinzana Station. If these measures do not solve the problems with N recovery, efforts to measure soil mineral N on site will be abandoned and samples will be shipped to Texas A&M for analysis.

References:

Available as Acrobat Reader files on the project's web site at the following page:
http//intdss.soil.ncsu.edu/sm-crsp/Download/Download.htm

Hossner, L.R., F.M. Hons, and F.J. Smith. 1998. Report on travel to Mali, February 22 - March 2, 1998. USAID Grant No. LAG-G-00-97-00002-00. SM-CRSP IntDSS Project. 10p.

Reid, S., F. Smith, J. Smyth and R. Yost. 1997. Report on trip to Senegal and Mali, September 25 - October 1, 1997. USAID Grant No. LAG-G-00-97-00002-00. SM-CRSP IntDSS Project. 9p.

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Mr. Zoumana Kouyate, Cowpea Program Leader

Mr. Saouti Toure, Cooperating Farmer

Ms. Sherry Blanton-Knewtson, Graduate Student, Texas A&M University.

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