Sustainable Agriculture and Natural Resource Management
Collaborative Research Support Program

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Trip Report: Bolivia

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Purpose: To enhance PROINPA soil testing laboratory capability. This involved construction and testing of K_{sat} (saturated hydraulic conductivity) measurement apparatus; construct and test a soil moisture tension table; review and practice all soil sampling, sample tracking, and laboratory analysis protocols; and identify and attempt to solve any problems or lack of capacity related to completing agreed upon soil sampling and laboratory analysis.

Sites Visited: Cochabamba and Tiraque, Bolivia.

Description of Activities:

The major objective of this trip was to develop the soil testing laboratory capability of PROINPA. This objective was met. Specific tasks completed include the following:

1. K_{sat} device was modified to allow use of siphon system to maintain constant water head for extended time (multiple day) K_{sat} determinations. PROINPA staff was trained in how to use the device and conduct the tests.
2. Soil moisture tension table was constructed and tested. PROINPA staff learned how to use the device to measure soil water content at multiple tensions.
3. PROINPA staff prepared to collect and handle intact soil cores for bulk density, K_{sat}, and soil moisture tension measurements.
4. PROINPA staff practiced conducting the following analytical procedures: bulk density, soil moisture content, K_{sat}, soil moisture tension, pH, KCl extractions, Mehlich3 extractions, potentially mineralizable N determination, and particulate organic matter determination.
5. PROINPA staff set up systems for sample identification and tracking, data collection, sample and extract storage, and laboratory QA/QC.

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6. PROINPA staff secured a freezer and refrigerator for sample storage and an oven for soil drying. The week following my visit physical renovation commenced on the small room designated for the soils laboratory.

During development and testing of the above procedures, problems became apparent that were either resolved or remain to be resolved. It also became apparent that there are some misunderstandings or lapses in communication between PROINPA and US collaborators.

1. As of the week of my visit, rains which normally begin in October in the Cochabamba region still had not materialized. In addition to major concerns with impacts on water and food supply, this has a direct impact on our baseline soil sampling. It is not possible to collect intact cores from the high silt content soils at the experiment sites because the powder dry soils are non-cohesive and fall out of the coring device. PROINPA staff will solve this problem by wetting soil in the sampling areas one day prior to sample collection.
2. A problem with excessive water flow between the intact soil core sleeve and the PVC collar on the K_{sat} apparatus was resolved by modifying core sampling depth from 15 to 12 cm. This allows us to use the plastic core sleeve rather than the PVC collar to maintain the needed water head.
3. The bit on the Giddings intact soil core sampler has an internal diameter that is approximately 2 mm less than the ID of the plastic sleeve into which the soil core is inserted. The resulting gap between the soil core and the sleeve presents a problem for water infiltration and hydraulic conductivity tests because water flows freely down the interface between soil and sleeve. This was resolved by adding dry, ground soil into the gap prior to saturating the soil core. Doing this sealed the gap without disturbing the intact core and will allow K_{sat} to be determined.
4. We decided not to attempt a determination of initial water infiltration rate using the Ksat apparatus for two reasons. First, with the current apparatus design it was extremely difficult to achieve equal delivery rates of water to all six soil cores. Secondly, the above described gap between soil and sleeve allowed water quickly flow down the core-sleeve interface and made it impossible to determine time to ponding of water on the soil surface.
5. The PROINPA team has access to a microplate reader which could be used for determination of NH_4^+ and NO_3^- in soil KCl extracts. However the chemicals listed below are not available in country and would best be brought to PROINPA from USA. The microplate reader needs a filter to allow operation at 650ηm for the colorimetric analysis of NH_4^+ and NO_3^-.
   a. Sodium salycylate
   b. Sodium nitroprusside
   c. Sodium tribasic phosphate, dodecahydrate
   d. Devarda's alloy

   If these chemicals and the needed filter could be delivered to PROINPA, Oscar and Ana Karina would be able to conduct NH_4^+ and NO_3^- analysis in house.
6. A roller grinder is needed to finely grind soil samples prior to total N and C determination. Dr. R. Gallagher is working on a design that would allow in country construction of a grinder.
7. There was some confusion concerning sending soil samples to US collaborators. The PROINPA team thought PSU wanted 500 g of each soil sample and that samples also

needed to be sent to Dr. Delgado for C and N analysis. I clarified with them that the only samples that needed to be sent were those for Mike Mulvaney at VT.

8. We still need to determine where ICP analysis of the Mehlich3 extracts will be conducted and where total C and N analysis will be conducted. One option might be to send these extracts and soil samples to Ecuador. Another, likely more expensive, option would be to send them to the US (PSU or VT).

Suggestions, Recommendations and/or Follow-up Items

1. As noted by Dr. Gallagher in his report, we need to continue to interact with our PROINPA collaborators to ensure that the experimental designs and soil sampling and analysis are being implemented as discussed. Soil sampling and in particular, soil analysis, is new to the PROPINPA staff and they want to do things right. Although they are capable and eager learners, they will need to rely on the experience of US collaborators in the beginning stages of this project.

2. Our SANREM team as a whole (VT, PSU, Ecuador, Bolivia, Delgado) needs to figure out how certain soil analyses, in particular ICP analysis of Mehlich3 extracts and total C and N analysis of soil samples, will be accomplished. Options would include developing the infrastructure at PROINPA, sample exchange between INIAP and PROINPA, or sending samples to PSU, VT or ARS (Delgado).

3. February, 2011 would be a good time for one of our team members (likely Dr. Gallagher) to make a return visit to PROINPA. In addition to facilitating the above two points, this trip should also seek to accomplish the following:
    a. Monitor progress on experiment implementation and soil sampling and analysis, and work with PROINPA staff to address any problems or issues they are facing.
    b. Initiate NH_4^+ and NO_3^- analysis using the microplate reader. This will require bringing and installing a 650 nm filter, bringing the needed chemicals noted above, and teaching the PROINPA staff the methodology.
    c. Bring any needed parts and construct a roller grinder.

Appendix 1: Log of Activities

Saturday, November 20, 2010

Departed Grand Rapids for La Paz Bolivia via Chicago and Miami. Checked one box containing a controlled temperature water bath, 3 lab reagents, and supplies to construct a soil moisture tension table.

Sunday, November 21, 2010

Arrived in La Paz, but due to airplane mechanical problems in Miami and a hurried last minute switch to a different airplane, the checked baggage did not follow. Proceeded to Cochabamba after arranging for checked box to be sent on to Cochabamba when it did arrive. Arrived in Cochabamba at 8:30 PM, met by Ruben Botello and Oscar Gutierrez of PROINPA.

Monday November 22, 2010

Met with Ruben Botello, Ana Karina Sevarda, and Oscar Gutierrez of PROINPA to discuss the week's objectives and agenda. Discussed additions needed to the K_{sat} apparatus to allow multi-day maintenance of constant head water levels on the soil cores and materials needed to do that. Went into town to purchase those materials and then drove to visit the four experiment sites where the primary and satellite experiments will be established. Sites range in elevation from 10,500 to 12,600 ft. Rains which normally begin in October in this region of Bolivia have still not materialized. Attempted to collect some intact soil cores, but because the high silt content soils are extremely dry they have no cohesiveness and fall out of the core like powder. We discussed options for sampling if rains do not come soon. PROINPA staff decided they would apply water to the soil to moisten it the day prior to sampling. Baseline sampling will begin in December.

Tuesday November 23, 2010

Spent most of the day working with Ruben on adding the water trough for maintaining constant water head on soil cores via siphon connection to the cores. Another problem with the device as constructed was that too much water flowed between the soil core sleeve and the PVC pipe core container. After email consultation with Dr. Robert Gallagher and Dr. Jack Watson, soil physicist at Penn State, decided to modify core collection protocol to collect 12 cm deep cores rather than 15 cm deep cores. This will allow us to utilize the plastic core sleeve to maintain a 3 cm water head rather than the PVC core holder. It had rained during the night in Cochabamba which allowed me to practiced collecting intact soil cores with Oscar. We discovered that the intact cores collected with Giddings soil corer were approximately 2 mm smaller in diameter than the plastic core sleeve they were inserted into. This results from a slight flare on the interior side of the sampling bit and the interior diameter of the entire sampling bit being slightly smaller than the plastic core sleeve. The resulting gap presents numerous problems for measuring both initial water infiltration rate and K_{sat} due to water flowing rapidly down the sleeve/soil core interface. Due to the high silt and low clay content of the soils we are working with, core saturation with water (required for K_{sat} determination) gave insufficient soil expansion to seal the

gap. Over the next 24 hours I consulted with Dr. Jack Watson and Dr. Rob Gallagher on possible solutions to this problem.

Wednesday November 24, 2010

We decided to test sealing the soil core/sleeve gap by carefully filling the gap with dry, ground soil, then lightly tamping the dry soil without disturbing or compacting the intact soil core. The initial water infiltration rate test we hoped to conduct must be conducted with cores at an "as sampled" moisture content. We attempted this test on a sealed gap core, but when water was added to the soil core surface it would rapidly flow down the core/sleeve interface and erode away the added dry soil, making it impossible to determine time to ponding, and also damaging the core for subsequent tests. The initial infiltration test (time to ponding) also requires delivery of water to the surface of all 6 cores in the apparatus at the same rate and a constant rate. We were unable to accomplish this with the apparatus as constructed. Given these problems we decided to abandon the initial infiltration test. Testing K_{sat} requires the use of a water saturated core. Adding dry soil to the sleeve/soil interface, followed by core saturation resulted in an effective seal for determination of K_{sat}.

I spent much of the afternoon conducting a step-by-step review of soil sampling and all soil analysis protocols with Ana Karina and Oscar.

The checked luggage box finally arrived at Cochabamba airport. Ruben picked it up and delivered it to PROINPA in the afternoon. He immediately began construction of the soil moisture tension table. We also completed installation of the water trough on the K_{sat} apparatus and conducted a successful initial test of the siphon system for maintaining constant water head.

Thursday November 25, 2010

Ruben completed construction of the moisture tension table and completed construction of the water circulation system for the K_{sat} apparatus. I spent much of the day working with Giovanna Prata (PROINPA staff who runs a soil microbiology lab). We reviewed availability of needed reagents and located lab equipment (glassware, pipettes, balances, shakers, etc.) to conduct all of the soil testing procedures. Several reagents needed to analyze NH_4^+ and NO_3^- in KCl extracts using the microplate reader are not available in Bolivia and will need to be brought there by whoever next travels to Cochabamba from the US. The plate reader in use at PROINPA is not capable of measuring absorption at 650 ηm, as required for the nitrogen procedures. I recorded the instrument make and model and will search in the US for needed filters to allow operation at 650 ηm. We conducted a step by step review of equipment calibration, reagent preparation and storage; soil extraction, shaking, filtering, drying, and storage using available laboratory equipment; and laboratory QA/QC procedures. We initiated overnight tests of both the K_{sat} and the tension table devices.

Friday November 26, 2010

The overnight runs of both K_{sat} and moisture tension table were successful. We practiced protocols for measuring K_{sat} water flow, and transferring cores from the K_{sat} device to the

moisture tension table. We practiced removing, weighing, and replacing cores on the moisture tension table and successfully tested tensions up to 70 cm. PROINPA staff will continue testing and attempt tensions up to 100cm.

Working with Ana Karina and Oscar I set up a system for assigning sample ID numbers and for sample tracking and data recording for each analytical protocol. Discovered there is some confusion about where/who will conduct which soil or soil extract analysis, and quantities of soil to be sent to VT, Penn State, and USDA/ARS (Delgado). This needs to be clarified among all project collaborators.

Met with Ruben, Ana Karina and Oscar to review satellite experiments they plan to conduct in conjunction with the main experiments at each location. These satellite experiments will utilize a similar cropping sequence at the main experiment but treatment variables will be fertility levels and addition of *Bacillus subtilus*, for its P solubilizing potential. We discussed possible experiment designs. I will discuss these with R. Gallagher upon return to US and communicate our opinions with PROINPA staff. Also discussed another experiment PROPINPA staff wish to conduct focusing on reduced cultivation and mulching production systems for both indigenous and bred varieties of potato. I will also discuss this experiment with R. Gallagher upon my return to US and communicate our opinions with PROINPA staff.

Departed Cochabamba for La Paz at 8:00 PM.

Saturday November 27, 2010

Departed La Paz for Miami. Overnight in Miami.

Sunday November 28, 2010

Departed Miami for Grand Rapids, MI via Chicago. Drove to State College from Grand Rapids.


Detail of K_{sat} device showing maintenance of constant water head on intact soil cores via siphon tubes from constant water level trough.


View of completed K_{sat} device on left and completed soil moisture tension table on right. Tension table is shown with a single soil core. It can accommodate at least six cores.