Sustainable Agriculture and Natural Resource Management
Collaborative Research Support Program

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Trip Report: Bolivia

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Purpose of Trip: To evaluate research plots, discuss current and potential collaboration with laboratory directors and interview a potential student

Sites Visited: PROINPA facilities in Cochabamba and in Quipaquipani (Altiplano), and field sites in the Tiraque watershed.

Description of Activities

Field site visits of SANREM/PROINPA research activities were conducted with the perspective of understanding how they contributed to our understanding of conservation agriculture, soil health, and sustainable production practices. Research plots were viewed just prior to harvest. Discussions were strongly directed to developing sustainable production practices for a conservation agriculture cropping system. Since the weather had been particularly difficult, preventing the establishment of three of four research sites, these discussions focused on how to move forward for next year, and how to develop soil health indices for research sites. Numerous conversations with laboratory directors addressed potentials for collaboration. The interview with the potential student was successfully conducted.

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USAID FROM THE AMERICAN PEOPLE

Appendix: Log of Activities

March 14: Travel from U.S. overnight via Miami and La Paz to Cochabamba

March 15: As the principle US pathologist on the Andean SANREM, my first efforts were to review with counterparts the events of the previous summer, and the successes and difficulties that transpired. Firstly, they had designated 4 different areas of the Tiraque watershed to establish Conservation Agriculture (CA) plots that would be planted with the crop sequences agreed upon the previous year. These sites were near communities named San Kayani (the highest), Cebada Jincana, Wayla Puyru, and 15 de Octubre (the lowest altitude). The altitudes ranged from almost 14000 ft to 11,000 ft. Brief discussions with Rubin Botello and Antonio Gandarillas indicated that there had been trouble establishing plantings at the four sites, and we would visit them the next day. We discussed the progress made in supporting plantings with microbes that would sustain the plants through multiple adversities. Discussions with Giovanna Plata and Mayra Claros were centered on their efforts to find plant associated microbes that would support plant health. Mayra had a large collection of phosphorus solubilizing bacteria that she had isolated from quinoa. Quinoa does not have arbuscular mycorrhizae that soubilize phosphates, so this is seen as a promising research direction in a phosphate deficient country. She has also isolated numerous nitrogen fixing bacteria, since quinoa does not support Rhizobium either. Similarly Giovanna has isolated numerous endophytes and ectophytes that are likely to suppress disease in quinoa and faba bean. We discussed screening methods to find the best P and N fixers, and the best epiphytes and endophytes. We proposed that Penn State would support efforts to find isolates that would not overly suppress other beneficial organisms either natural or added in consortia (often called cocktails).

March 16: Giovanna Plata, Rubin Botello, Juan Jose Calisaya, Anna Karina Saavedra and I proceeded to the Tiraque watershed for the day. The 4 research sites had been prepared in October, and then they waited for rains in order to seed the fields. It was a La Niña year with unusual rainfall patterns. Through mid-December, there were no rains, with the first rains in the region occurring Dec. 20. Rains very soon changed to flooding, frequent rains that prevented planting, and washed out those that had been made. The only site with viable plants from the cropping sequence (the rest were largely weeds only) was the 15 de Octubre site, and since these were late planted the plants were stunted and provided less than optimal ground cover. After discussions with Rob Gallagher, Penn State's soils/cropping sequence scientist following his early March trip, the PROINPA staff and I all agreed that only the 15 de Octubre site would advance to Year 2, while the other 3 sites would all be planted to the year one cropping sequences next October.

Collection of chinoa seed stocks before harvest

Farmer fields in the region were visited, particularly those producing fava bean and quinoa. Diseases had developed on both crops, supported by frequent rains occurring during

January-March. Harvest for fava was about 1 -2 months away, while quinoa harvest was just beginning. Key diseases in quinoa were downy mildew (Peronospora) and Ascochyta leafspot, plus Fusarium root and vascular disease, while key diseases in faba were chocolate disease, rust, anthracnose, and Alternaria leafspot. The farm sites we visited were often showing high levels of defoliation that is most certainly caused by infections of multiple pathogens for both quinoa and faba (though they had better plant growth than I expected).

March 17: A meeting was held with Dr. Jose Castillo, particularly to examine the possibility of leveraging SANREM funding to develop a NSF-Gates BREAD proposal. This funding had been attempted in 2009-10 to create a project on metagenomics of altiplano soils and plants but narrowly missed funding because the objectives were a little too lofty and considered to be difficult to attain. After discussions, It was decided to organize a proposal based on quinoa that examined the interactions of multiple beneficial organisms that would be applied to address multiple adversities (soil borne and foliage disease, nutrient deficiencies, insects) evaluating plant genes activated, population dynamics of applied beneficials, and population changes in pests and native plant microflora. This was decided based on the PROINPA team that was available, and the fact that this team and its Penn State partner were beginning to generate data on several of these objectives. It was also hoped that we could establish farmer-based interactions to export the products that were similar to the Moka disease clubs (Banana) in Columbia. Dr. Alejandro Bonefacio (Quipaquipani, central altiplano) would make a fine addition to the team to extract indigenous knowledge and to return the new technologies to end-users.

A meeting was held with Juan Jose Calisaya, who had been identified as a potential M.S. level graduate student funded by SANREM and anticipating an application to the plant pathology program at Penn State Univ. After discussions, it was decided that the best time for him to target his application would be for a January 2012 arrival at Penn State. Acceptable TOEFL and GRE scores should be generated in the intervening period.
A meeting was held with Noel Ortuño who directs the program on symbiotic nutrient absorption and fixation, as well as the program for biological pest control, and the manufacturing (fermentation and marketing) of biological organisms. The first discussions were how to coordinate Penn State's activities between the PROINPA groups under his leadership and to answer our mutual questions of how this might be accomplished. A clarity of process and communication goals, and exchanges of microbial isolates evolved. Rubin Botello the SANREM leader for PROINPA, joined us later, and discussions evolved as to how to develop a baseline index of root and soil health for our CA plots. My discussions indicated that our lead PSU scientist for this was Beth Gugino, who almost immediately sent the Cornell University (plus other collaborators including her's) methods for determining soil health with her interpretations which follow:

> *In general it is assumed that healthier soils will have a large population of non-pathogenic organisms to help carry out functions such as nutrient cycling, decomposition of organic matter, etc. Two methods to measure the relative biological activity of the soil are active carbon and potentially mineralizable nitrogen.*
>
> *Active carbon is a measure of the fraction of soil organic matter that is readily available as a carbon and energy source for the soil microbial community. Active carbon is a "leading*

indicator" of soil health response to changes in crop and soil management, usually responding much sooner than total organic matter content. The soil sample is mixed with potassium permanganate (deep purple color) and as it oxidizes the active carbon, the color (absorbance) is measured using a spectrophotometer.

Potentially mineralizable nitrogen is the amount of nitrogen that is converted (mineralized) from an organic form to a plant-available form by the soil microbial community over 7 days in an incubator. It is a measure of soil biological activity and an indicator of the amount of nitrogen that is rapidly available to the plant.

Both of these measurements do discriminate between non-pathogenic and pathogenic soilborne organisms so we also included a root health assessment bioassay to measure the quality and function of the crop roots as indicated by size, color, texture and the absence of symptoms and damage by root pathogens like Fusarium, Pythium, Rhizoctonia, nematodes, etc. For vegetable production systems, we have used snap bean as our bioassay plant because it is susceptible to many of the soilborne pathogens that we find in vegetable production fields in the Northeast U.S. but a different crop could be used.

These tests are used as part of the Cornell Soil Health Test which is a standardized set of measurements that are used to quantify the physical, biological and chemical properties of the soil in order to identify soil constraints to crop production and aid in the development of a soil management program. The Cornell Soil Health Assessment Training Manual and additional information can also be found on their website at http://soilhealth.cals.cornell.edu. The Manual describes the methodology for each of the soil health tests as well as how to interpret the information and can be downloaded for free (the file is too large to send attached to an email).

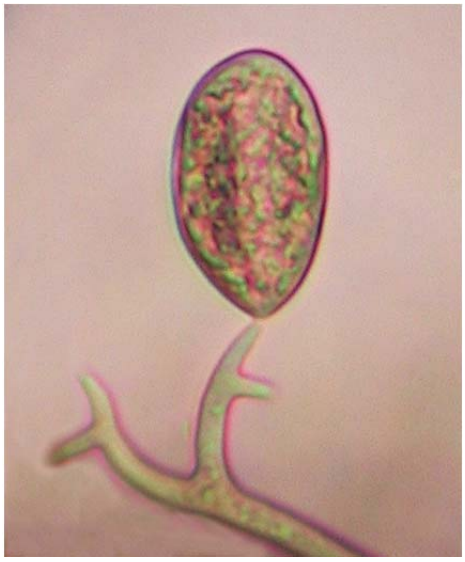
I think that Rubin Botello would have liked something a little more doable in a short timeframe in order that he could present a poster at the SANREM meeting in Virginia Tech. Though I doubt that he can accomplish his goal in this timeframe, it might be possible to accomplish the goal in time for Spring planting in October. Further, these methods might work for other projects currently underway in other SANREM projects.

A meeting was held with Dr. Javier Franco who primarily is a nematologist, though he does work on biocontrol of potato diseases and nematodes. He informed me of his efforts to develop his own lines of mustards that are used as biofumigant green manures like in the US. He wanted a toxic indigenous line that could be used in Bolivia, since US seed were hybrids, and their seed would not have beneficial attributes if saved for planting by farmers. We also discussed his progress on lupins and barley as biofumigant and trap crops respectively for managing potato nematodes.

Calls were made to the US Embassy to determine if the USAID representative (Mr. Roca) would be available on Friday, but he was unavailable, so the day was programmed for a visit to the nearby altiplano.

March 18: Departure from Cochabamba on the first flight, arriving in La Paz (El Alto) at 7:15. I was picked up by Dr. Alejandro Bonefacio who was my host for the day, taking me to the Quipaquipani station of PROINPA. The primary goals were to inform of the advances that were being made in developing quinoa lines that were resistant to multiple pests, but particularly the key pest, downy mildew. On this walking tour of many plots, I was accompanied Dr. Bonefacio

and by Amalia Vargas, a recent BYU M.S. grad, as well as Raul Sarabia, entomologist, who were all diligently adding to the information that was passed to me. The tour of plots revealed that many quinoa breeding lines had advanced to F6, and some were as far as the F9 stage of development. Examination of leaf tissues showed evidence on the same leaf, that resistance was sometimes a mixture of vertical (single gene) and horizontal (multigenic) resistance. They did not seem to have a clear idea of how many races of *Pernospora junceae* that might exist, but clearly there were differentials that pointed towards multiple races. Comparisons to local varieties of quinoa indicated that they were retaining much more leaf tissue on improved lines than on local varieties.



A *Pernospora junceae* spore, the key chinoa pathogene

Another tour focused on quinoa cropping systems. As we saw in Tiraque, the weather can be fickle during the planting season, and thus the researchers at Quipaquipani were diligently planting the subsequent crop before the current crop was harvested. Particularly, they were planting barley between rows of potato when potato was about a month away from harvest. Similarly, they planted vetch among the quinoa stems that were at least a month away from harvest. In both cases, the standing crops protected the emerging seedlings from the harsh environment, and the next plants seemed to be prospering in this protected environment. This system might be emulated at many SANREM sites around the world to assure establishment of subsequent crops.

Chinoa leaf infected by *Pernospora junceae*

Another issue is the drying of quinoa immediately after harvest. Traditional systems stack the stalks in Tepee fashion, while the natural dry climate dries the seed heads down. If it should rain (which it was doing while I was there), they cap the Tepee with plastic to prevent rain penetration that could cause the seed heads to rot. Unfortunately the plastic entraps moisture underneath, and caps are not rapidly deployed. Crop losses occur because of the rot problem. Discussions were held with Ms. Vargas to discuss methods to assess disease resistance on detached quinoa leaves. Particularly we discussed attenuation of pathogen dose, days to first symptom, and rate of expansion of the lesion to determine the r component of a disease progress curve. We also discussed her purchase of a microscope (which I plan to help her with) and haemocytometer so that she can more easily

determine bacteria or fungal spores per ml. Following the plot tours and lunch we (with Raul Sarabia) traveled back to my La Paz hotel for an early morning departure back to the U.S.

March 19: Travel to the US.

List of Contacts Made:

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