Sustainable Agriculture and Natural Resource Management
Collaborative Research Support Program

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Trip Report: Ecuador

21 June – 21 August 2012

Kathleen Webber, Pennsylvania State University

Purpose of Trip: Initiate greenhouse experiment to be run by INIAP Santa Catalina for Webber's Master's degree

Sites visited: Santa Catalina Experimental Research Station, Project sites in Guaranda and Chillanes, Bolívar Province

Description of Activities

Greenhouse experiment plans were discussed and implemented with Soraya Alvarado and Franklin Valverde and several revisions were made to the initial experiment plan. We were able to acquire materials to construct planting containers and set up an initial greenhouse experiment that is expected to last about six months that will evaluate the effect that the placement of lime and fertilizer within a 5x5cm band placed 5 cm below the crop seeds will have on crop production and on the bioavailability of phosphorus in volcanic soils. This will be part of Webber's Master's thesis. A complete description of the greenhouse experiment is appended to this Trip Report.

Shortly after beginning construction we decided to double the size of the experiment by including another more acidic Andic soil from the Santa Catalina Experimental Research Station (referred to as the "Santa Catalina" soil). Initial plans had been to use only the soil from the Illangama CAPS experiment site. No additional funds were necessary to expand the project. We also made plans to follow up this initial greenhouse study with a similar field experiment at Santa Catalina evaluating the success of this technique in the field growing potatoes.

Danny Farías is the undergraduate student hired by SANREM to work with Webber on her Master's thesis. Farías will be in charge of the greenhouse experiment in Webber's absence and perform laboratory analysis on samples and write his undergraduate thesis on the topic.

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Current project sites of the SANREM project in Bolívar Province in both the Illangama and Alumbre micro-watersheds were visited to observe experiments in place and visit the INIAP group working out of Guaranda, as well as to collect over a ton of soil from the Illangama micro-watershed (property of Humberto Paguay) that would be used in the greenhouse experiment at Santa Catalina.

I participated in a Field Day in the Alumbre micro-watershed focused on expanding knowledge about blackberry production, soil conservation, and other topics.

Dr. Soraya Alvarado (INIAP, Santa Catalina) and I began discussions over a joint collaboration on the theme of phosphorus fixation in many acid soils (Ultisols, Oxisols, Andisols) across Ecuador, using the same band treatment, with Dr. Jose Espinosa. Dr. Espinosa used to work at INIAP and now works as Director of Research and Technology Transfer (ITT) at the Universidad Tecnológica Equinoccial (UTE) of Ecuador.

I was able to help run the first sampling period for the greenhouse experiment, performed 15 days after seeding the boxes. Plant height data was measured on the sampling day, and is included for the first period in the Index.

Suggestions, Recommendations:

I plan on returning to Ecuador with Rick Stehouwer for 1 week at the end of the cultivar cycle (November 2012) for final sample collection and analysis, assessment of any missing data, and to begin the process of data reduction and analysis.

List of Contacts Made:

Name	Title/Organization	Contact Info (address, phone, email)
Dr. Soraya Alvarado	INIAP	Spalv2000@yahoo.com
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Local participation in Field Day in Chillanes.

SANREM group at the Field Day

Appendix

Evaluation of the Effect of Liming on the Bio-availability of Phosphorus in Andisols

Kathleen Webber, Richard Stehouwer, Soraya Alvarado

SANREM, The Pennsylvania University, INIAP

Greenhouse Study Problem Statement and Justification

In the High Andes of Ecuador, many soils are classified under the order Andisol, which is well known for its tilth, dark color, and high organic matter content, as well as its high phosphorus fixation capacity, which results from high soil acidity, naturally-occuring amorphous clay mineralogy, and other factors. Farmers producing crops on Andisols in the Sierra of Ecuador struggle with soil phosphorus fertility issues. The potato is a main cash crop for many farmers, and requires very high phosphorus inputs to be productive. Increasing bioavailable phosphorus in soil would increase productivity and improve the quality of life of these farmers.

In order to maximize the effect that phosphorus fertilizers have for potato production in Alto Guanujo, a town in the Bolívar Province, farmers place a band of fertilizer including N, P, K, and micronutrients 5 to 10 cm directly underneath a seed potato. As excess phosphorus applied to the soil in one planting cycle will virtually all be adsorbed to the soil by the next, the band makes economic sense for farmers, and additionally reduces the quantity of other nutrient fertilizers (N, K, etc.) required to produce the crop.

We will design and conduct a preliminary greenhouse experiment to test our hypothesis: mixing lime with the fertilizers that are placed in the band may reduce phosphorus sorption and increase bio-availability of this limiting nutrient. This is a function of the reduction of soil acidity, which causes the release of aluminum from clay minerals, which forms complexes with phosphorus in low pH soils. We plan to measure the bio-availability, crop uptake, and mobility of phosphorus, as well as aluminum, pH, crop yields, and other related components over the course of the growing cycle.

Two soils are available for our preliminary work: one pH neutral soil that comes from Alto Guanujo in the Bolívar Province that has high phosphorus fixation capacity and low soil phosphorus, and one acidic soil that is located in Quito at the Santa Catalina Experimental Agricultural Research Station that has a medium level of soil phosphorus and currently is engaged in a long-term liming study (the soil used in this experiment has never been limed). The soils were collected from the top 0-20 cm and then were screened to 2mm to remove debris and homogenize the soil.

There are four treatments that will be used in a complete randomized block within the band to test our hypothesis (at right), and six replications of each treatment, divided between two designs: one set of boxes will be sequentially sampled to measure soil chemistry changes during a growing cycle, and the other set will be used to measure changes at the end of the growing cycle.

Treatments:	**No Lime**	**Lime**
No Fertilizers	1	2
Fertilizers	3	4

Potatoes can prove difficult to produce successfully in a greenhouse setting, and as we are currently mostly interested in observing the effects lime may have on soil chemistry, barley has been suggested as a suitable test crop. We will still be able to measure biomass, analyse for P throughout the experiment, and treat all conditions as if we were growing potatoes. An added benefit of using barley in the greenhouse is the possibility of actually harvesting the plant after its full growth cycle, which is much harder to accomplish with potatoes. All plating practices will intend to mimic those used to produce potatoes in Alto Guanujo, but barley seeds will be planted at a typical density per INIAP recommendations, and fertilizer rates will be based off of soil test results and INIAP barley fertilization recommendations, and increased somewhat to better observe chemistry changes. Lime rates are based off of the current recommendation created by the Santa Catalina resarch plots, which have been in place for over twenty years. In order to compare the experiments, and observe differences in soil chemistry between the neutral, low P soil and the acidic, high P soil, fertilizer and lime rates will be constant for all treatments. Fertilizer rates are based off the low P soil from Alto Guanujo.

Box Design

The boxes have an inside measurement of 50cm long x 30cm wide x 30cm tall (Figure 1) and one of the 30 cm x 30 cm ends of twenty-four of the boxes are attached using screws so that the end can be taken off the boxes for sequential soil sampling. These same twenty-four boxes will have laminate sheets of Triplex material placed every 5 cm so that they have ten cells of soil for plant growth. All the boxes will be filled with entirely with untreated soil except for a 5 cm x 5cm treatment band placed in the middle of the box at 10 cm depth with or without fertilizers and lime running down the entire length of the middle of the box. A bulk density of ~0.9 g/cm3 will be used for all the boxes, based on data collected from the project site in Alto Guanujo.

For the half of the boxes in each set will be used to develop a chronological sequence of soil chemistry change, the box will be split into ten, 5 cm x 30 cm “slices” with the use of thin board that will be sampled sequentially from a few days into the growing cycle until far along in the development of the plants at harvest when the experiment ends. The boxes will also be used to evaluate the growth cycle of the barley and its production. As samples are taken in chronological succession, plant biomass will be sampled and root patterns will be observed. At these sampling times, which will vary along an expected gradient of soil chemistry change and crop response, visual observations of any soil change and plant growth (including root distribution), soil samples within and outside the treatment band, and plant tissue samples will be collected. Each slice will be sampled along its wide, verticle face at a point inside the treatment band, at points just outside the treatment band, and at points far from the treatment band. Sample analysis will include bioavailable and plant biomass P, calcium, magnesium, aluminum, and iron concentrations, and nitrogen, as well as pH.

The second set of boxes will be harvested at the conclusion of the experiment, when plant biomass will be determined. Final soil and plant tissue samples will be collected and analyzed from these boxes to determine long-term soil and plant impacts of the treatment bands. Soil samples will be analyzed to determine pH, Mehlich-3 extractable P, total P (total P will also be measured at initial stages of set-up), and other indicator elements such as Ca and Al. Plant tissue P content will be measured to determine P uptake.

In addition to the experiment in the greenhouse, we are also interested in comparing results of analysis performed on these two soils based in Olsen, Mehlich-3, and H_2O extractions. Olsen is used in the Santa Catalina Soils Laboratory, but it has a high pH and is better suited for use in calcareous soils. For her Masters work, Webber is interested in using Mehlich-3, as it is intended to mimic plant acids in acidic

soils. Alvarado would like to compare the results of Mehlich-3, Olsen, and H2O extractions, with possible consequences including a shift towards using Mehlich-3 regularly in the Santa Catalina laboratory.

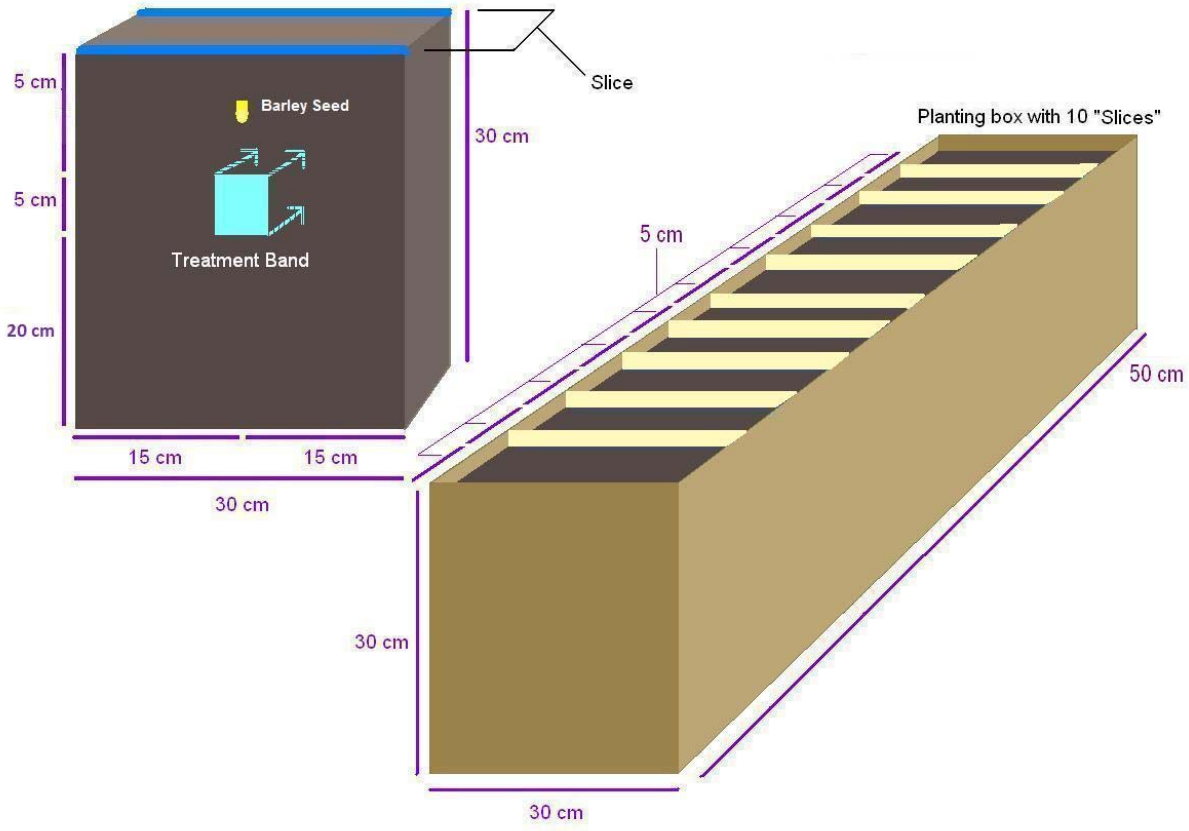


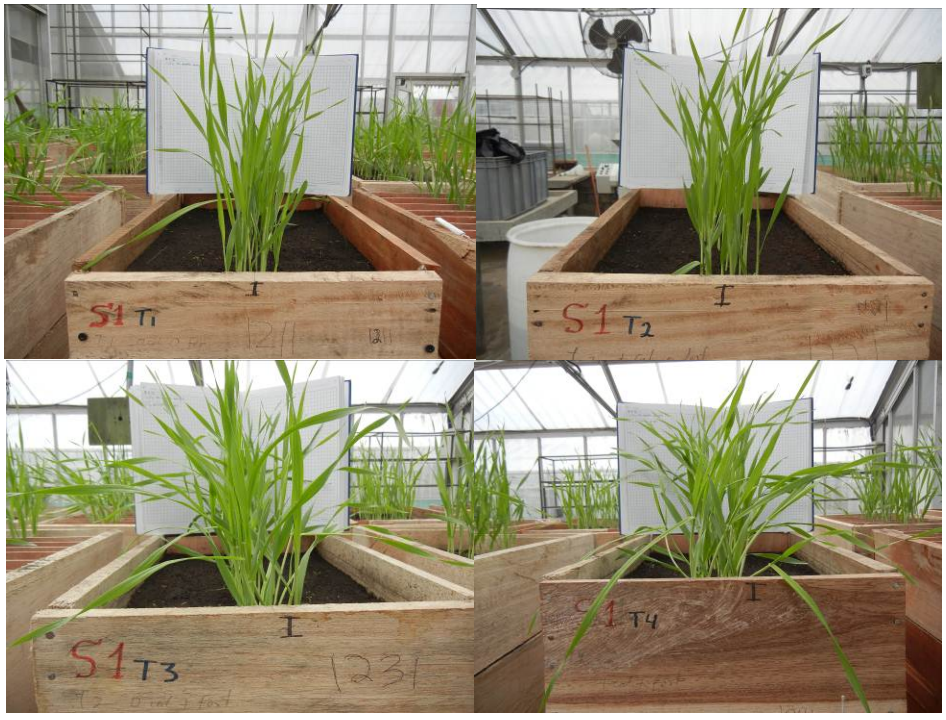
Figure 1: Planting box specifications and slice visual.

Cookie-cutter device made by R. Parra used for sampling greenhouse experiment.

Greenhouse experiment shortly after the emergence of barley plants.

Repetition 1 at Day 37

Repetition 2 at Day 37



Four boxes in one replicate with different band treatments at about 2 ½ weeks of development (treatments are listed in profile above). S1 is Soil from the Illangama Micro-watershed.

	Date of Observation
Treatment ID	8/16/2012
S1T1	upright plants, seem less vigorous, shoots are not very thick
S1T2	upright plants, either with no tillers or just starting to tiller
S1T3	plants seem tall, have lots of large tillers, thick shoots
S1T4	lots of large tillers
S2T1	upright plants, no tillers
S2T2	upright plants but starting to fall over, no tillers
S2T3	either with no tillers or just starting to tiller
S2T4	falling over, few tillers

Visual Observations were made about the quality of vegetative growth on Day 18. It was noted that both treatments containing fertilizer resulted in plants with thicker stems, regardless of the soil that the plants were growing in, than the treatments that did not contain fertilizer. Also, it was noted that the plants that did not have any fertilizer in their treatments were very erect, while the treatments containing fertilizer were falling over. There was also an impact in the amount of tillers the plants were producing. The plants grown in Soil 1 (Illangama Soil), and having treatments with fertilizer all had tillers at Day 18, while those Soil 1, No Fertilizer treatments, and in all the Soil 2 (Santa Catalina) treatments had not tillers.

Type ID	Average Height
S1T1	26.5
S1T2	27.5
S1T3	33.16
S1T4	33.33
S2T1	32
S2T2	31.58
S2T3	34
S2T4	32.83

Plant Height Data

	15-Aug	
Box ID	Plant Height (cm)	# plants
S1T1R1	22	4
S1T2R1	25	4
S1T3R1	33	4
S1T4R1	33	4
S2T1R1	31.5	3
S2T2R1	30	4
S2T3R1	33.5	4
S2T4R1	32	4
S1T1R2	30.5	4
S1T2R2	29	4
S1T3R2	34.5	4
S1T4R2	32.5	4
S2T1R2	33.5	4
S2T2R2	34	4
S2T3R2	35	4
S2T4R2	35	4
S1T1R3	27	4
S1T2R3	28.5	4
S1T3R3	32	4
S1T4R3	34.5	4
S2T1R3	31	4
S2T2R3	30.75	4
S2T3R3	33.5	5
S2T4R3	31.5	4