SANREM CRSP

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Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program

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Executive Summary

The Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program (SANREM CRSP) promotes stakeholder empowerment and improved livelihoods through the discovery, organization, and dissemination of sustainable agriculture (SA) and natural resource management (NRM) knowledge. The approach is participatory, engaging stakeholders at all levels in research problem formulation within priority areas of inquiry, focusing on multiple countries and/or regions to facilitate scaling research findings up and out. Program efforts are competitively driven and organized through a nested landscape systems approach. Gender sensitivity is integral to the SANREM approach and reinforced by gender-sensitive participant training programs that include degree and non-degree plans. All activities link sustainable NRM with the economic concerns of local populations and the promotion of good governance.

Program objectives and strategy

The objectives of the SANREM CRSP program are to:

- increase scientific knowledge and technical innovations in SA and NRM
- improve knowledge management, education, and communication leading to behavioral changes in adaptation and adoption of new SA and NRM technologies and practices
- reform and strengthen SA and NRM governance, policies, and local institutions
- promote the functioning of sustainable resource-based local enterprises in national, regional, and global markets

The majority of SANREM CRSP research is conducted through its Long-term Research Award (LTRA) programs. The SANREM CRSP Phase IV LTRA activities were initiated in 2010 and this annual report describes their accomplishments from October 1, 2011 to September 30, 2012. Each of the projects has established a set of field trials testing their 'best bet' CAPS practices and initial findings are emerging. On-farm and on-station research trials were established nearly simultaneously in most sites. The annual report also reports on progress of the four cross-cutting research activities (CCRAs) dealing with economic impact analysis, gendered knowledge, soil quality and carbon sequestration, and technology networks, and describes the accomplishments of the management entity (ME) during FY 2012.

Training and knowledge dissemination

SANREM CRSP training, publications, and other knowledge dissemination products for the first half of fiscal year 2012 (FY2012) included the following:

- 21 students supported for Ph.D. training (9 women and 12 men)
- 35 students supported for master's training (15 women and 20 men)
- 14 undergraduate students supported (5 women and 9 men)
- 8,814 short-term training participants (4,109 women and 4,705 men)
- 18 refereed journal articles
- 2 books/book chapters

- 12 theses and dissertations
- 3 working papers
- 2 conference proceedings
- 15 papers or seminars presented
- 26 electronic presentations
- 19 posters
- 1 video
- 2 abstracts
- 14 other documents
- 2 websites
- 4 social media outlets

Phase IV Long-term research award activities (LTRAs)

LTRA-6: A Conservation Agriculture Production System Program for the Central Plateau of Haiti

Principal investigator: Thomas Thompson, professor and department head, Department of Crop and Soil Environmental Sciences, Virginia Tech

Project partners: Virginia Tech (lead), Caritas/Hinche, Zanmi Agrikol

The goal of this LTRA is to 1) understand the socioeconomic and biophysical constraints to CAPS (Conservation Agriculture Production Systems) adaptation and adoption in the Central Plateau of Haiti, 2) to design and test strategies to work around those barriers in ways that increase agricultural productivity, and 3) to work with smallholders to discover pathways to adoption. We are focusing on CAPS systems as defined by the FAO that include use of crop rotation, reduced tillage, and cover crop residue.

During the past year, Thompson became P.I. of the project in place of Hodges, who continues in the project. Four team members have traveled to the Central Plateau on five trips during 2012 so far. Meetings carried out in Haiti have strengthened ties with our in-country partners. We have hired a full-time assistant site coordinator, Dilou Prospere. He is an agronomist who graduated at FAMV, State University of Haiti, and will facilitate communication and ensure that in-country activities are properly coordinated. One graduate student (M.S.) involved with the project has graduated from Virginia Tech, and another student continues to make progress toward a Ph.D. We are also recruiting one more graduate student (M.S. or Ph.D.).

Maize was harvested at three experimental sites (Corporant, Lachateau, and Maïssade) during Nov. 2011, and the data were received from our partners. Cover crop and tillage experiments were successfully initiated at the same locations in January 2012. Soil samples were collected from the plots for 'baseline' characterization of soil properties before the experiments were initiated. During May-June 2012, a local maize cultivar was planted into the CAPS plots and yield trials with advanced cultivars from CIMMYT were started in separate plots at the three

locations. Maize will be harvested in Oct.-Nov. 2012 and several cover crops will be re-planted into the CAPS plots. Workshops featuring CAPS techniques and advanced maize cultivars were attended by more than 200 individuals (farmers, agronomists, students) at Corporant, Lachateau, and Maïssade during July 2012. Follow-up work for the 'baseline survey' was conducted during a three-week period during June and July. This survey of >600 households in the Central Plateau is now complete and data are being analyzed.

Significant success has been achieved during the past year in the following:
1) improved communication with our in-country partners
2) timely submission of receipts and invoices
3) implementation of replicated CAPS experiments by our Haitian partners
4) completion of the baseline survey
5) successful and well-attended CAPS workshops

During the next year, we will target continued progress in the following areas as well: 1) timely planting of cover crops in CAPS plots (during rainy season), 2) better cover crop performance and weed control in CAPS plots, 3) earlier maize planting (Mar.-Apr.), and 4) "train-the-trainer" workshops for agronomists and technicians.

LTRA-7: Conservation Agriculture as a Potential Pathway to Better Resource Management, Higher Productivity, and Improved Socioeconomic Conditions in the Andean Region

Principal investigator: **Jeffrey Alwang**, professor, Department of Agricultural and Applied Economics, Virginia Tech

Project Partners: Virginia Tech (lead), Penn State University, University of Denver, U.S. Department of Agriculture Soil Plant Nutrient Research Unit, Instituto Nacional de Investigaciones Agropecuarias (INIAP), International Plant Nutrition Institute, Secretaría Nacional de Ciencia y Tecnología (SENACYT), Universidad Estatal de Bolívar (UEB), Escuela Superior Politécnica del Chimborazo (ESPOCH), Secretaría Nacional del Agua (SENAGUA), Gobierno de la Provincia de Bolívar (GBP), Alcaldía de Guaranda y Chillanes Sistema de Información Geográfica Agropecuaria (SIGAGRO-MAG), Fundación para la Promoción e Investigación de Productos Andinos (PROINPA), Universidad Mayor de San Simón, Centro Regional Avaroa, Sindicato Agrario Tiraque, and Alcaldía de Tiraque

This project tests the concept of conservation agriculture (CA) for smallholder farmers in high-altitude, fragile areas of the Andean Region (Ecuador and Bolivia). As the concept continues to be tested and successful conservation agricultural production systems (CAPS) are identified, the project will diffuse the CAPS to project areas and other sites. The research evaluates CAPS impacts on: soil health and productivity, farm incomes and their variability, food security, gender relations and other social considerations. CA trials have been established in Ecuador and Bolivia, and we now have preliminary results from both sites. These results show the

promise of CA: in most cases CA treatments have equal or higher yields, lower costs, and positive impacts on soil health. Trials in both countries are well under way and we have finished two planting cycles in Ecuador and one first complete cycle in Bolivia.

In the upper (Illangama) watershed in Ecuador, potatoes are the main staple, and agricultural productivity is constrained by poor soil conditions and erratic rainfall. The lower Ecuador watershed (Alumbre) is characterized by warmer temperatures, predominance of maize and beans, very poor soil quality, low and declining productivity, low incomes and high poverty. The site in Bolivia is a high-altitude area with low productivity, poor soils, and characterized by predominance of potatoes mixed with small grains and tubers. SANREM researchers have built a strong base of collaborators among local stakeholders and identified a number of agricultural technologies with potential for incorporation in the CAPS. We now are: (i) using established research designs for on-farm CA experiments; (ii) continuing baseline evaluations of soils and socioeconomic conditions; (iii) collecting cost and economic information from our experiments; (iv) working collaboratively with partners who now have functioning soils laboratories in both countries, each of which benefited greatly from interactions with SANREM scientists (particularly those from Penn State); (v) using a nitrogen index tool calibrated for conditions in the Andes so thatfarmers and technicians are able to better evaluate and manage soil fertility; and (vi) solidifying networks between researchers and other stakeholders to facilitate research and generate local buy in.

Our field research continues to be ongoing as plots are established on farmer fields and we enter the new agricultural cycle. In both sites, the principal planting periods occur in September-November. Plots have also been established for erosion trials. During the prior SANREM phase, we examined the relationship between management practices and erosion on small-scale erosion trials. We have altered these trials to reflect our most-likely CAPS and we are using them to measure erosion under different CAPS alternatives. Along with the CA work, we have field trials and laboratory experiments to examine production costs of biological agents for pest and disease control and to stimulate plant growth.

Editorially, we have taken advantage of our prior SANREM research and published several refereed journal articles on: market access and gendered decision making, impacts of access to cellular telephones on potato market choice, biological control of plant diseases, and diversification over space as a means of mitigating agricultural risks. A special edition of the research journal Revista de Agricultura (Bolivia) devoted an issue to SANREM research; this refereed publication included ten articles on different dimensions of our research. We have two additional articles under review at refereed publications (Trimestre Económico and Food Policy). We have also identified research with the potential for publication where additional work was needed.

Our training program has proceeded according to plans. We have one male and four female long-term graduate trainees who have started their programs at U.S. universities, and have worked with our partner institutions to identify long-term training needs. We are involving

undergraduate honors students from the host countries to assist in the research. These young professionals are being trained in soil evaluation and other laboratory techniques, field experiment design, project administration, and collaboration with multiple stakeholders. This capacity strengthening represents a major output of the project. We have completed a number of important short-term training exercises.

We have established important networks between participating scientists, our research team and local stakeholders. All participating U.S. scientists have established primary contact points with host-country researchers and are now engaged in collaborative research. An example of such collaboration is the training exchange that recently occurred between Dr. Delgado and the Ecuador and Bolivia research teams. In addition to scientific networks, each of the host-country teams has taken steps to build networks with local stakeholders. In Ecuador, a partnership has emerged between the research team, the Bolivar Provincial government, the Guaranda city government, the local university (where Carlos Monar, former SANREM researcher is now an academic dean) and local governments and farmer groups. We have established seven model farms where ongoing research is conducted. Neighboring farmers visit these farms for informational purposes or to participate in research activities. In Bolivia, linkages between local farmer groups and the Tiraque municipal government have been solidified. In both countries, our teams have conducted informational meetings with USAID and other stakeholders.

LTRA-8: Improving Soil Quality and Crop Productivity through Farmers' Tested and Recommended Conservation Agricultural Practices in Cropping Systems of West Africa

Principal investigator: P.V. Vara Prasad**,** associate professor, Department of Agronomy, Kansas State University

Project Partners: Kansas State University (lead), Savanna Agricultural Research Institute (SARI), Wa Polytechnic, Institut d'Economie Rurale du Mali (IER)

Due to restrictions of USAID operation in Mali, activities were suspended in March 2012. Results of experiments harvested in 2011 will be reported when restrictions are lifted and data are summarized.

Soils in northern Ghana generally have low soil fertility and low soil organic carbon. Similarly, productivity of food grain crops in this region is low due to several biophysical and socioeconomic conditions. Therefore, there is a need for development of improved and efficient crop management practices included in sustainable and intensive conservation agricultural production systems (CAPS).

We evaluated several crop, soil and water management practices in farmer's fields (both long-term mother tests with multiple treatments; and short-term baby tests with selected components of CAPS by farmers). Our research has shown that with improved fertilizer and water management practices, minimum tillage produced similar yield to those of conventional tillage

in most tests. Similarly, sole crops of maize or soybean produced greater maize grain and stover yields than intercropping in conventional tillage or minimum tillage. In a few test locations, conventional tillage produced higher grain yield mainly due to ineffective weed control. This suggests a need for optimization and development of efficient weed management practices. Among various nutrient management practices, application of compound fertilizer (NPK, 37:16:31 kg/ha, respectively) or application of inorganic P fertilizer only (26 kg P/ha) produced similar and significantly higher yields of maize and soybean yields compared to the no fertilizer control under all tillage practices. Soil and water management practices significantly influenced grain yield of maize. Planting crops on tied ridges produced significantly higher grain yield than planting on flat beds either with or without strips of grass or *Gliricidia* strips in all locations. These results confirm the research results from the previous year at these locations. Overall, these results suggest opportunities for developing appropriate tillage, weed and fertilizer management practices, and soil and water conservation practices.

Networking activities were initiated within the Upper East Region with SARI and additional contacts were made with University of Ghana (Accra), University of Developmental Studies (Tamale and Wa), Africa RISING program of IITA (International Institute of Tropical Agriculture), ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), AGRA (Alliance for Green Revolution in Africa) and FARA (Forum for Agricultural Research in Africa).

LTRA-9: Developing Sustainable Conservation Agricultural Production Systems for Smallholder Farmers in Southern Africa

Principal investigator: Neal Eash, associate professor and soil scientist, Department of Biosystems Engineering and Soil Science, University of Tennessee (UT)

Project partners: University of Tennessee (lead), National University of Lesotho, Global Conservation Agriculture Program, Centro Internacional Para el Mejoramiento del Maíz y el Trigo (CIMMYT), Growing Nations

The Southern Africa Conservation Agriculture Production Systems (CAPS) research and extension program is completing its third year of the five year program. Since October 2011, we have upscaled our efforts in Lesotho and Mozambique with an increased emphasis in Mozambique due to its inclusion in the Feed the Future initiative. In Lesotho, some upscaling has occurred but there was a calculated shift of effort to Mozambique in direct response to the priorities outlined by USAID. However, Lesotho has had a second consecutive dismal production year, with countrywide crop failures again, this time due to a record dry season. Recent reports suggest that up to 40% of the population may experience famine until the next harvest in May 2013. In Mozambique, we are upscaling research and demonstrations in both the Manica and Sofala provinces.

We are also exploring possibilities for CAPS with soya bean in Nampula province, as this region is considered a high priority for USAID Mozambique. Ox-drawn planters and planting hoes were purchased for both the Mozambique and Lesotho projects.

Again, in spite of the extreme weather conditions in Lesotho, the stability of the conservation agriculture systems developed during this project stood the acid test of extreme weather events as record yields in maize were obtained in both on-station and on-farm trials and demonstrations alike. We found during our visit in July 2012 that yield averages ranged from 6 to 7 tonnes per hectare against the backdrop of reported disastrous crop failures nationally in the same period and regions of project operations.

During the July 2012 visit, PI's met with project collaborators, discussed project progression with actors in the local supply chain, and developed a list of priorities for further upscaling on-farm demonstrations. Dr. Marake has developed a plan for upscaling farm level activities in the 2012-2013 season that includes leveraging collaborative links with the Lesotho Ministry of Agriculture and Food Security and NGOs, especially World Vision International in Lesotho. Research efforts during the 2011-2012 season focused on understanding the factors determining maize yield in Lesotho and continued to refine agronomic performance of the CA systems analyzed as a function of planting date, plant population, fertilizer rate, and weed management. Two M.S. graduate students from the University of Tennessee participated in these research efforts, and also managed on-going carbon analysis and fertilizer calibration/management studies. The students presented their work at the ASA meetings in San Antonio, Texas (October 2011) and one has completed her thesis with the other thesis defense scheduled in October 2012. Two Basotho, two Mozambicans, one Kenyan, and two U.S. students have also been recruited and began studies in 2012.

A number of field days and workshops (18) were held at Maphutseng, Lesotho by project cooperators to highlight the work that is being conducted on conservation agriculture. In Mozambique, our cooperators hosted 44 field days and numerous workshops (details on Form 17) that were well attended by extension personnel and local farmers. Overall more than 4,500 farmers participated in trainings organized by this project. The field days were attended by representatives from various UN organizations including the FAO and UNDP, Ministry of Agriculture and Food Security, and other NGOs. In Lesotho, considerable dialogue occurred with the Honorable Michele Bond, US Ambassador to Lesotho, regarding ways and means to upscale our CA research and outreach given the extent of the food shortage in Lesotho in the 2012 harvest season.

Baseline household surveys were completed in the Butha-Buthe district (northern Lesotho) in 2010. Figure 2 (see project details) suggests that field-level labor appears to be pretty evenly mixed between males and females. Table 1 (located in project details) indicates that the distance to CA fields is much less than those who use conventional tillage. This may suggest that as farmers move from extensive agriculture— where they farm more land area—to more intensive agriculture, they are able to move to smaller plots closer to their residence. This is an important

point because more timely management of plots may further reduce labor demands due to the greater effectiveness of those activities. Survey respondents also indicated that planting dates were timely and followed the early rains in November. This survey data is currently being analyzed and will be included in upcoming publications. The baseline survey for Mozambique was completed in early 2012. Approximately 535 households completed surveys in northwest and west-central Mozambique and this data is currently being analyzed for inclusion in upcoming publications.

In year 4, we plan to further upscale our work in both Lesotho and Mozambique. In Lesotho we continue to work with August Basson and Jaap Knot (Growing Nations, Maphutseng), 'Malehana Mafisa (World Vision Lesotho, Mohale's Hoek District) and Dr. Marake. In 2012 nearly 80 on-farm comparisons were completed evaluating the use of fertilizers and cover crops throughout the Mohale's Hoek area. These on-farm demonstrations will be continued in year 4. In September, we again met with our Mozambique counterparts and participated in research and demonstration planning for the ongoing CA work there. The PI's met with representatives from USAID-Mozambique to discuss current and future activities.

LTRA-10: Development and transfer of conservation agriculture production systems (CAPS) for smallholder farms in eastern Uganda and western Kenya

Principal investigator: Jay Norton, assistant professor of soil fertility, Department of Renewable Resources, University of Wyoming

Project partners: University of Wyoming (lead), Makerere University, SACRED Africa, AT Uganda, Moi University, Manor House Agricultural Center (MHAC)

During year 3 of the project, we remained on schedule in implementing objectives 1, 2, 3 of our CAPS development and implementation initiatives in Kenya and Uganda. For objective 1, large stakeholder advisory groups developed during year 2 actively participated in on-going research work and demonstrated excellent understanding of this work by taking turns to accurately describe every step of research establishment, management, and basic data collection, including timing of these activities, during the Reflection and Training Workshops held in November, 2011. Building upon the advisory committees constituted at the beginning of the project, social network analysis (SNA) feedback workshops in February 2012 facilitated by Research Associate Lamb provided additional contacts that will be very important in the processes of adoption and/or scaling up of CAPS. These workshops shared research results from previous SNA work and explored strategies for promoting CAPS in the region. Under objective 2, Reflection and Training Workshops revisited training on erosion and soil depletion processes as caused by conventional tillage practices and reviewed CAPS and CA definitions and processes. SNA feedback workshops also provided an excellent forum for exchange of information on stakeholders' understanding CAPS concepts. Four prototype multifunction implements (MFIs) designed by a U.S. engineer to increase the efficiency of minimum tilling operations were shipped to East Africa in March and September 2012 and tested with oxen and donkeys in both

countries. Tests revealed that the MFI exceeded expectations and will be playing a key role in all future CAPs operations. Under objective 3, we collected agronomic data and second phase soil samples, and successfully prepared and planted each of our nine treatments at each of the 20 study areas for the second phase implementation of the study. Preliminary agronomic data, suggesting that intensive tillage practices in Uganda may not be as necessary as generally believed, were shared among stakeholders. The six Kenyan and Ugandan graduate students involved in the project have all taken active roles in each stage and will visit all the sites and participating farmers frequently.

LTRA-11: Sustainable Management of Agroecological Resources for Tribal Societies (SMARTS)

Principal investigator: Catherine Chan-Halbrendt, professor and chair of the Department of Natural Resource and Environmental Management, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa

Project partners: University of Hawaii at Manoa (lead), Local Initiatives for Biodiversity, Research, and Development (LI-BIRD), Orissa University of Agricultural Technology, Institute of Agriculture and Animal Science (IAAS) of Tribhuvan University

In India results from both on-station and on-farm trials showed that maize yield in conventional tillage and minimum tillage with or without intercropping were similar. Results from on-farm trials showed maize yield with minimum tillage plus intercropping was significantly better than conventional tillage with intercropping. From a financial perspective, only maize + cowpea under minimum tillage had higher profitability (9.7%) than the control of sole-maize under conventional tillage. It was too early to see any significant effect of treatments on soil properties, but minimum tillage with intercropping in the rainy season followed by horse gram as a cover crop in post-rainy season conditions showed a positive trend on bulk density, organic carbon and nutrient availability.

In Nepal, results from on-farm trials showed the yields of maize and cowpea under sole-crop and intercrop with millet under conventional tillage and strip tillage were statistically not different, but yield of millet in sole-cropping was higher than in intercropping. The biomass yield in terms of Land Equivalency Ratio (LER) from sole maize/millet + cowpea intercropping with conventional tillage was significantly higher than sole cropping. Development workers and researchers preferred sole maize/millet + cowpea intercrop with strip tillage to all other treatments in terms of the potential for improving income. This met their expectations, as millet + cowpea with strip tillage is the only treatment that includes two of the three CAPS principles. Hyrkrang and Thumka villages ranked sole maize -cowpea with conventional tillage much higher than other CAPS, suggesting that the perceived advantages of intercropping or strip tillage have not been communicated well to the farmers. Profitability analysis showed profitability of millet + cowpea was about $520 per ha and year higher than sole-millet.

Soil samples collected in Nepal from the plots before putting in CAPS trials (baseline) have been analyzed. Large differences were noticed regarding soil nutrients across different villages. The results indicated significant differences between villages for nitrogen content, available phosphorous, available potassium, organic matter, bulk density and porosity. One parameter that was similar across all villages was soil pH.

The data on gender roles and functions on agriculture system in Nepal have been collected through household surveys in about 50 % households. Preliminary results show that men and women tend to share the burden of agricultural labor, however, the control over agricultural decision-making and sales of crops tends to be somewhat imbalanced. On average, the women surveyed only felt some control over decision making related to the adoption of new agricultural practices, while control over land use decisions was considered as almost equal between the male and female. Women participate in a large proportion of household and agricultural activities; nevertheless wage earning and market sales remain predominantly male-dominated activities. In terms of community inclusion of women, 7% of women engaged in community leadership roles and 15% participated in savings groups. Since both men and women share the burden of agricultural labor, yet women disproportionately maintain household activities, the labor implications of CAPS treatments must be considered to ensure a balanced and feasible shift of labor demands for each gender.

Overall, 555 males including 174 females were in short-term training programs and 114 males including 50 females were in long-term training programs. Long-term trainings included farmers involved in the trials, students and research fellows, professors and project staffs in the host country.

The results from the research were disseminated through three posters and one oral presentation at the CTAHR Research Symposium in 2012 at the University of Hawaii. Results of a fuzzy cognitive mapping exercise comparing farmers' mental model of CAPS with researchers' mental model and papers analyzing data of two AHP exercises, one each from India and Nepal, were presented at the 22nd IFAMA Symposium in Shanghai, China. One paper entitled "Comparative Economic and Gender Labor Analysis of Conservation Agricultural Practices in Tribal Village in India," was published in International Food and Agribusiness Management Review. Moreover, about five working papers are being drafted which are expected to be finalized by December 2012, and submitted to refereed journals.

LTRA-12: Conservation Agriculture for Food Security in Cambodia and the Philippines

Principal investigator: Manuel R. Reyes, professor, biological engineering, North Carolina Agricultural and Technical State University (NCA&T)

Project partners: North Carolina Agricultural and Technical State University (lead), U.S. Department of Agriculture-Natural Resources Conservation Service East National Tech Support Center, Royal University of Agriculture of Cambodia, Centre de Cooperation International en Recherche Agronomique pour le Développement (CIRAD), University of the Philippines-Los Baños, Landcare Foundation of the Philippines

Year 3 progress demonstrated potential of conservation agriculture production system (CAPS) for food security in Cambodia and the Philippines. In Cambodia, Year 3 results showed increasing yield of maize in CAPS compared with decreasing yield of maize grown in plow-based system. The gross profit margin of CAPS was less than plow-based in years 1 and 2, but greater than plow-based by Year 3. Furthermore, there was severe rain deficit during the first part of the 2012's cropping season and farmers saw that CAPS are more resilient to drought compared with plow-based systems. There was a doubling of CAPS pilot extension participation from 31 families on 59.5 ha in 2011 to 61 families on 149 ha in 2012 in two villages. In addition, spontaneous extension happened in a third village, where five families which adapted CAPS and purchased CAPS seeders for 75 additional hectares.

In Cambodia, two CAPS farmer organizations (FOCAPS) were formed. FOCAPS were trained to weekly monitor market price of maize and grow cover crops for seed production. FOCAPS members have clearly expressed their preference for the cover crops *Cajanus cajan* and *Vigna umbellata*, to replace the first introduced and poorly performing cover crop *Stylosanthes guianensis.* Contracts were agreed upon and signed between FOCAPS and Seed Asia for a six-month maize seed purchase credit. The initial plan for improved credit access by connecting the bank system with FOCAPS through a production contract with a buyer did not materialize since FOCAPS membership was still small. In 2012, as well as 2010 and 2011, most inputs in pilot extension have been pre-financed with PADAC's cost-shared internal revolving funds. This situation may undermine the self-financing capacity of the pilot extension program in 2013 and 2014, since PADAC operations end March 2013.

In the Philippines, Year 3 maize grain yields with CAPS treatments were generally the same as the plow-based system. Maize + *Arachis pintoi* showed highest total biomass among the five treatments with maize as main crop. The association of cassava with *Stylosanthes guanensis*, however, ranked first in total biomass compared with five other treatments with maize as main crop. S*tylosanthes guanensis* and *Arachis pintoi* were found to be promising legume cover crops. General comparisons of five CAPS treatments with the plow-based treatment indicated possible signs of soil quality improvement under CAPS as: a) soil organic matter at the top 5 cm was higher in CAPS than in plow-based system; b) CAPS organic matter in the top 5 cm increased

from 2010 to 2012 by about 0.6% while plow-based organic matter decreased by about 1.5%; c) soil pH at the top 5 cm was higher in CAPS than in plow-based systems with pH from CAPS increasing and pH from plow-based systems decreasing from 2010 to 2012, and d) CAPS residual soil moisture contents were significantly higher than residual soil moisture content of plow-based system. Simulation results based on DSSAT-CERES Maize crop model showed that maize yield would increase by as much as 10% under CAPS and decrease by as much as 29% under plow-based system. Solute transport model simulation showed that peak solute concentration would decrease and the time-to-peak would be delayed under CAPS which suggests that soil nutrients from fertilizers would tend to be retained at a relatively longer time under CAPS than plow-based systems thereby maximizing nutrient uptake by crops under CAPS.

Several small experiments were conducted testing vartiants of NPK (nitrogen, phosphorus, and potassium). First, in an NPK omission experiment, we found that no application of N resulted in the reduction of maize yield up to 67%, omission of P resulted in a 59% yield decrease, and omission of K caused a 21% yield reduction. The results suggested that N is the most limiting nutrient, followed by P and K. Second, in an NPK addition experiment we found that the optimum rate of N application was 120 N kg/ha, and P optimum rate was 20 kg/ha. Third, different varieties of "Adlai" (*Coix lacryma-jobi* L.) were evaluated. Adlai which belongs to the family of grasses, the same as wheat, maize, and rice, is a very promising crop because of its potential as food and feed sources and possible also because of medicinal properties. We found that Kiboa variety produced the highest grain yield and total dry matter yield, followed by Ginampay, and Tapol.

Our results showed that Adlai grass has a huge potential for CAPS in sloping degraded acid upland soils which are prevalent in many parts of the Philippines as well in many Southeast Asia countries. Fourth, we evaluated different cassava *(Manihot esculenta* Crantz) cultivars. We found that Rayong 72 cultivar from Thailand yielded highest both in fresh roots and aboveground biomass, followed by VISCA 4 which was bred from Visayas State University (VSU) in the Philippines. Other promising varieties were Lakan and local yellow gold.
A socio-economic survey was completed which indicated that most farmers in Claveria planted two crops of maize annually with some growing vegetables in rotation with maize. About 94% of the population are earning below the poverty threshold level with 52% of farmers having farm sizes less than one hectare of which 80% is sloping land.

There were problems again in farmer-managed experiments. Some changes were done in the set of farmer cooperators since some farmers plowed and some gave up participation in the study. With funding from SANREM and several other international agencies and partnership from several Philippine institutions, a Conservation Agriculture with Trees (CAT) center is being established at SANREM's researcher-managed site.

Three Ph.D. students are supported by SANREM: one each from the U.S., Cambodia and the Philippines. They are studying at North Carolina Agricultural and Technical State University

(NCA&T). In addition, SANREM is supporting two Ph.D. students studying in the Philippines and supported two recent M.S. graduates who completed degrees in the Philippines as well. The French research agency, CIRAD, organized the Third International Conservation Agriculture Conference in Southeast Asia to be held in Hanoi, Vietnam, December 2012 and SANREM is a co-sponsor. SANREM will organize the Fourth International Conservation Agriculture Conference in Southeast Asia, at the University of Battambang, in Battambang, Cambodia, in December 2013. Numerous opportunities for networking took place including a joint field day with the Chief of Party and agronomists of USAID-HARVEST multimillion dollar program in Cambodia together with SANREM director and representatives of the US-Thai seed company Seed Asia.

From SANREM phase III, three books about vegetable agroforestry systems were published and launched in Indonesia and the Philippines. In addition, a Soil and Water Assessment Tool (SWAT) workshop was held in Bogor, Indonesia June 2012 and the third International SWAT conference in Southeast Asia will be held in Bogor, Indonesia June 2013. SANREM phase III was instrumental in extending SWAT in Southeast Asia and SANREM IV is still a partner as well.

As a spin-off, CAPS experimental studies for urban home vegetable production funded by the United States Department of Agriculture and the Environmental Protection Agency has been set-up at the campus of North Carolina Agricultural & Technical State and in campuses of four high schools, a middle school and an elementary school. We will be providing experiential training to K-12, especially high school students; undergraduate and graduate students and integrating CAPS, biomass, crop yield, and soil quality concepts learned from SANREM into the urban garden.

Phase IV cross-cutting research activities (CCRAs)

CCRA-6: Economic Analysis and Impact

The focus of the Economic Impact CCRA this year was collaboration with each of the regional LTRAs to compile a standardized data set that will eventually permit an overall economic impact analysis of SANREM Phase IV. This activity first fills the need to assess the profitability of the Conservation Agriculture Production Systems (CAPS), as that will likely affect their adoption and spread in the study regions. A uniform enterprise budget form was developed and distributed to the regional LTRAs, and the linear programming approach developed the previous year was shared with regional projects (South Asia, West Africa) that expressed an interest in the method. All regional projects were contacted in the effort to combine, summarize, and compare input cost and yield data for the experimental conservation agriculture practices and systems being investigated.

Economic barriers to CAPS adoption include genuine and perceived risks associated with transitioning to a new cropping system as well as increases in short-term input costs. These economic costs, combined with eventual yield gains and other potential benefits of adoption, will determine the success or failure of the CAPS being developed and implemented through SANREM. It is essential to identify, analyze, and compare these economic costs and benefits to help assess the long-term viability of CAPS. CAPS budget data collected in the regional programs will be combined with a range of CA adoption projections and supply and demand elasticities to project aggregate benefits of the CAPS.

In West Africa, data are being collected by economists at Kansas State University (KSU) to assess profitability of reduced tillage, cover crops, and rotations for maize, beans, sorghum and millet in the northern region of Ghana. A linear programming model is planned there to analyze the set of optimal practices. Some cost and yield data exist for cover crops, tied ridges for water management, and intercropping for sorghum, millet, and brassicas. In Southern Africa, costs and yield data for maize cover crops and no-till are being collected in Lesotho and Mozambique by economists at the University of Tennessee (UTK). Baseline surveys were completed in Lesotho and Mozambique. In South Asia, yield and labor use data have been collected for rotations and intercropping by economists at the University of Hawaii and a format was provided to them for collection of additional cost of production and yield data. In Bolivia, costs and yield data were gathered for experiments on quinoa, habas, and potatoes with direct seeding, cover crops, and rotations. In Ecuador, cost and yield data were collected for potatoes, maize, habas, barley, beans with cover crops such as oats and vetch, rotations, and reduced tillage. Results from the linear programming model provide information on the optimal set of practices for two sub-watersheds. In the Philippines, cost and yield data are available for researcher-managed trials and are being collected on farmer-managed trials with an emphasis on maize, cowpeas, rice and beans. Practices include cover crops, reduced tillage,

and rotations. In Cambodia, maize and cassava are the primary crops and the Ministry of Agriculture has collected some cost and yield data with the help from PADAC.

Another activity this year was the submission and revision of a journal article based on economic analysis completed in Latin America in collaboration with LTRA-7. The impact assessment findings in the thesis of M.S. student Nguema were summarized in a journal article manuscript and submitted to *Experimental Agriculture*. The model in the article was also designed as a template for use in other sites to identify optimal CAPS elements and cropping systems to be assessed. The model found that specific cover crops, crop rotations, and reduced tillage designed to reduce soil erosion and increase soil organic matter can lead to increased incomes for farm households in a time period as short as two years. It appears that conservation agriculture practices have the potential to improve the livelihoods of the rural poor in Ecuador because conservation agriculture activities entered the revenue-maximizing model solution for both sub-watersheds.

CCRA-7: Gendered Perspectives for Conservation Agriculture: Local soil knowledge and crop-livestock interaction

The Gender CCRA is a project carrying out qualitative, case-study-based research that collaborates with individual LTRAs and CCRAs. Its objectives regard 1) local, gendered knowledge, beliefs and perceptions of soils, and 2) linking crop-livestock interaction with gendered access to assets. This year, there was collaboration with SANREM's Soil and Networks CCRAs as well as LTRAs 7 and 12. The goal is to identity gender-based constraints and opportunities for CAPS adoption.

In February 2012, the CCRA launched collaboration with LTRA-12 in the Philippines (ICRAF and UPLB), mapping and discussing local soil knowledge, a study on access to resources, and agricultural practices, and preparation of logistics for summer research. In July and August, a SANREM graduate research assistant from Virginia Tech carried out fieldwork in the Philippines. Two other graduate students are involved with the Gender CCRA; one is now writing her thesis, and the other is preparing for fieldwork in Cambodia.

Initial data analysis show local soil knowledge is related to crops and grasses, specifically how plant growth and quality correlates to soil quality; women do not have the same access to resources as men, particularly land, and there is a gendered division of labor both on and off the farm with men being responsible for land preparation and women being responsible for household duties and marketing. Products include a trip report with detailed methodology and recommendations. Research in the Philippines built on pilot methodology from Bolivia (FY 2011) and will in turn be revised for application in Cambodia in the next fiscal year. A graduate student in geography was recruited for research in Cambodia in FY 2013 and is partially funded by Virginia Tech and other sponsored projects.

Development impacts include a raised awareness of SANREM and conservation agriculture for farmers in the Philippines site; a raised awareness of gender concepts in agriculture and qualitative research for host-institutions; and a revised fieldwork methodology and strategy. One recommendation is to stress the importance of land tenure issues, particularly access to land titles, to the municipal government from the perspective of soil conservation. The local government has been funding trainings and soil sampling but because of difficulties getting titles to land, farmers do not know if they will continue to have access to their land. This is a recommendation for SANREM as well, as farmers will not invest in CAPS if results are promised in the long term and they have nothing to gain short-term.

CCRA-8: Technology Networks Cross-Cutting Research Activity

The technology networks research is interested in two key areas: 1) knowledge and beliefs about agricultural production and 2) size, composition, and structure of farmer and agricultural service sector networks. This implies two different types of statistical analysis. This report highlights key findings for the LTRA-10 Kenyan and Ugandan communities for these two types of analyses. These findings have been presented in a working paper on the social network analyses of these four communities, four extension handouts on community technology networks, and two papers prepared for journal submission.

Two major data collection efforts were completed this year. These focused on the technology network modules identifying network contacts of agricultural service sector and community agents and indicators of their agricultural knowledge and perceptions. The first involved completing the service sector/community agents' survey for two communities of farmers around Botha Bothe in Lesotho, building on the work of LTRA-9. The second effort involved interviews with the service sector/community agents in the region of Mopti, Mali (LTRA-8). These data have been entered into Excel files for subsequent analysis in SPSS and UCINet. Only household level data have been collected by LTRA-6 economics graduate students in Haiti and these data have been entered and await analysis.

Three working papers were prepared this year. The first two have been completed and are available on the SANREM CRSP website. These cover a qualitative analysis of network agents in Lesotho and the other paper presents the Kenya and Uganda findings mentioned above. A third working paper currently under revision focuses on the Lesotho analyses.

Network feedback workshops were held in the four communities of Kenya and Uganda. These events were based on the working paper documenting the research findings concerning the four communities and provided the foundation for the paper presented at the Rural Sociological Society Annual Meeting and revised for submission to Agricultural Systems. Jeni Lamb who completed her master's degree in applied and agricultural economics during the Fall 2011 semester led the effort and has continued on as a research associate working with data from Lesotho, Kenya and Uganda.

A new collaboration has been initiated with the Network Dynamics and Simulation Science Laboratory (NDSSL) of the Virginia Bioinformatics Institute (VBI). The Technology Networks CCRA and NDSSL are sharing an undergraduate research assistant who is adapting the Kenya and Uganda data set for social network simulation analyses.

CCRA-9: Soil Carbon and Soil Quality

Coordination of soil and agronomic investigations among all 13 developing countries before and after conservation agricultural production systems (CAPS) are implemented is critical to develop meaningful and scientifically verifiable comparisons of soil fertility and carbon sequestration changes due to CAPS across all project sites. Time 0 soil samples from researcher-managed sites in Ecuador, Bolivia, the Philippines, Cambodia, and Haiti are being used to establish a common minimum dataset so that scientifically valid comparisons among project sites can be made. We have fractionated almost all useful Time 0 soil samples and begun spectroscopic quantification of carbon speciation of the fractionated samples to determine labile and recalcitrant carbon. Additionally, we are collaborating with the Gender cross-cutting research activity (CCRA) to establish gendered knowledge of soils in Bolivia and the Philippines. One graduate student finished his MS, while another resigned effective Aug. 15, 2012, and we are currently seeking a replacement. Two papers are currently under peer-review, and one Proceedings book is in press. The PI served as co-organizer of the Special Session on Conservation Agriculture for the ASA/CSSA/SSSAInternational Meetings in October, 2012. Ultimately, we plan to make general recommendations for the practical establishment of CAPS to increase soil fertility and carbon sequestration throughout the developing world based on data collected from this project.

Management Entity activities

The SANREM CRSP Management Entity (ME) provided administrative support and technical back-up for the Phase IV program of Long-Term Research Awards (LTRAs) and Cross-Cutting Research Activities (CCRAs). Sustainable agricultural and natural resource management innovations, policies, and practices continue to be tested and the results disseminated through professional publications, extension documents, and various reports to partner organizations.

Noteworthy

This year the SANREM ME saw particular success in two areas: conservation agriculture implements and research in climate-smart crops. In Western Africa, the SANREM ME assisted in developing and promoting a multifunctional implement (MFI) that greatly increases the efficiency of low-till plowing and weed control. The ME provided funding to build two new prototypes and conduct additional field tests. The tool was developed at the University of Wyoming by a U.S. engineer and tested extensively by LTRA-10 P.I. Jay Norton and his team using both oxen and donkeys. Initial tests in the U.S., Kenya, Tanzania and Uganda were highly successful and the MFI is anticipated to be integral to CAPS projects in 2013. Four MFIs were deployed in FY 2012 and are now being used by farmers in Kitale and Bungoma in Kenya, and Tororo and Kapchorwa in Uganda. The third and final version of the MFI is expected to be completed in 2013 after incorporating farmers' suggestions for improvement. Additional funding is being pursued to scale-up manufacturing, expand field tests, train technical personnel, conduct market analysis, and engage factories in Africa.

At LTRA-12 in the Philippines, research plots testing the hardiness of climate-smart crops also enjoyed success. Specifically, tests of Adlai grass revealed that this crop was an effective biopump in the acidic upward sloping hillsides of the Philippines. Three adlai varieties were tested in research plots at Claveria: Kiboa, Ginampay and Tapol. Kiboa produced the highest grain yield of 3.5 tons per hectare and a total dry matter yield (TDMY) of 8.8 tons per hectare, followed by the Ginampay variety with a grain yield of 3.0 tons per hectare and a TDMY of 7.4 tons per hectare. The Tapol variety was the poorest performer.

The SANREM ME personnel spent considerable time and effort organizing SANREM's annual meeting and a Special Session entitled "Conservation Agriculture for Improving Food Security and Livelihoods of Rural Smallholders In Rain-fed Regions of Africa, Asia, Latin America and the Caribbean" during the ASA/CSSA/SSSA meeting. Both meetings were successfully held in October in Cincinnati. Details will be provided in next year SANREM's annual report.
The SANREM ME also assisted in promoting initiatives to increase the performance of LTRAs. For example, it funded the training in the U.S. of Ms. Mayra Claros from Bolivia on high-throughput testing of bacteria that improve plant growth. The ME also participated in the three inception workshops and other meetings of the Africa RISING (Africa Research in Sustainable Intensification for the Next Generation) program in Ethiopia, Ghana and Tanzania.

Publications and publicity

SANREM CRSP Knowledgebase

The SANREM CRSP Knowledgebase is an online and open access repository of books, reports, journal articles, videos, abstracts, and presentations produced or identified, classified, and summarized by SANREM CRSP researchers. Currently, there are over 3,800 resources in this database. 638 of these resources are products of Phase III research while nearly 200 entries are already derived from Phase IV projects. During FY2012, 116 items were added to the SKB. Since July 2011, the SKB has been listed on the "Related Databases" of the USDA's National Agricultural Library Alternative Farming Systems Information Center. It joined 30 other databases in this listing, among them the Agriculture Network Information Center (AgNIC) and the National Sustainable Agriculture Information Service (ATTRA). Its addition to this listing will improve access to and awareness of the SKB's extensive resources relating to Sustainable Agriculture and Natural Resource Management.

Training and institutional development

In FY2012, 10 U.S. and 8 host country universities and institutions provided long-term training for 56 graduate students (21PhD and 35 MS) and 14 undergraduate students associated with SANREM CRSP activities. Of these, 29 were women and 41 were men. SANREM CRSP researchers and partners held 267 short-term training events serving more than 8,814 people, including 4,109 women. Training events were held in 14 countries. In addition to farmers, municipal authorities, technicians, NGO staff, students, and extension agents received training from the SANREM CRSP. Over a 100 field days were offered in several countries to 3,976 people. For a full accounting of these training events, see table in the Appendixes.

Introduction

The Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program (SANREM CRSP) promotes stakeholder empowerment and improved livelihoods through the discovery, organization, and dissemination of sustainable agriculture (SA) and natural resource management (NRM) knowledge. Program efforts are competitively driven and focused on the development of Conservation Agriculture Production Systems (CAPS). The approach is participatory, engaging stakeholders at all levels in research problem formulation within priority areas of inquiry, focusing on multiple countries and/or regions to facilitate scaling research findings. Gender sensitivity is integral to the SANREM approach and reinforced by gender-sensitive participant training programs that include degree and non-degree plans. All activities link sustainable NRM with the economic concerns of local populations and the promotion of good governance.

The objectives of the SANREM CRSP program are to:

- increase scientific knowledge and technical innovations in SA and NRM;
- improve knowledge management, education, and communication leading to behavioral changes in adaptation and adoption of new SA and NRM technologies and practices;
- reform and strengthen SA and NRM governance, policies, and local institutions; and
- promote the functioning of sustainable resource-based local enterprises in national, regional, and global markets.

This annual report documents the research and technology dissemination of the SANREM CRSP for the period October 1, 2011 – September 30, 2012. The majority of SANREM CRSP research is conducted through its Long-term Research Award (LTRA) activities. Progress has been made in developing conservation agriculture production systems (CAPS) during the third year of Phase IV (2009-2014). This includes progress in the four cross-cutting research activities (CCRAs) dealing with economic impact analysis, gendered knowledge, soil quality and carbon sequestration, and technology networks.

SANREM CRSP Management Entity activities

The Virginia Tech Management Entity (ME) provides overall administrative and intellectual leadership of SANREM CRSP activities. This leadership is most clearly demonstrated in the financial management and program coordination of the Long-Term Research Awards (LTRAs) and Cross-Cutting Research Activities (CCRAs), networking with information providers and users, promoting sustainable agriculture (SA) and natural resource management (NRM), supporting SANREM CRSP researchers, and disseminating SANREM-generated knowledge to potential users. The ME also keeps abreast of innovations and new approaches in SA and NRM inquiry areas, nurtures innovative research and outreach activities, and circulates SA and NRM knowledge and information among partners and the public through the SANREM CRSP website, a quarterly newsletter, working papers, and research briefs.

SANREM CRSP Knowledgebase

The SANREM CRSP Knowledgebase is an online repository of books, reports, journal articles, videos, abstracts, and presentations produced or identified, classified, and summarized by SANREM CRSP researchers. Currently, there are over 3,800 resources in this database—nearly 200 of which are already from Phase IV projects. It can be searched by author, language, title, location, entry date, research activity, keywords, creation date, and resource type. This repository provides easy access of resources concerning sustainable agriculture and natural resource management to the general public and has a growing number of resources pertaining to Conservation Agriculture. The SKB can be accessed from the SANREM CRSP website at: http://www.oired.vt.edu/sanremcrsp/professionals/knowledgebase/.

Since going online in 2005, the SKB has grown into a dynamic and reliable repository. Its dual purpose of electronic storage for SANREM CRSP-generated resources as well as a searchable database of SA and NRM information for the general public has helped guide its development. Data entry and searches are facilitated by the SKB Metadata User Guide, Version 6, which was updated in April 2011. With the web programmer, ME now provides links to example Metadata formats within the Metadata entry page itself. The entire document can be accessed at: http://www.oired.vt.edu/sanremcrsp/documents/skb/SKB.Metadata.UserGuide2011.pdf.

Communications program

The SANREM CRSP communications program disseminates pertinent information in multiple forms for various purposes. This program consists of the SANREM CRSP website, newsletters, working papers, research and policy briefs, press releases, and other publications. The communications coordinator also maintains an editorial file of articles submitted to newspapers, magazines, and other websites that highlight SANREM CRSP activities or researchers.

Social media

SANREM's Facebook page (www.facebook.com/pages/SANREMCRSP/) had 195 new likes over the last year, an increase of 325 percent. SANREM's Twitter account (www.twitter.com/SANREMCRSP) has 173 followers and participates in ongoing dialogues with USAID, other CRSPs and known agriculture/development entities in the industry.

SANREM website

SANREM CRSP partners, development practitioners, policymakers, other stakeholders, and the public are informed of SANREM CRSP activities and announcements through the SANREM CRSP website, http://www.oired.vt.edu/sanremcrsp.

To increase usability and appeal to all audiences, the SANREM CRSP website is continually evaluated. Updates are planned to enhance blogging ability in 2013.

Google Analytics

The SANREM ME tracks visitors to the website using Google Analytics, a free service that generates detailed statistics on website visits. This year, visits to the SANREM website proper and the SANREM Knowledgebase have been disaggregated. When the data are combined, it indicates increases in all areas of visitation, including the number of visits, length of time on the site, and the average number pages viewed.

Since the SANREM CRSP ME launched the website in August 2006, there have been over 57,894 visits and more than 178,015 pageviews.

Figure 1. Google Analytics data for the SANREM CRSP website, FY 2012

Table 1. Annual Change in SANREM CRSP website data, FY2011 to FY2012

	FY2011	FY2012	Change (percent)
Visits	12349	10306	-16.5
Unique visitors	6575	6890	+4.8
Page views	33599	26197	-22.0
Pages per visit	2.7	2.5	-6.6
Average visit duration	3.1	2.4	-16.0
Bounce rate	56.0	55.5	-0.9
% New visits	51.9	65.4	+26.0

Visit: a period of interaction between a person's browser and a particular website, ending when the browser is closed or shut down, or when the user was inactive on that site for 30 minutes
Pageview: an instance of a web page being loaded by a browser
Pages/Visit: average number of pages viewed during each visit
Bounce rate: the percentage of single-page visits, i.e. the person left the site from the homepage
Avg. Time on Site: Time on site: how long a visitor is connected. Time on site can be misleading because visitors often leave browser windows open when they are not actually viewing or using a site
New visit: a computer accessing the website for the first time

Global distribution of website visits

Visits in FY2012 came from 175 countries involved more than 10,000 visitors. Of those, just over half were from the United States. About a fifth of the visits were direct traffic (visitor entered the URL directly) and another half were generated by search engines. Just over a quarter of the visits involved referral traffic from other websites with links to the SANREM CRSP website. The Virginia Tech College of Agriculture and Life Sciences, the CRSPs.org site, and USAID websites had the highest percentage of visits. Interestingly, there are some important new arrivals on the top-ten list of referrals. In particular, Wikipedia, the University of Michigan, and Facebook should be noted (Table 2).

Table 2. Top 10 referralls to SANREM CRSP website, FY2012

	Source	Visits	Contribution to total
1	apps.cals.vt.edu	394	14.20%
2	crsps.org	272	9.80%
3	usaid.gov	237	8.54%
4	google.com	170	6.13%
5	en.wikipedia.org	150	5.41%
6	vt.edu	137	4.94%
7	sitemaker.umich.edu	122	4.40%
8	facebook.com	119	4.29%
9	crsps.net	56	2.02%
10	rmportal.net	55	1.98%

Table 3. Top 10 countries visiting SANREM CRSP website, FY2011

Country	Visits	New Visits	Change in visits from FY2011
1. United States	5641	50.35%	-33.15%
2. India	528	95.83%	+63.47%
3. Philippines	474	85.65%	+54.90%
4. United Kingdom	226	89.82%	+31.40%
5. Canada	194	77.32%	+81.31%
6. Greece	163	10.43%	+1381.82%
7. Kenya	134	80.60%	+4.69%
8. Indonesia	131	85.50%	+32.32%
9. Pakistan	119	93.28%	+138.00
10. Germany	102	71.57%	-2.86%

Visits to the SANREM CRSP Knowledgebase

Since beginning to monitor visits to the SKB itself in May 2011, the SKB has received over 300 hits by 180 unique visitors viewing nearly 1800 pages of content. Over 15 percent of these visits since May 2011 were referred through the SKB's partnership with AGNIC, a group of several agriculture-related online repositories. The average time spent on the site has been approximately 6 minutes with about 5.5 page views per visitor.

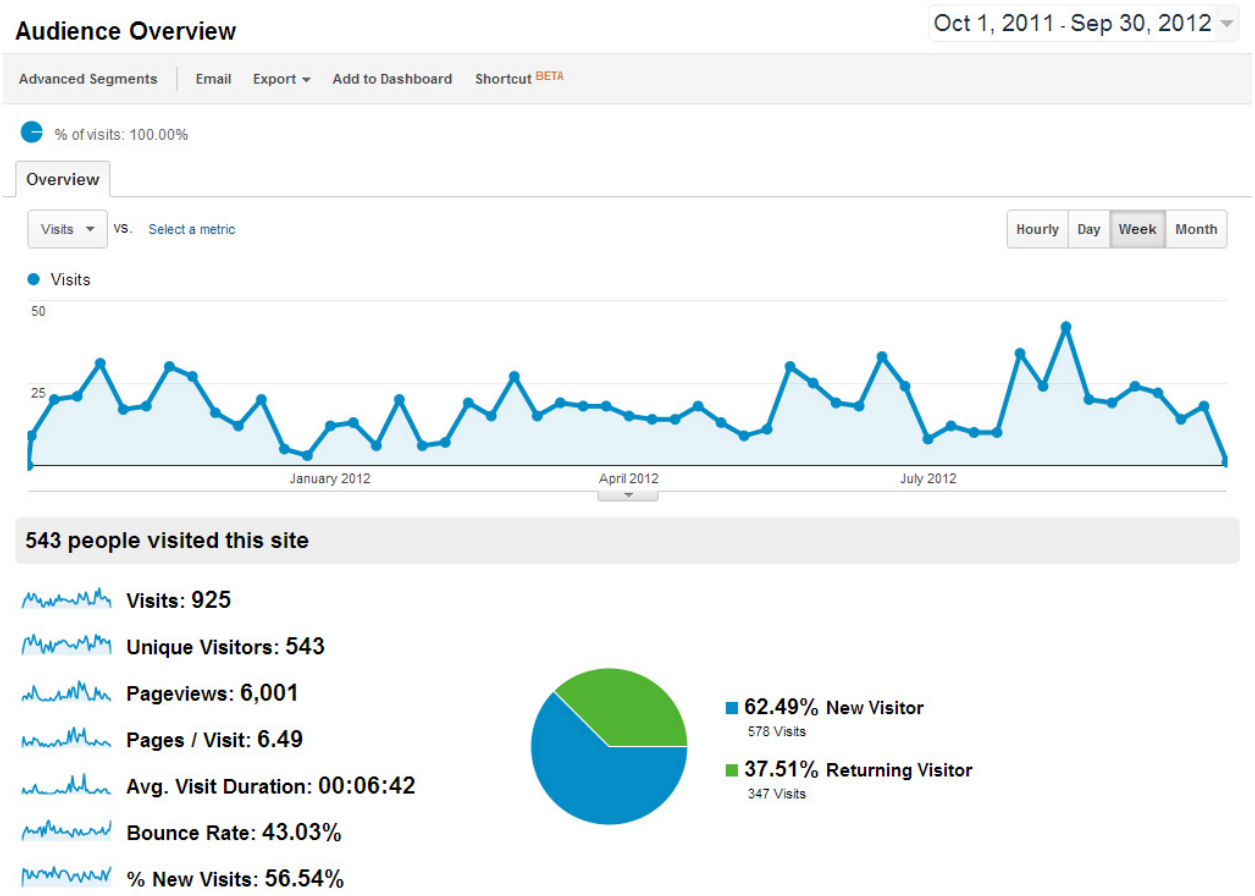


Figure 2. Google Analytics data for the SANREM Knowledgebase, FY2012

Information products

The ***SANREM CRSP Newsletter*** is published as an e-mail bulletin and online at http://www.oired.vt.edu/sanremcrsp/public/news/newsletters/. It provides a concise update of SANREM CRSP activities, accomplishments, and future events.

SANREM CRSP research briefs promote and disseminate relevant sustainable agriculture and natural resource management messages and information. These concise summaries of peer-reviewed SANREM CRSP research findings suggest how new knowledge can be applied in the field. Three research briefs were produced during FY2012. ***Policy briefs*** present peer-reviewed findings with direct policy implications or recommendations for sustainable development. Two were produced during FY2012 The objective is to provide policy makers with easily accessible information to increase understanding of often complicated policy issues. Research and policy briefs are available at http://www.oired.vt.edu/sanremcrsp/public/media/research-briefs/ and http://www.oired.vt.edu/sanremcrsp/public/media/policy-briefs/, respectively

The ***SANREM CRSP working papers*** series provides an early look at research in progress. Each paper was internally reviewed by the ME, but not yet refined for formal publication. Examples

are preliminary baseline studies reports, discussions of methodological or thematic issues, and topical syntheses and literature reviews. The Phase III series, inaugurated in 2006, has posted 30 entries. Three working papers were published in FY 2012. All are available on the website: http://www.oired.vt.edu/sanremcrsp/professionals/research-themes/working-papers/.

SANREM CRSP publicity

Part of the SANREM CRSP's mission is to establish the program as a respected authority on sustainable agriculture and natural resource management, raise the profile of the program, and to disseminate SANREM CRSP generated knowledge around the world. The ME achieves this in part by publishing print stories in newspapers, industry and other popular press publications, as well multimedia stories online. This fiscal year we have created original content for the website as well published articles on myriad platforms including print and online articles, in addition to videos and slideshows. To that end we have published articles covering a broad range of topics.

SANREM LTRA-6 in-country community partner Dilou Prospere's collaborative efforts with training workshops in Haiti was featured on the Virginia Tech Outreach and International Affairs (OIA) website http://www.outreach.vt.edu/Story.aspx?StoryID=710

Graduate Research Assistant Mary Harman was also featured on the OIA website in a piece for the OIA newsletter which detailed research she was preparing to conduct in the Philippines at LTRA-12. Our communications officer also created a follow-up slideshow which chronicled Mary's experiences in the field. http://www.outreach.vt.edu/Story.aspx?StoryID=634, https://www.youtube.com/watch?v=dUJFrU71aEE&feature=g-uplOIA newsletter

Internal publication *VT Research Magazine* profiled SANREM Assistant Director Michael Mulvaney and SANREM's role in creating healthy soil around the world, and soil's importance to sustaining agriculture. http://www.research.vt.edu/resmag/2012summer/soil.html

SANREM's work at LTRA-6 in Haiti was highlighted in the VT Sustainability report in which Haiti was mentioned as a sustainability initiative http://facilities.vt.edu/documents/sustainability/BOGA11_Annual_Report_Campus_Sustainability_Aug_2011.pdf

The SANREM CRSP communications liaison contributed an article to the popular press publication Monthly Developments magazine http://www.monthlydevelopments.org/issue/oct2012 creating brand awareness for SANREM in the development arena.

P.I. Jeff Alwang and his work were featured on an NPR program in November by reporter Sandy Housman that highlighted SANREM projects in Ecuador. http://www.wvtf.org/index.php?option=com_content&view=article&id=2506:virginia-tech-around-the-world&catid=48:wvtf-news&Itemid=119

Press release on the Virginia Tech website highlighted research done using Adlai grass http://www.vtnews.vt.edu/articles/2012/10/101912-oired-adlaigrass.html

Networking and partnership

In July 2010, SANREM CRSP was invited to participate in the Agriculture Network Information Center (AgNIC). AgNIC is a voluntary alliance and partnership of 60+ institutions and organizations working to provide quick and reliable access to quality agricultural information and sources. The SANREM CRSP continues to develop our partnership with AgNIC. As a member, the SKB linked its metadata to allow for greater searchability through AgNIC's website. The AgNIC membership helps SANREM CRSP to share the information in the SKB to reach a larger readership and increase the access to agricultural resources from other AgNIC members. Since May 2011, fifteen percent of the traffic coming to the SANREM Knowledge Base has come through this link.

Conference participation

Mike Mulvaney attended the ASA-CSSA-SSSA International Annual Meetings on October 31-November 4, 2010 in Long Beach, CA, and represented SANREM ME at the Regional Conservation Agriculture Symposium for southern Africa on February 8-10, 2011 in Johannesburg, South Africa. SANREM Co-sponsored the Second International Conservation Agriculture Workshop and Conference in Southeast Asia on July 4-7, 2011 in Phnom Penh, Cambodia which was attended by 80 people, and funded the publication of the proceedings of the meeting. Adrian Ares participated in the CRSP Council Meeting on July 24-26, 2011 in Kampala, Uganda. Keith Moore and Mike Mulvaney presented oral and posters presentations at the 5th World Congress of Conservation Agriculture-3rd Farming Systems Design Conference on September 26-20, 2011 in Brisbane, Australia.

SANREM CRSP leveraged funding

SANREM CRSP researchers were successful in leveraging additional funding to enhance their research and outreach activities (Table 4). Funding sources included U.S. and international funding agencies, as well as host country sources. This year, SANREM CRSP PIs and Co-PIs generated $398,666 in leveraged funding. All of those funds went directly to the support of SANREM CRSP activities. The governments of Indonesia, Vietnam, and Ecuador, as well as the French Embassy, are among the host country organizations offering support to SANREM CRSP research activities.

Table 4. SANREM CRSP leveraged funding, FY2012

Source of funding/support	Non-tracked funding or support contributing to SANREM CRSP activities	Funding or support for non-SANREM CRSP activities resulting from SANREM CRSP activities	Total ($)
U.S. organizations	$362,209	-	$362,209
Host country organizations	$36,457	-	$36,457
Total	**$398,666**	**-**	**$398,666**

Training and institutional capacity development

Long-term degree training

The SANREM CRSP uses degree training to strengthen the technical skills of researchers, extension agents, and teachers from U.S. and host country universities, national agricultural research services, non-governmental organizations, and relevant ministries. While developing a global knowledgebase in U.S. universities, SANREM CRSP addresses specific host country SA and NRM questions, opportunities, and constraints. In FY 2011, eighteen U.S. and host country universities and institutions provided long-term training for 44 graduate students (20 PhD and 24 MS) and 12 undergraduate students associated with SANREM CRSP activities. Of these, 30 are women and 26 are men. (For a full accounting of these training events, see in the appendixes).

Table 5. Long-term degree training participants by country, FY 2012

Country	Doctorate		Master's		Bachelor's		Total
	Men	Women	Men	Women	Men	Women	
Bolivia		1			4		5
Cambodia	1						1
Ecuador					4	2	6
Ghana	2						2
India		1	1	2			4
Kenya	1	1	1	2			5
Lesotho			2				2
Mozambique			3				3
Nepal	1		3	1			5
Philippines	2		1	2			5
Uganda			2				2
United States	5	6	7	8	1	3	30
Total	12	9	20	15	9	5	70

Short-term training

SANREM CRSP researchers and partners held 267 short-term training events serving 8,814 people, including 4109 women. Training events were held in 13 countries. In addition to farmers, municipal authorities, technicians, NGO staff, students, and extension agents received training from the SANREM CRSP. The predominant activities included workshops (1895 men and 1600 women), field days (2108 men and 1868 women), short courses (351 men and 367 women), conferences (163 men and 80 women), mentoring activities (127 men and 100 women), and various other training events (61 men and 94 women). For a full accounting of these training events, see table in the Appendixes.

Table 6. Short-term training participants by country, FY 2012

Country	Men	Women	Total
Bolivia	27	19	46
Ecuador	470	189	659
Ghana	101	50	151
Guatemala	12	6	18
Haiti	347	271	618
India	321	168	489
Kenya	50	27	77
Lesotho	377	397	774
Mozambique	1934	2117	4051
Nepal	161	96	257
Philippines	569	439	1008
Uganda	327	324	651
United States	9	6	15
TOTAL	**4,705**	**4,109**	**8,814**

Phase IV Long-Term Research Award (LTRA) program

LTRA-6: A Conservation Agriculture Production System Program for the Central Plateau of Haiti

Principal Investigator: Thomas L. Thompson, department head, College of Agriculture and Life Sciences, Virginia Tech

Host Country: Haiti

Research Team:

- Virginia Tech: Crop and Soil Environmental Sciences: Wade Thomason; Department of Forestry: Gregory S. Amacher;
- Haiti Ministry of Agriculture and National Resources: Robert J. Badio
- Caritas/Hinche: Jacques Volcius, Augustin Guedry
- Zamni Agrikol: Gillaine Warne, Larose Deus, Stenio Louis-Jeune, Fereste Sonneus

Research progress by objective:

Objective 1: Assess the adaptability of existing agricultural production and livelihood systems for transformation to CAPS.

Critical Research Accomplishments

We completed the baseline economic data survey. The sampling strategy was developed in order to sample at least 500 agriculture-based households representative of those on the Lower Central Plateau. At the same time, logistical considerations including accessibility and partner support also influenced the decision on how and where to sample. Zanmi Agrikol's team of agronomists, agents, and technicians primarily operate in an area south and west of their headquarters in Cange. After consultation with Zanmi Agrikol and other experts familiar with the region, a 16 by 16 km square centered near the town of Duffalty was identified as the sample area. This area was divided into 256 one-kilometer square quadrats, which were subsequently used to produce a random sample of 80 one-kilometer square quadrats. The survey area contained various topography and socioeconomic conditions that are largely representative of those on the Central Plateau. It included the mountain regions of Bois Joli and Balandre; the foothills of Boucane Carre and Porc Cabrit; and the lowland areas of Corporant and Grand Savane. A team of six Haitian agronomists visited every household within each of the 80 sampled quadrats. Once a household was identified, an enumerator would flip a coin resulting in a 50/50 chance that a household would be surveyed. This additional element of randomization was incorporated into the sampling strategy in order to achieve broad coverage of the study area while attaining the target of at least 500 completed household surveys. We surveyed 603 households in the lower plateau, concentrating on rural farm households. The survey data comprise information on over 3200 individuals, 1400 agricultural plots farmed by

households, 1200 fuel wood and water collection sites, and over 3300 crop plantings. The rejection rate among participating households was 1.4%, which is low considering sampling was conducted during the harvesting season. A follow-up survey effort was implemented in May-June 2012 to collect final harvest data for households who participated in the survey.

The following is a synopsis of data analysis thus far.We are currently analyzing baseline data to investigate the adoption decision for agricultural conservation practices, both with respect to the decision to adopt, and the scale of adoption for households in the Central Plateau of Haiti. We are also considering the plot-level application of several soil- and resource-conserving practices. This will cover the range of conservation agricultural technologies that have been used historically and will be conducted at both the household and plot level. For adopters, the scale of adoption will be considered using our data on the area that each practice was applied across plots. The adoption econometric model will follow from a household optimization problem that compares the net benefits of adoption with those of not adopting, and then considers the farm operation of each household in determining scale of adoption. A two stage Probit-Tobit model consistent with the household model is currently being estimated. This econometric analysis will be conducted for specific practices as well as groups of related practices.

Table 7 summarizes descriptive statistics from our data and presents a summary of those households that have at least one conservation agriculture practice being applied to their plots. Information for a total of 1383 plots was collected as part of our 2011 household survey conducted in the Central Plateau. After removal of missing data, 640 plots remained. Of these 640 plots, 253 had at least one conservation practice and 387 plots had no conservation practices present. The most common practices include live barriers such as fence-rows or tree shelter, extended rock barriers, rock walls/terraces, and ”trash” barriers.

Many of the explanatory variables that we will consider, have been used in similar studies around the world. Factors such as education level and farm size will be re-examined in the context of Haiti. The scope of the household survey also gives us the opportunity to use a wide range of potential drivers of conservation adoption, including some that have not been previously investigated but that are clearly important to adoption. The amount of diversity in the types of crops that are harvested may be significant in the soil conservation decision and a proxy for risk preferences. Other rarely used variables, such as household income from fruit, charcoal, and wood products, will also be examined in conjunction with crop diversity.

Referring to Table 7, we see that there are differences in data for households who have and have not adopted conservation agricultural practices. These variables will likely be important to our econometric model. We see that plots that have a greater slope are more likely to have conservation practices. This makes sense, as plots that are more sloped have higher rates of erosion and therefore these practices could have a greater mitigating effect and higher net benefits to the household from their adoption. Plots without conservation practices have heads of household with more years of education and more adult males and females per karo. They

are also associated with households that have higher income from fruit sales, wood products, and non-agricultural activities. However, households with higher levels of income from charcoal are associated with fields that have conversation practices. Additionally, higher levels of formal or informal credit utilization are related to these same fields. In Table 7, we have included descriptive statistics for each group of households; i.e., those who have and do not have conservation practices. To use sample differences would obscure the average and standard deviation information in this table.

Development Impact

Data collection for the baseline survey is complete. Analysis of the data will help us investigate factors influencing the adoption decision for agricultural conservation practices, both with respect to the decision to adopt, and the scale of adoption for households in the Central Plateau of Haiti. This information will contribute to tailor our research and outreach efforts to best meet the needs of households for information and technical support. The relevant timelines have been met and any challenges were overcome.

Table 7.Comparison of Sampled Farm Household Characteristics

	Conservation Practice (n = 253)		No Conservation Practice (n=387)	
	Average	Standard Deviation	Average	Standard Deviation
Household Fruit Sales (Haitian Dollars[1])	189.90	538.75	265.02	796.13
Household Wood Product Sales (Haitian Dollar)	80.00	584.60	143.51	1073.46
Household Non-Agricultural Revenue (HaitianDollar)	2943.71	3565.17	3552.63	4966.91
Household Charcoal Revenue (Haitian Dollar)	951.28	3044.18	426.56	1458.07
Household Livestock Sales (Haitian Dollar)	643.54	1722.46	556.29	1649.46
Number of Plots Sharecropped or Rented Out	0.06	0.32	0.02	0.13
Household Total Crop Value (Haitian Dollar)	3749.22	4488.25	3243.22	4316.19
Household Ratio, Crop Consumed/Total Crop Value	0.56	0.24	0.53	0.28
Household Credit Utilization (Haitian Dollar)	592.57	1399.03	358.14	981.28
Household Value of Livestock (Haitian Dollar)	5298.66	5808.27	5354.34	6065.82
Total Farm Size in Karo (ha)	1.38	0.98	1.19	0.90
Number of Plots	2.55	0.94	2.48	0.91
Household Number of Fruit Trees	24.52	52.72	18.67	25.48
Household Adult Males per Karo	2.16	2.53	2.90	3.35
Household Adult Females per Karo	1.95	2.24	2.90	3.69
Number of Household Members (per household)	5.51	2.22	5.65	2.38
Head of Household Age (years)	46.98	13.36	47.32	13.40
Percentage of Male Household Heads	84	37	80	40
Years of Education for Household Head	2.55	3.25	3.27	3.60
Secure Plot Tenure (1 = Recognized Legal or Customary Tenure)	0.84	0.37	0.77	0.42
Number of Years Under Cultivation	16.08	20.79	13.52	11.68
Distance to Household (Minutes Walking by Foot)	32.37	37.19	24.57	37.77
Household Plot Diversity Gini-Simpson Index	0.51	0.21	0.52	0.21
Percent of Households Stating Poor Plot Fertility	0.08	0.26	0.13	0.34
Percent of Households Who Stated Average Plot Fertility	0.84	0.37	0.79	0.41
Percent of Households Who Stated Good Plot Fertility	0.08	0.28	0.08	0.28
Percent of Households with Flat Sloped Plots	0.27	0.45	0.70	0.46
Percent of Households with Steep Sloped Plots	0.06	0.24	0.03	0.17
Plot Size (Karo)	0.55	0.37	0.47	0.38
Kilograms of Fertilizer Applied	0.25	3.24	8.54	41.82
Plot Irrigation (1 = Has Irrigation)	0.04	0.20	0.11	0.32
Plot Crop Gini-Simpson Index	0.49	0.24	0.42	0.26
Plot Harvest Value (Haitian Dollar)	1759.26	2403.09	1479.77	2014.09
Percent Plot Harvest to Total	0.53	0.30	0.53	0.31
Plot Percent of Total Farm Size	0.47	0.26	0.47	0.26
Total Farm Crop Gini-Simpson Index	0.60	0.17	0.56	0.21

[1] **One Haitian dollar is equal to five Haitian Gourdes**

Objective 2: Increase agricultural production through development of CAPS.

Critical Research Accomplishments

At each of the three experimental sites (Corporant, Lachateau, Maïssade) crimson clover (*Trifolium incarnatum* L.), spring oats (*Avena sativa* L.), and velvet bean (*Mucuna pruriens* L.) were planted in a split plot experimental design. In preparation for maize planting (during April), each of these cover crop areas was split and ½ of the cover crop residue left on the surface as a mulch and ½ was plowed as normal. These studies were established in the dry season and were provided supplemental irrigation. In the future, these cover crops will be established in fall after cash crop harvest or fallow.

During the team member visit in Feb. 2012, successful initiation of these experimental designs was confirmed, thus indicating progress toward the following tasks (Tasks 2.1, 2.3, and 2.5 from our 2011-12 work plan): *building research capacity to conduct agronomic trials, introduction and evaluation of cover crops (on-station);* and *integrate cover crops, planting practices, and rotations into the on-station testing protocols.* None of these cover crops were particularly successful. Small plots of additional cover crops were planted in May for evaluation.

Harvest of maize cultivars best suited to CAPS systems occurred in Fall 2011 at Corporant, Lachateau, and Maïssade experimental sites (Table 8). In this year's testing we evaluated the lowland elite tropical late yellow normal and quality protein maize (QPM) hybrid maize nursery from CIMMYT along with three local check maize cultivars:

- At Corporant, yield of the best improved cultivar was 26% higher than that of the best local check.
- At Lachateau, yield differences were more pronounced and the yield of the highest producing CIMMYT line was 180% that of the highest local check maize entry.
- At Maïssade, yields were exceedingly low.
- Because of the poor results from the cover crops planted in January 2011; q1crimson clover (*Trifolium incarnatum*), spring oats (*Avena sativa*), and velvet bean (*Mucuna pruriens*), we have decided to try additional cover crops. During May 2012, we delivered seeds from several possible cover crops to our partners: velvet bean (*Mucuna pruriens*), lablab (*Lablab purpureus*), sunn hemp (*Crotalaria juncea*), cowpea (*Vigna unguiculata*), sesbania (*Sesbania exaltata*), and stylosanthes (*Stylosanthes guianensis*). These were planted in small blocks by our partners in early June. Our observations in July 2012 indicated that several of these have excellent potential as cover crops and will be used in the Fall 2012 CAPS plots.

Table 8. Average yield of CIMMYT lowland elite tropical late yellow normal and quality protein maize (QPM) hybrid maize over three locations, 2011. Line listing is the pedigree for the CIMMYT entries.

Entry	Line	15% moist yield kg/ha
3	CLQRCYQ70/CML161	1741
13	CLRCY039/CLRCY017	1725
8	CLO2720/CLRCY017	1704
6	CML451Q/CLO2450Q	1540
9	CLYN205/CLRCY017	1535
7	CML161/CML165	1392
1	CLO2450Q/CML161	1380
14	CLRCY045/CLRCY017	1347
15	CML451/CLO2450	1316
10	CLO2720/CLRCY016	1281
2	CLQRCYQ59/CLQRCYQ49	1270
11	CLO2720/CLO2450	1243
5	CLQRCYQ71/CLQRCYQ49	1241
4	CLQRCYQ59/CML161	1058
12	CML451/CLRCY016	1044
18	Local check-3	1034
16	Local check-1	934
17	Local check-2	847
	Mean	1313

Development Impact

The successful layout and planting of the replicated CAPS field experiments by our Haitian partners was very encouraging. This is progress toward their ability to independently initiate and complete experiments. Furthermore, these experiments gave our partner agronomists the opportunity to evaluate cover crops. See above under 'Critical Research Accomplishments.' Automated weather stations were also deployed at each of the three research sites. Partner agronomists have been trained in downloading data.

Challenges and Responses

1. We have made significant progress during the past year. However, because of delays during 2010 caused by the earthquake in Haiti and a cholera outbreak, we will only be able to complete three years of CAPS experiments.
2. We have been forced to re-evaluate the cover crops to be used. Please see above.
3. It is clear that the normal approach to hand cultivation results in excessive soil disturbance. During 'train-the-trainer' workshops to be held during 2013 (possibly in January), we will introduce different implements (e.g., smaller hoes) for cultivation, as well as seeding methods adapted for no-till planting.
4. Crop yields at Maïssade have been far lower than at the other two locations. This location is drier, and based on field observation and soil testing, soil fertility is much more

limiting to crop growth. We are considering the possibility of applying fertilizer or manure to this soil in the near future.

5. The following will be areas targeted for improvement during 2012-2013:
    a. timely planting of cover crops in CAPS plots (during rainy season),
    b. better cover crop performance and weed control in CAPS plots, and
    c. early maize planting (Mar.-Apr.).

Objective 3: Increase the capacity of smallholders to adapt and improve CAPS.

Development Impact

During Jan. 2012 our team was able to spend more than one hour with approximately 50 farmers from the area near the Maïssade farm, of which approximately 50% were female. Topics of discussion included the major barriers to crop production and conservation practices currently in use. We shared key elements of conservation agriculture (crop rotation, reduced tillage, cover crops), and explained the basic features of our project with Caritas. The successful initiation of the cover crop x tillage trials by Zanmi Agrikol and Caritas agronomists illustrates progress toward effective demonstration and research projects to benefit local farmers.

CAPS workshops were held in the field at each research location (Corporant, Lachateau, Maïssade) during July. More than 200 individuals attended—students, farmers, and agronomists. During our presentations, we stressed the need to find site-appropriate CAPS methods, and the need for flexibility in testing and implementing CA on their farms. We also stressed that this LTRA will run for two more years, and we will have more complete information to share as the experiments proceed. The attendees expressed interest in the subject matter and we fielded many questions. Questions tended to focus on weed control, cover crop selection, and planting methods to be used with conservation agriculture. Several participants indicated that they would implement some of the suggestions. During 2012, we were able to present and demonstrate CAPS principals to more than 250 individuals, mostly farmers.We found that some growers have been able to access seed from the CIMMYT cultivars that we have introduced to the research locations, with positive results.

Challenges and Responses

We are at least one year behind where we wanted to be at this point compared to what was originally proposed. We now believe that estimate was overly optimistic even discounting the challenges of a major devastating earthquake, a cholera epidemic, election violence, and other disruptions. On the other hand, it has taken considerable time to build trust with our partners, for them to understand why we are in Haiti, and what we are asking them to do. Only as we gain that trust and see value in the project will they work with us to open doors to the community with which they work. With the knowledge base being built by the baseline household survey, the planned collaborative soil, field, and practice survey with CCRA-9, and our growing competency in research methods appropriate for Haiti, we believe we can make begin to move forward much more rapidly.

Until we make progress with Objectives 2 and 3, the main contribution will only be providing training that makes smallholders more aware of erosion and its harmful effects on food security. We will continue to focus on these objectives, and on awareness training. In the upper Plateau, we will need to work with a newly assigned agronomist with regards to training.

Objective 4: Strengthen human and institutional research and extension capacity for CAPS

Critical Research Accomplishments

The research farm sites provide a model for testing a private/NGO system for national agricultural outreach/extension. With research trials now in place, progress has been made toward creating more capacity for research and demonstration in CAPS. Each farm center (Corporant, Lachateau, Maïssade) offers a focal point for locally adapted CAPS technological innovation and outreach, as well as for future research.

Development Impact

Agronomists with our partner organizations (Zanmi Agrikol and Caritas) have demonstrated that they can use a plot map to set up replicated field experiments independently. This will enhance their ability to conduct independent research in the future. Our new in-country assistant coordinator has gained valuable experience in experimental design, data analysis, and project management. This will benefit him in future employment. Partner agronomists took an active role in planning and execution of CAPS workshops.

Challenges and Responses

1. Our interactions with FAMV partners have not recovered from the devastation caused by the 2010 earthquake. During late 2012 and early 2013, a concerted effort will be made to re-connect with these partners and encourage their participation in our CAPS projects.
2. More training is needed for partner agronomists and technicians. Toward this end, we will be conducting train-the-trainer workshops at two locations in the Central Plateau in Jan.-Feb. 2013.

Degree and nondegree training activities

A total of 11 workshops, short courses, and training were conducted by the SANREM team and our partner agronomists. A total of 618 individuals—347 male and 27 female—attended. Two graduate students were trained, and one was graduated with an M.S.

Publications, presentations, and other SANREM products

1. The following presentations were made to audiences at three locations in the Central Plateau during July 2012:
    a. Introduction to SANREM CRSP (Thompson)
    b. Principles of Conservation Agriculture (Mulvaney)

   c. Conservation Agriculture Practices (Thomason)
   d. Field demonstrations (All)
2. A 12-page document was prepared in English and Kreyol explaining and illustrating the principles and practices of conservation agriculture. More than 200 copies in Kreyol were distributed at the July workshops. These documents will be entered in the SANREM CRSP Knowledge Base.
3. LTRA-6 has enjoyed increased publicity on the Virginia Tech website and in other publications. An article featuring in-country partner Dilou Prospere can be accessed here http://www.outreach.vt.edu/Story.aspx?StoryID=710, and the project was mentioned in the university's 2011 Annual Report on Campus Sustainability at Virginia Tech which can accessed here (pg. 22) http://facilities.vt.edu/documents/sustainability/BOGA11_Annual_Report_Campus_Sustainability_Aug_2011.pdf. An article also appeared in the CRSP Digest Newsletter in Fall 2012 highlighting the workshops conducted in the Central Plateau.

Networking activities

Thompson (PI) and Badio (in-country coordinator) met with James Wooley (USAID mission in Haiti) during June 2012. Two individuals from the USAID WINNER project attended the CAPS workshop in Maïssade during July 2012.

Project highlights

- The first complete year of CAPS experiments (cover crop planting followed by maize planting) at three locations in the central Plateau of Haiti is nearing completion.
- Training and education in CAPS was given to more than 600 individuals during the past year at three locations in the Central Plateau of Haiti (347 male and 271 female).
- We recently completed a baseline socioeconomic survey of more than 600 households in the Central Plateau of Haiti, comprising 3200 individuals, 1400 agricultural plots farmed by households, 1200 fuel wood and water collection sites, and over 3300 crop plantings. Data are currently being analyzed.

LTRA-7: Conservation Agriculture as a Potential Pathway to Better Resource Management, Higher Productivity, and Improved Socioeconomic Conditions in the Andean Region

Principal Investigator: Jeffrey Alwang, professor, Department of Agricultural and Applied Economics, Virginia Tech

Host Countries: Ecuador, Bolivia

Research Team:

- Virginia Tech: Department of Agricultural and Applied Economics: George W. Norton, Darrell Bosch
- Penn State University: Department of Plant Pathology: Paul Backman; Department of Crop and Soil Sciences: Robert Sean Gallagher, Richard Stehouwer
- University of Denver: International Development: Sarah Hamilton
- U.S. Department of Agriculture Soil Plant Nutrient Research Unit: Jorge A. Delgado

Research progress by objective

Objective 1: Identify and evaluate production practices and farming components that can be assembled into CA production systems for Bolivar, Ecuador and Tiraque, Bolivia.

Critical Research Accomplishments

Task 1.1: Establish field research design and identify locations for crop and cover crop research. This has been completed and we now have farmer field trials being established in Ecuador and Bolivia.

Ecuador: The experimental design has been established and treatments are in production (see below). We have experiments on farmer fields in the upper (Illangama) and lower (Alumbre) watersheds.

Bolivia: We work in four areas of the Tiraque watershed with CA plots that are currently in their second and third cycles. These are near communities named San Kayani (the highest altitude), Cebada Jincana, Wayla Puyru, and 15 de Octubre (the lowest altitude). Altitudes range from almost 4,260 m at their highest to 3,340 m at their lowest. CAPS experiments include 1) vetch cover crop and inclusion in a potato – quinoa – faba bean rotation 2) supplemental fertility management for the potato phase of the potato – quinoa – fava bean rotation, 3) potato with reduced tillage, and 4) alternative forage options to precede the potato-based systems. Because of climate challenges noted in last year's report, the second year of the cycle only happened at the 15 de Octubre site; the other three sites would all be planted to the year-one cropping sequences this year. This year we also began quinoa trials in Anzaldo: the purpose of these trials is to evaluate the promise of CA in moisture stressed regions where quinoa has strong potential.

In both countries, the research team decided to supplement natural rainfall with aspersion irrigation. This added moisture will compensate for below average rainfall by bringing total water availability up to average levels. It was made necessary by the presence of drought and the damage it could do to a five-year experiment. As irrigation is available at most sites in the area, we are calculating the costs of irrigation as a part of the economic evaluation of the CAPS. We have also established a variety of satellite experiments to investigate cost-reducing and yield enhancing practices, many of which involve biological agents.

Task 1.2: Assess potential CA components for each farming system. We have conducted an assessment of feasible components. The research designs have been adjusted following scientist visits to the area throughout the first two years of the project.

Task 1.3: Identify the most likely full CAPS for each farming system.

Ecuador: See table 9.

Table 9. Description of CAPS in two cultivation systems, Ecuador

Illangama sub-watershed (Upper watershed)—Potato-pasture system	Alumbre sub-watershed (Lower watershed)-Maize-beans system
Soil conservation practices: with and without deviation ditches.	Soil conservation practices: with and without deviation ditches.
Tillage: conventional and reduced.	Tillage: conventional, reduced and no-till.
Rotation 1: potato, barley, faba, and forage mix. Note: improved forage mix was identified during prior research.	Rotation 1: hard maize, bush beans, hard maize, peas and hard maize.
Rotation 2: potato, barley, oats-vetch and forage mix.	Rotation 2: hard maize, bush beans, hard maize, oats-vetch and hard maize.
Management: soil use (fallow, grass with residuals removed, grass with residuals retained), fertilization with N and cover crops (faba and quinoa).	Management: tillage options (conventional and reduced), cover crops (peas, oats-vetch, maralfalfa--*Pennisetum sp.* and native trees).
Intensive pasture management (improved forages) with overseeding of clover.	Use of maralfalfa and fruit trees in contours to form live barriers.

Bolivia: Our experiments and likely CAPS for Bolivia have been presented elsewhere.

Objective 2: Validate candidate CAPS in terms of impacts on: soil health, soil retention, carbon and nutrient balances; sustained productivity; profitability; risk bearing; the environment; compatibility with household livelihood strategies; and social conditions including gender considerations.

Critical Research Accomplishments

Task 2.1: Create protocol for evaluating soil and crop sustainability in experiments: physical, chemical and biological changes over time and due to differences in practices.
A suite of soil chemical and physical property measurements have been implemented in both Bolivia and Ecuador that have been shown in other studies to be relatively parsimonious indicators of soil health, and are feasibly implemented given the technological capabilities available in PROINPA and INIAP. The soil chemical measurements include:

1. **Inorganic nitrogen availability:** This is a measure of the soil nitrogen that is readily available for plant growth (i.e., nitrate and ammonium).This measurement is accomplished by extracting sieved soil with a potassium chloride (KCL) solution that can later be evaluated colorimetrically for ammonium content. Nitrate is assessed by reducing the nitrate to ammonium by a chemical catalyst. This measurement is particularly valuable to assess the nitrogen mineralization from cover crops and the available nitrogen remaining after crop harvest that will likely be lost to leaching. A frequent sampling regime (i.e., every 1 to 2 weeks) throughout the growing season is best to understand the dynamics of inorganic nitrogen.

2. **Potentially mineralizable nitrogen (PMN):** This is a measure of nitrogen that is part of the soil organic matter (SOM), but is likely to become available that growing season due to its labile chemical nature.This measurement is accomplished by doing an initial extraction of a soil sample with KCL as described above, and again after the sample has been incubated at 25° C for 4 weeks.The difference in the available nitrogen from these two samples is the amount of nitrogen that was mineralized during the incubation process. Although the PMN measurement cannot typically be used to predict future nitrogen availability, it is useful to make comparisons among treatments. For example, CAPS treatments that include a cover crop that is retained in the system would be expected to have higher PMN values that treatments where the cover biomass is removed for forage, or treatments without a cover crop. It is valuable to take this measurement prior to crop establishment and after crop harvest.

3. **Particulate organic matter (POM):** This is a measure of the SOM fraction that is greater than 53 microns.This size fraction of organic matter tends to represent the most recent organic matter additions to a system, and the SOM fraction that will contribute to crop fertility. In that sense, it is a similar measurement to PMN described above, which estimates nitrogen from the POM as well as the microbial biomass. This measurement is accomplished by passing a pre-sieved (2 mm) soil sample through a 53 micron soil sieve. The soil material remaining on the 53 micron sieve is the POM fraction. A soil carbon analyzer (LECO), as is available at INIAP in Ecuador, is typically needed to measure the amount of carbon in the POM sample. More advanced LECO instrumentation can also measure total nitrogen in solid and liquid samples. Since a LECO is not readily available in Bolivia, POM will not be

determined there. Similar to PMN, it is valuable to take this measurement prior to crop establishment and after crop harvest.

4. **Total carbon and nitrogen:** Total carbon and nitrogen, as the names suggest, is all of the carbon and nitrogen in a soil sample, and will be orders of magnitude higher than the nitrogen and carbon measurements described above. We typically do not expect these values to change dramatically in response to CAPS or other treatments, but these measurements provide a needed baseline on which to compare changes in the labile carbon and nitrogen measurements, and to help understand changes in the soil physical properties (described below). As such, total nitrogen measurements really only need to be done at the beginning and the end of a crop rotation experiment. Total carbon measurements, however, are needed to make the necessary calculations for POM. Total carbon, as described above, can be measured using LECO instrumentation, with more advanced instruments also measuring total nitrogen. Otherwise, total nitrogen is obtained by a laboratory digestion procedure called "micro kjeldahl". PROINPA in Bolivia does not have the laboratory facilities to conduct micro kjeldahl analysis and must hire out the procedure with the soils laboratory associated with the University of Cochabamba. INIAP soil group, headed by Dr. Soraya Alvarado, on the other hand, is well equipped and knowledgeable in this procedure. Micro kjeldahl, however, is time consuming and tedious, and requires a large time commitment from a trained laboratory technician.

5. **Available phosphorous**: Similar to inorganic nitrogen described above, available phosphorus is the phosphorus in the soil that is readily available for plant growth. Available phosphorus pool is typically far smaller than the total phosphorus pool, and is influenced by the soil chemical properties, among other factors. Available phosphorus is a useful indicator if supplemental phosphorous will be needed to optimize crop growth and yield potential. Supplementation can occur through the addition of inorganic fertilizers or by the addition of animal manures or compost. Large additions of animal manure or compost can result in substantial changes in both available and total phosphorous levels. In addition, available phosphorous measurements are useful in the *Bacillus* and microliming experiments describe elsewhere in this report by detecting if treatment differences are due to phosphorous availability as hypothesized, or to other factors. This measurement is accomplished by extracting a sieved soil sample with a Melich III solution, which can then be analyzed colorimetrically with a microplate reader (described below) or spectrophotometer, or by atomic absorption (AA) or ICP instrumentation. AA and ICP instrumentation is available with INIAP, but not PROINPA.

6. **Available cations:** Available cations are the positively charged plant nutrient elements that are essential to plant growth and development. As previously indicated, available phosphorus is included in this measurement, but also includes such elements at potassium, magnesium and calcium, among others. As was the case with total carbon and nitrogen, we do not typically expect the concentration of available cations to change appreciably with cropping system treatments. However, it is important to get a baseline value for these nutrients to determine if supplemental fertilizer is needed and help explain plant growth abnormalities. As such, it is only necessary to determine the level of available cations at the

beginning and end of an experiment. As with available phosphorus, available cations are typically determined with AA or ICP instrumentation. For AA, a separate sample run is necessary for each cation to be determined. In contrast, a single sample run with ICP will provide data for all the cations. As such, ICP is a more efficient means to determine available cations, but the instrumentation is considerably more expensive (to buy and operate) and complex than AA.

7. **Soil pH:** Soil pH is a measure of soil acidity, which affects plant growth and nutrient availability, among other factors. Different soil types tend to have an inherent range in pH, but crop and soil management can influence soil pH. For example, repeated applications of inorganic nitrogen fertilizers tend to lower soil pH making it more acidic, whereas application of lime is a means to increase soil pH. Since soil pH is a very easy and inexpensive measurement to take, it is common to take a pH measurement before each cropping season.

The soil physical measurements include:

1. **Saturated hydraulic conductivity:** Saturated hydraulic conductivity is a measure of macro pore flow in intact (i.e., non disturbed) soil cores under fully hydrated conditions (i.e., both micro and macro pores saturated with water). Although fully hydrated conditions are rare in the field, saturating the intact soil core is a means to establish the same level of hydration among cores. The water flow through the core is an indicator of soil infiltration rate, a key indicator of soil erosion potential. Saturated hydraulic conductivity can be estimated directly in the field by ring infiltrometer methodologies. This approach is time consuming and tedious, and is not a widely accepted approach. Alternatively, we are using a method where intact soil cores, encased in a plastic sleeve, are equilibrated in the laboratory and saturated flow measured once the cores have reached equilibrium. Gallagher and Stehouwer have worked with the teams Bolivia and Ecuador to construct a hydraulic conductivity apparatus that permits running six intact core samples at a time. It is very likely that saturated hydraulic conductivity will be affected by the CAPS treatments. For example, tillage tends to be detrimental to soil macroporosity, whereas cover crops tend to promote soil macroporosity; directly by leaving root channels, and indirectly by promoting soil biological activity. Greater macroporosity tends to lead to greater saturated hydraulic conductivity. As such, it is useful if this measurement can be conducted each cropping year, with sampling occurring before any soil tillage is implemented, or after the crop has been harvested.

2. **Water holding capacity:** Soil water holding capacity is a measure of the ability of a soil to retain water under a range of tensions, and is a good indicator of 1) organic matter status, and 2) susceptibility to drought, among other factors. Methodologies for measuring soil water holding capacity can be quite complex and time consuming, including the use of vacuum plate mechanisms and thermocouple psychrometer. Such equipment is available at INIAP in Ecuador, but not at PROINPA in Bolivia. A simpler alternative, however, is the use of a tension table. Here, the same intact cores used to determine saturated hydraulic conductivity are placed on a saturated blotter paper within a plastic table. After the intact core has been equilibrated under zero tension, it is weighed, and then

placed back on the table to be equilibrated at the first level of tension. This process is continued until the increasing level of tension can no longer be maintained. These data are used to generate a soil water retention curve, which can be compared among samples and treatments.

3. **Bulk density:** Bulk density is a standard soil physical property that is needed to make a number of field scale calculations related to soil carbon and nitrogen. As a simple dry weight to volume measurement, it is also a good indicator of soil porosity and compaction. Greater porosity, as influenced by such CAPS factor such as cover crops and reduced tillage, typically corresponds to lower soil bulk density. The measurement is accomplished by taking the same intact cores used in the hydraulic conductivity and water holding capacity measurements described above and drying them to determine the dry weight to volume ratio.

Task 2.1.0: Continue methods development for soil and plant protocols

The project has trained the laboratory personal associated with each project in the methodologies described in Task 2.1. In Bolivia, this training was conducted primarily with Saavedra-Rivera and Gutierrez during October 2011. Gutierrez, however, left the SANREM project pursuing another professional opportunity. The training was repeated by Edino González, who replaced Gutierrez in April. Although all members of the primary PROINPA SANREM project had the basic university training in agronomy and laboratory protocols, none of them had experience in the soil protocols outlined in Task 2.0.

In addition to the soil processing protocols outlined above, training was conducted on use of the chromate microplate reader and associated equipment. A microplate reader, when configured with the appropriate filters, permits the rapid colorimetric determination of inorganic N and available phosphorus with the generation of a minimum of chemical waste. For example, 96 samples can be analyzed in less than 5 seconds and produces about 25 ml of chemical waste. This microplate technology will greatly improve the cost effectiveness of many of the soil chemical protocols for our project.

A similar training regime was conducted in Ecuador with Soraya Alvarado's soils group. Since Alvarado has considerable soil science expertise, her team adapted quite readily to the experimental protocols and instrument operation. A key problem in Ecuador, was the lack of availability of the necessary reagents to do the microplate determination of inorganic nitrogen and phosphorous. These reagents have been purchased and are now available for use.

Task 2.1.1: Process baseline soil and plant samples from CAPS system experiments

Partners in Bolivia and Ecuador have the knowhow and the necessary reagents to do the soil extractions and prepare the soils for the protocols outlined in Task 2.1. However, both are seriously behind in this task. Students are now being integrated into the work to help with the work load.

<u>Task 2.1.2</u>: Analyze baseline soil and plant data from systems experiments
Good progress has been made toward analyzing crop biomass and yield data as it becomes available. Since most of the soil analyses have not yet been completed, we are behind in this area.

<u>Task 2.1.3:</u> Conduct analysis, interpretation and publishing of erosion plot data from the previous SANREM phase in collaboration with host country scientists
A preliminary evaluation is now available of the 2007 and 2008 water run-off data from the soil erosion experiments from upper and lower watershed sites in Ecuador. In the lower watershed in 2007, there was a positive relationship between the amount of rainfall and the amount of run-off, but this was more pronounced in the plots planted to maize and/or bean compared to the plots in native pasture (Figure 3 A). Intercropping maize with beans reduce the run-off potential compared to maize alone. In 2008, the experimental design was changed to include four treatments 1) pasture; 2) bare cultivated soil; 3) maize; and 4) beans. Run-off potential was the lowest in the pasture treatment; highest in the cultivated bare soil treatment; and intermediate in the maize and bean treatments (Figure 3 B).

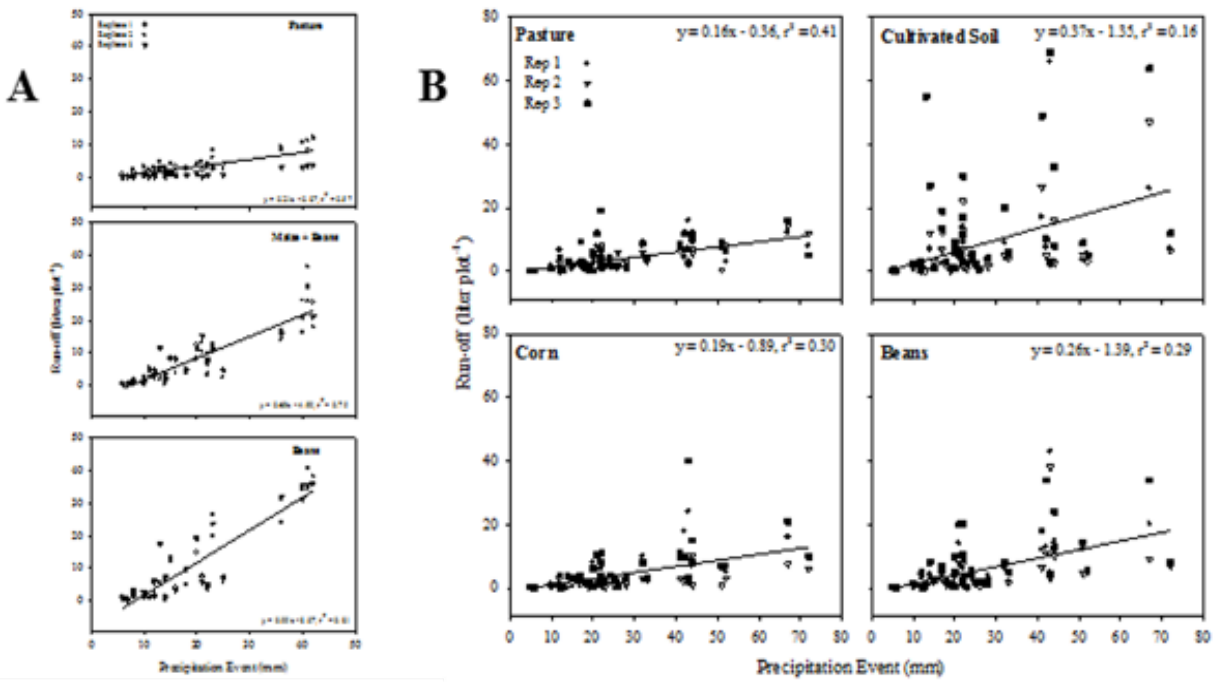


Figure 3. The relationship between rainfall events and water run-off from the soil erosion experiment at the Alumbre, Ecuador site in 2007 (A) and 2008 (B).

A similar analysis was conducted on the data from the Illangama Ecuador site, but no discernible trends were found (data not shown). According to Barrera, this may be due to the fact the rainfall events were estimated from a nearby weather station rather than directly at the site of the experiment. In addition to the run-off data, there are data on the amount of soil that moved from the top of the erosion plots for both the upper and lower water shed experiments. These data, however, have not been analyzed.

<u>Task 2.2:</u> Establish experiments for CA components, component combinations and full CAPS: We now have basic data from our trials. The Ecuador trials are divided into old (established during the prior phase of SANREM and continued to take advantage of the information) and new (begun following the start of the new phase in 2009).

Evaluation of cropping systems, tillage and rotation in hard maize (*Zea mays* L.) in Alumbre, Ecuador (old trials)

Figure 4. Trial (old SANREM) in maize-bean system. Alumbre-Ecuador, 2012.

Yields

We conducted an analysis of variance of maize yields, first-cycle oats-vetch (dry yield) and second cycle oat-vetch and found no statistically significant difference between the CA practices and the control (T1). In contrast, the analysis of variance on bush bean yields uncovered statistically significant yield differences ($P<0.05$). The CA treatments were statistically different from the control, and a Duncan test at 5% indicates that the treatment T2 (minimum tillage, oats-vetch without removal and bush beans w/o removal) with a mean yield of 1.55 tons/ha of bush beans had the highest yield. This difference is possibly related to the residue from the oat-vetch.

Table 10. Mean yields and results of Duncan test (at P = 0.05) (original SANREM trial). Alumbre-Ecuador, 2011 - 2012

With removal = cut residue and use as animal feed or sell. Bean plant is completely removed. W/o removal = cut

Treatments	Hard maize tons/ha	Oats-vetch tons/ha 1st cycle	Bush beans tons/ha	Oats-vetch tons/ha 2nd cycle
T1= Minimum tillage, hard maize with fertilization, oats-vetch with removal and fertilization, bush beans with residue removal without fertilization and oats-vetch with removal and without fertilization.	2.95	42.83	1.45 ab	20.54
T2= Minimum tillage, hard maize with fertilization, oats-vetch w/o removal and with fertilization, bush beans w/o residue removal w/o fertilization and oats-vetch w/o removal and w/o fertilizer.	2.92	40.98	1.55 a	20.75
T3=No-till hard maize with fertilization, oats-vetch with removal and fertilization, bush beans with residue removal without fertilization and oats-vetch with removal and without fertilization.	3.35	45.70	1.20 b	16.50
T4= No-til hard maize with fertilization, oats-vetch w/o removal and with fertilization, bush beans w/o residue removal with fertilization and oats-vetch w/o removal and without fertilization.	3.13	46.64	1.18 b	18.81

Different letters indicate statistical significance ($P < 0.05$).

Soil chemistry

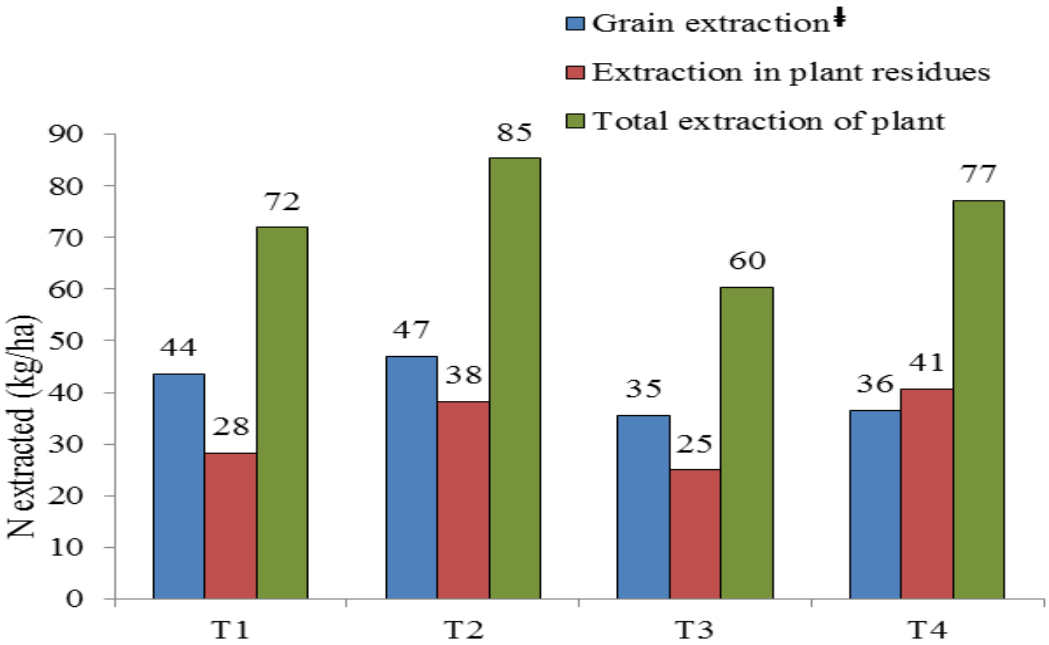
The soil chemistry tests (table 11) show a significant impact of vegetative cover and tillage on certain variables such as $N\text{-}NO_3^-$ and $N\text{-}NH_4^+$. This effect is strongest during the first 30 days after bean planting at a depth between 0 and 5 cm for $N\text{-}NH_4^+$ and 5 to 10 cm for $N\text{-}NO_3^-$. At 30 days and at a depth of 5 to 10 cm, the concentration of $N\text{-}NH_4^+$ was lowest in T2 and greatest in T4, demonstrating the effect of tillage and ground cover ($P<0.05$). The concentration of $N\text{-}NH_4^+$ is greater with no-til and slightly lower with reduced tillage; this effect is likely due to the oxidation of $N\text{-}NH_4^+$ even with minimum tillage. With respect to $N\text{-}NO_3^-$ at 30 days and at 0-5 cm, the concentration was greatest in T2 and lowest in T4, indicating a different tendency.

The highest concentrations of N and C were found at the superficial level (0-5 cm), independent of the treatments, demonstrating the effect of accumulation of vegetative residues and a stratification of biological activity.

Table 11. Means and and results of Tukey test (At P = 0.05) for soil chemical variables, bush bean cycle (old trial), Alumbre-Ecuador. Treatment definitions are the same than those in Table 10.

Treatment	Time	TN	TOC	N-NO_3^-	N-NH_4^+	PMN	PMNIS	POM
	DAP			ppm		%COT		
T1	30	0.59	6.7	47.9 a	20.9 a	20.9 b	469.0 c	0.73
	60	0.59	6.5	9.2 b	15.4 b	35.1 a	584.1 b	0.73
	90	0.60	6.5	14.7 b	22.9 a	26.1 ab	665.6 a	0.71
T2	30	0.60	7.0	65.4 a	20.4 ab	23.7	499.8 b	0.83
	60	0.61	6.9	9.3 b	17.1 b	36.7	601.2 a	0.86
	90	0.60	6.8	20.7b	24.3 a	27.3	652.7 a	0.94
T3	30	0.60	6.6	48.4 a	20.7 ab	19.9 b	486.7 b	0.74
	60	0.59	6.5	5.4 c	14.8 b	37.0 a	584.4 a	0.75
	90	0.57	6.5	16.3 b	24.3 a	19.1 b	644.4 a	0.76
T4	30	0.58	6.6	44.0 a	24.2 a	22.1 b	491.3 b	0.79
	60	0.60	6.6	8.0 b	17.6 b	38.2 a	575.8 a	0.79
	90	0.60	6.7	13.7 b	23.6 a	22.3 b	622.7 a	0.74

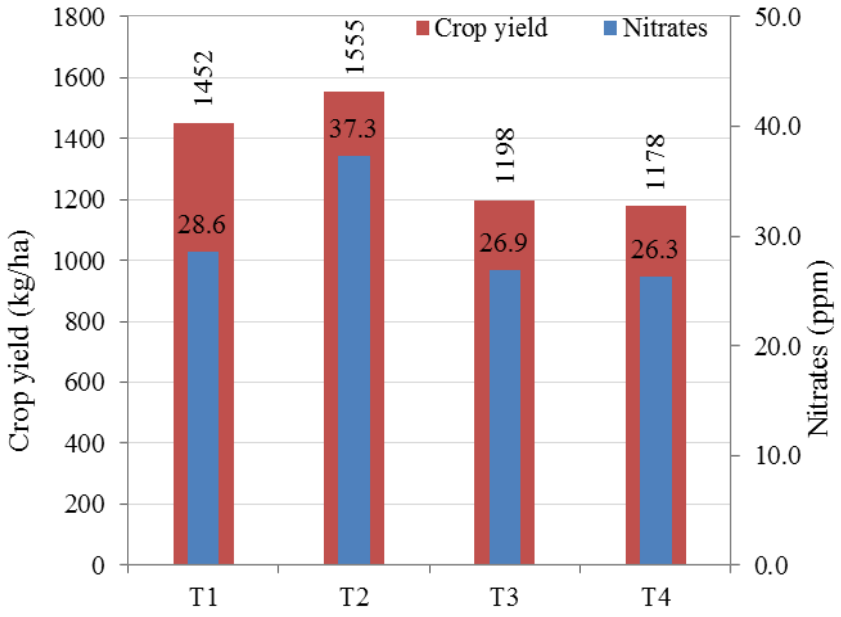
TN: total nitrogen; TOC: total organic carbon; PMN: potentially mineralizable nitrogen by aerobic incubation; PMNIS: potentially mineralizable nitrogen by Illinois soil nitrogen test; POM: particulate organic matter; DAP: days after planting; PPM: parts per million. With removal = cut residue and use as animal feed or sell. Bean plant is completely removed.W/o removal = cut residue and leave on surface.



T1: Minimum tillage with removal of oats-vetch, bush bean without fertilization.
T2: Minimum tillage with incorporation of oats-vetch, bush bean without fertilization.
T3: No-till with removal of oats-vetch, bush bean without fertilization.
T4: No-till with incorporation of oats-vetch , bush bean without fertilization.

Figure 5. Nitrogen from bean grain, plant residues and entire plant by treatment (old trial), Alumbre-Ecuador, 2012.

Results for nitrogen from the grain, plant residues, and total plant (for beans) show only minor differences by treatment (figure 5). However, extraction of nitrogen from the bean grain showed a positive impact of minimum tillage ($P<0.05$); this effect reflects the higher bio-availability of $N\text{-}NO_3^-$,and is also reflected in the higher yield. Nitrogen levels in plant residues and total plant (bean) are higher in treatments with incorporation of the oats-vetch, reflecting increased availability of potentially mineralizable N.



T1: Minimum tillage with removal of oats-vetch, bush bean without fertilization.
T2: Minimum tillage with incorporation of oats-vetch, bush bean without fertilization.
T3: No-till with removal of oats-vetch, bush bean without fertilization.
T4: No-till with incorporation of oats-vetch , bush bean without fertilization.
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Figure 6. Relationship between N-NO_3- and bush bean yield by treatment, Alumbre-Ecuador, 2012.

Physical soil measures

Results from the physical analysis of the soils indicate no statistically significant differences across treatments (Table 12). Differences in bulk density (PB), gravimetric soil moisture content (Θg) and compaction were not significantly affected by tillage (minimum and zero tillage) type.

Table 12. Mean values of physical soil measures undermaize-beans (old trial), Alumbre-Ecuador. Treatment definitions are the same than those in Tables 10 and 11.

		P_B g/cc	Θ_g %	Soil compaction kgF/cm²		
Treatments				**High**	**Low**	**Mean**
T1		0.82	59.3	74	86	80
T2		0.80	61.7	65	74	69
T3		0.78	62.4	70	86	78
T4		0.81	62.8	78	75	76
	Mean			**72**	**80**	**76**
Effect						
Tillage	Minimum	0.81	60.5	70	80	75
	Zero	0.80	62.6	74	80	77
Cover	With removal	0.80	60.8	72	86	79
	W/o removal	0.81	62.3	72	74	73
Depth (cm)						
0-10				56	53	54
10-20				61	69	65
20-30				75	85	80
30-40				94	114	104

With removal = cut residue and use as animal feed or sell. Bean plant is completely removed. W/o removal = cut residue and left on surface.

Partial Budget analysis

The marginal rate of return (13%) indicates that when maize-bean producers in Alumbre move from T4 (no-till, oats-vetch w/o removal, and beans w/o removal) to T2 (minimum tillage, oats-vetch w/o removal, and beans w/o removal), they obtain an additional USD 0.13 per dollar invested in the change of technology (tables 13 and 14). The difference is due to changes in tillage. Note that values of physical and chemical changes in the soil are not included in this analysis, but these results indicate that benefits of the CAPS will only grow over time. Current analysis shows small

differences in net returns, but each of the treatments represents a small improvement over the control (T1); these differences are likely to grow over time.

Table 13. Dominance analysis for study treatments. Alumbre-Ecuador, 2011-2012. Treatment definitions are the same than those in Tables 10 to 12.

Treatments	Gross returns ($/ha)	Variable costs ($/ha)	Net returns ($/ha)	Dominance*
T2	14 438	3 514	10 924	Not dominated
T4	14 175	3 281	10 894	Not dominated
T3	14 243	3 387	10 856	Dominated
T1	14 385	3 629	10 756	Dominated

* A treatment dominates another when it has higher net benefits and lower variable costs than another.

Table 14. Marginal rate of return. Alumbre-Ecuador, 2011-2012. Treatment definitions are the same than those in Tables 10 to 13.

Treatments	Gross returns ($/ha)	Variable costs ($/ha)	Marginal net benefit ($/ha)	Marginal variable costs ($/ha)	Marginal rate of return (%)
T2	10 924	3 514	30	233	13
T4	10 894	3 281	0	0	

Evaluation of cropping systems, tillage, cover crops and rotations in the maize-beans system in Alumbre, Ecuador (new trial)

Figure 7. Maize-beans system with oats vetch cover (new trial), Alumbre-Ecuador, 2012.

Agronomic variables

The analysis of the yield variables for the new treatments shows no statistically significant difference (P>0.05) across the treatments for the first cycle and the bean crop (table 15). However, biomass yields of T4 and T3 were significantly higher in the second cycle. Apparently, the residuals are leading to higher biomass production over time; these findings justify a longer-term approach to evaluating CAPS in the Andean region.T4 attained a yield of more than three times that of the control.

Table 15. Mean values and results of Duncan test (at P = 0.05) for biomass (grass and/or oats-vetch), yields of beans (new trial). Alumbre-Ecuador, 2011 - 2012.

Treatments	1st cycle, biomass (t/ha)	Total bean yield (t/ha)	2nd cycle biomass (t/ha)
T1= Minimum tillage, natural grass with removal, bush beans with removal and fertilizer, and natural grass with removal (control).	18.72	1.38	7.25 b
T2= No-till, natural grass w/o removal, bush beans with removal and with fertilization, natural grass without removal.	17.79	1.32	7.02 b
T3= No till, oats-vetch with removal and fertilization, bush beans with removal and w/o fertilization, and oats-vetch w/ removal and w/o fertilization.	19.57	0.99	12.43 b
T4= No-till, oats-vetch w/o removal and w/ fertilization, bush beans w/o removal and w/o fertilization, and oats-vetch w/o removal and w/o fertilization.	23.94	1.07	23.98 a

With removal = cut residue and use as animal feed or sell. Bean plant is completely removed.
W/o removal = cut residue and leave on surface.

Soil chemistry

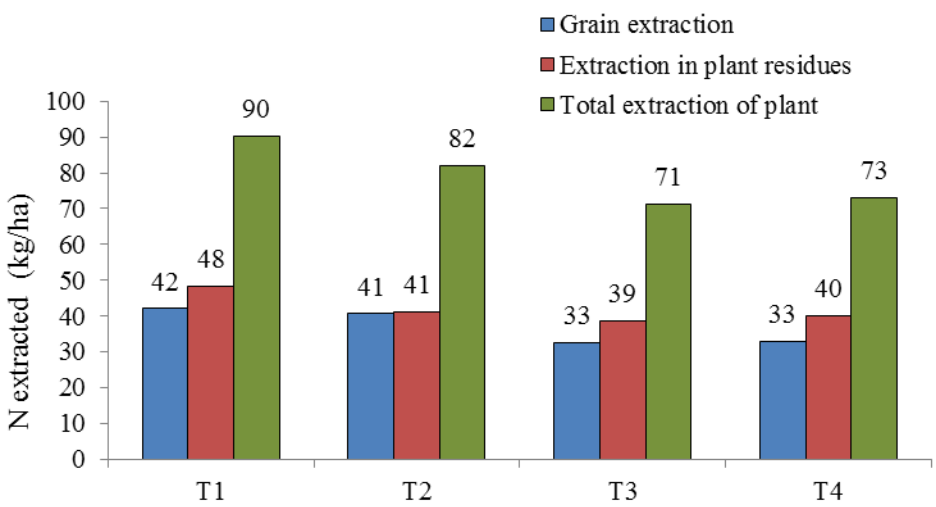
The soil chemistry analysis shows a significant effect of vegetative cover and tillage type on TN, COT and N-NH_4^+ (table 16). The largest of these effects were found at the superficial level (0 a 5 cm), and at 30 days from planting for TN, COT, and at 30 and 90 days for N-NH_4^+. At 30 days, the largest concentrations of TN, COT and NH_4^+ were found in T2 and the smallest in T3. At 90 days, the largest concentrations of NH_4^+ were found in T3 and T4, indicating an increased ammonization due to accumulation of organic material in the soil.

Results following nitrogen extraction from the grain and plant residuals (figure 8) do not show statistically significant differences across treatments, but more N was present in the plants in T1. This difference is also reflected in yield differences (Figure 9).

Table 16. Means and results of Tukey test (at P = 0.05) for soil chemistry indicators (new trial).

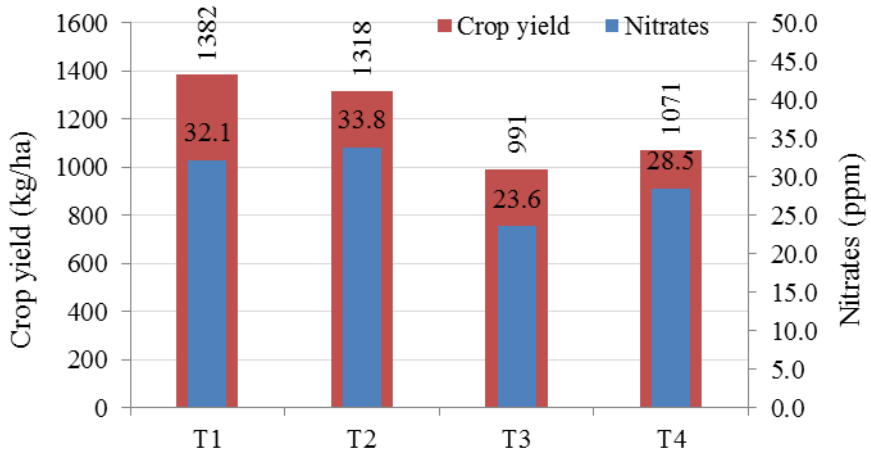
Treatments	Timing	NT	TOC	N-NO_3^-	N-NH_4^+	PMN	PMNIS	POM
	DAP	ppm				%TOC		
T1	30	0.53 b	5.9 b	49.7 a	24.9	15.0 b	552.8 b	0.77
	60	0.58 ab	6.3 ab	14.6 b	20.7	33.6 a	596.4 ab	0.95
	90	0.59 a	6.4 a	17.0 b	26.2	19.1 b	679.6 a	1.09
T2	30	0.59	6.7	48.3 a	25.2 b	27.1 ab	567.7	1.03
	60	0.62	6.7	19.4 b	15.9 c	39.2 a	611.6	1.21
	90	0.61	6.8	15.7 b	29.7 a	20.9 b	639.6	1.23
T3	30	0.54 ab	5.9 b	38.0 a	22.4 b	22.4	480.6 c	0.98
	60	0.58 a	6.3 ab	9.1 c	16.7 b	26.0	550.5 b	1.14
	90	0.59 a	6.6 a	21.2 b	34.5 a	23.8	641.1 a	1.16
T4	30	0.58 b	6.5 b	46.1 a	26.0 b	21.0	545.7 b	0.91 b
	60	0.59 b	6.4 b	10.9 c	18.5 c	29.1	613.2 a	1.19 ab
	90	0.63 a	7.1 a	25.2 b	35.5 a	27.4	623.4 a	1.43 a

Tn: total nitrogen; TOC: total organic carbon; PMN: potentially mineralizable nitrogen by aerobic incubation; PMNIS: potentially mineralizable nitrogen by Illinois soil nitrogen test; POM: particulate organic matter; DAP: days after planting; PPM: parts per million. With removal = cut residue and use as animal feed or sell. Bean plant is completely removed.W/o removal = cut residue and leave on surface.



T1: Minimum tillage with removal of natural pasture, bush bean with fertilization.
T2: No-till with incorporation of natural pasture, bush bean with fertilization.
T3: No-till with removal of oats-vetch, bush bean without fertilization.
T4: No-till with incorporation of oats-vetch , bush bean without fertilization.

Figure 8. Soil nitrogen extracted (new trial),Alumbre-Ecuador, 2012



T1: Minimum tillage with removal of natural pasture, bush bean with fertilization.
T2: No-till with incorporation of natural pasture, bush bean with fertilization.
T3: No-till with removal of oats-vetch, bush bean without fertilization.
T4: No-till with incorporation of oats-vetch , bush bean without fertilization.

Figure 9. Relationship between N-NO_{3-} and bean yield (new trial), Alumbre-Ecuador, 2012

Physical indicators

No statistically significant differences were found across the treatments in the new trials (table 17).

Table 17. Mean values of physical soil indicators (new trial), Alumbre-Ecuador, 2012.Treatment definitions are the same than those in Tables 15 and 16.

	Soil Compaction kgF/cm²			
Treatments	**High**	**Low**	**Median**	**Mean**
T1	61	57	77	65
T2	56	65	49	57
T3	52	50	58	53
T4	63	65	77	68
Mean	**58**	**59**	**65**	**61**
Depth (cm)				
0-10	43	40	48	43
10-20	51	51	47	60
20-30	58	58	65	73
30-40	80	80	85	80

Economic analysis

Treatment T4 has by far the highest gross and net returns, with a net return of more than twice that of the others (table 18 and 19). The no-till system has slightly higher variable costs compared to T1 and T2 (and thus does not dominate them), but differences in net returns are striking.These differences carry over to the marginal budget analysis, where the net marginal benefits (of over 500%) show that T4, as of this stage in the trial, is far superior to the control (T1) and other treatments. The source of this superiority is the very high yields of the cover crops; it is hoped that subsequent maize yields are also high.

Table 18. Dominance analysis (new trial), Alumbre-Ecuador, 2011 - 2012.Treatment definitions are the same than those in Tables 14 to 16.

Treatments	Gross benefit ($/ha)	Variable costs ($/ha)	Net benefit ($/ha)	Dominance
T4	5 610	1 875	3 735	Not dominated
T3	3 690	1 988	1 702	Dominated
T1	3 246	1 508	1 738	Not dominated
T2	3 128	1 405	1 723	Not dominated

*A treatment dominates another when it has higher net benefits and lower variable costs than another.

Table 19. Marginal rate of return for various treatments, Alumbre-Ecuador, 2012.Treatment definitions are the same than those in Tables 14 to 17.

Treatments	Gross benefit ($/ha)	Variable costs ($/ha)	Marginal net benefit ($/ha)	Marginal variable costs ($/ha)	Marginal net return (%)
T4	3 735	1 875	1 997	367	544
T1	1 738	1 508	15	103	15
T2	1 723	1 405	0	0	

Evaluation of cropping systems, tillage, and rotations in potato (*Solanum tuberosum*) Illangama, Ecudaor (old trial)

Figure 10. Potato-pasture system, including barley (old trial), Illangama-Ecuador, 2012

Agronomic variables

An analysis of variance revealed differences across the treatments (table 20). The Duncan tests (at P = 0.05) showed that T6, with conventional tillage, had a statistically significant highest yield of potatoes. Reduced tillage yields were highest in T4, and both T6 and T4 leave the oats-vetch as groundcover. In fact, all the treatments where groundcover was maintained had greater potato yields compared to the same treatment with removal (except T7 and T8, both of which had lower yields than the other treatments). Thus CA, which implies less labor, is equal to or better than the conventional alternatives. No significant differences in wet yield of the cover crop were observed.

Table 20. Means and results of Duncan test (at P = 0.05) for crop yield, Illangama-Ecuador, 2011-2012.

Treatment	Potato yield tons/ha	Biomass, oats-vetch tons/ha
T1= With deviation ditches, conventional tillage, potato w/ fertilizer, oats-vetch w/removal and w/o fertilization.	10.45 b	41.25
T2= With deviation ditches, conventional tillage, potato w/ fertilizer, oats-vetch w/o removal and w/o fertilization.	14.40 ab	39.76
T3= With deviation ditches, reduced tillage, potato w/ fertilizer, oats-vetch w/ removal and w/o fertilization.	9.17 b	37.92
T4= With deviation ditches, reduced tillage, potato w/ fertilizer, oats-vetch w/o removal and w/o fertilization.	13.69 ab	43.13
T5= W/o deviation ditches, conventional tillage, potato w/ fertilizer, oats-vetch w/removal and w/o fertilization (control).	15.28 ab	37.74
T6 W/o deviation ditches, conventional tillage, potato w/ fertilizer, oats-vetch w/o removal and w/o fertilization.	16.85 a	43.13
T7= W/o deviation ditches, reduced tillage, potato w/ fertilizer, oats-vetch w/removal and w/o fertilization.	9.06 b	43.99
T8= W/o deviation ditches, reduced tillage, potato w/ fertilizer, oats-vetch w/o removal and w/o fertilization.	9.01 b	36.63

Physical soil variables

We conducted the same analysis of physical characteristics of the soil and differences were not statistically significant (table 21). In general, the CA practices show minimal improvement in soil characteristics.

Table 21. Means of physical soil measurements, old potato-pasture trial, Illangama-Ecuador, 2012. Treatment definitions are the same than those in Table 20.

Treatment		P_B g/cm^3	Θ_g %	Soil compaction kgF/cm^2		
				High	Low	Mean
T1		0.85	49.2	89	83	86
T2		0.83	48.3	86	83	85
T3		0.85	50.4	91	91	91
T4		0.84	50.3	94	74	84
T5		0.92	47.9	87	85	86
T6		0.83	47.0	113	91	102
T7		0.84	50.3	98	72	85
T8		0.90	49.8	81	97	89
Mean		**0.86**	**49.2**	**92**	**85**	**88**
	Ditches	With		0.84	49.6	90
		Wo		0.87	48.8	94
	Tillage	Conventional		0.86	48.1	94
		Reduced		0.86	50.2	91
	Cover	With removal		0.87	49.5	91
		W/o removal		0.85	48.9	93
	Depth (cm)					
	0-10					26
	10-20					68
	20-30					121
	30-40					154

Economic analysis

Each of the "even" treatments, containing an oats-vetch option without removal dominated the other treatments (table 22). This is clear evidence of the benefits of continuous ground cover, and we expect those treatments to have higher barley yields as the next component of the rotation. As we do not include the cost of establishing the deviation ditches in these budgets, we question their economic rationale. Any economic benefit from the use of deviation ditches will only emerge over time as soil depth is enhanced and fertility grows compared to no ditches (a result of lower erosion).

Table 22. Dominance analysis of economic results (old trial), Illangama-Ecuador. Treatment definitions are the same than those in Tables 20 and 21.

Treatments	Gross benefit ($/ha)	Variable costs ($/ha)	Net benefit ($/ha)	Dominance
T6	9 874	3 060	6 814	Not dominated
T4	8 831	2 991	5 840	Not dominated
T2	8 728	2 974	5 754	Not dominated
T5	8 816	3 180	5 636	Dominated
T1	7 574	3 066	4 508	Dominated
T7	7 389	2 998	4 391	Dominated
T3	6 818	3 033	3 785	Dominated
T8	6 636	2 873	3 763	Not dominated

Treatments T1, T3, T5 and T7 are all dominated by the "even" treatments. The rate of return analysis (table 23) shows that the "even" treatments are all preferred to the odd one (removal of the ground cover). Rates of return are quite high and show the value of groundcover as an economically viable option. Differences between the "even" treatments are due to use of deviation ditches and tillage (T6 uses conventional tillage, but T4 and T2 use reduced tillage). These results are relatively promising, as differences will only grow over time as soil health improves under CA.

Table 23. Marginal rate of return (old trial), Illangama-Ecuador, 2011-2012. Treatment definitions are the same than those in Tables 20 to 22.

Treatments	Gross benefit ($/ha)	Variable costs ($/ha)	Marginal net benefit ($/ha)	Marginal variable costs ($/ha)	Marginal net return (%)
T6	6 814	3 060	974	69	1 412
T4	5 840	2 991	86	17	506
T2	5 754	2 974	1 991	180	1 106
T8	3 763	2 794	0	0	

Evaluation of systems of tillage, soil use, fertilization and rotations in potato-pasture system (new trial), Illangama Ecuador

Figure 11. New trial with oats-vetch, Illangama-Ecuador, 2012

Agronomic variables

Potato yields were found to vary among treatments (table 24), but oats-vetch yields were not statistically different ($P<0.05$). T1, T2 and T3 were all statistically different from T4 (which was included to see the impact of reduced nitrogen applied to potatoes). Once again, the CA treatments had yields that were indistinguishable from the conventional (T1); these treatments imply lower labor costs and long-term benefits to enhanced soil health.

Table 24. Means and results of Duncan test (at P = 0.05) for yield (new trial), Illangama-Ecuador, 2011-2012.

Treatment	Potato yield tons/ha	Biomass, yield, oats-vetch tons/ha
T1= Conventional tillage, pasture with removal, potato with fertilization, and oats-vetch with removal and w/o fertilization (control)	15.81 a	36.98
T2= Reduced tillage, pasture with removal, potato with fertilization, and oats-vetch with removal and w/o fertilization	13.97 a	34.06
T3= Reduced tillage, pasture with w/o removal, potato with fertilization, and oats-vetch w/o removal and w/o fertilization	14.55 a	32.54
T4= Reduced tillage, pasture with w/o removal, potato with fertilization (no added N), and oats-vetch w/o removal and w/o fertilization	5.39 b	24.13

Soil chemistry and physical measures

No statistically significant difference was observed across the treatments (table 25). Similarly, no statistically significant differences in physical properties of the soil were found (table 26).

Table 25. Means and results of Duncan test (at 5%) for soil chemistry indicators, Illangama-Ecuador. Treatment definitions are the same than those in Table 24.

Treatment	NH_4^+ ppm	P ppm	K meq/100 ml	pH	MO %
T1	100.00	16.00	0.26	6.48	10.03
T2	97.33	16.33	0.22	6.54	9.76
T3	97.33	15.33	0.21	6.45	9.56
T4	95.00	16.33	0.19	6.45	9.56

Table 26. Physical soil properties (new trial), Illangama-Ecuador, 2012. Treatment definitions are the same than those in Tables 24 and 25.

Treatment	P_B g/cc	Θ_g %	Compaction kgF/cm²			
			High	Medium	Low	Mean
T1	0.85	52.0	74	72	80	75
T2	0.88	52.3	94	98	103	98
T3	0.92	51.2	86	97	95	93
T4	0.85	52.3	94	110	79	94
Depth (cm)						
0-10			26	25	27	26
10-20			54	55	56	55
20-30			112	134	120	122
30-40			156	163	153	158
Mean	**0.87**	**52.0**	**87**	**94**	**89**	**90**

Economic analysis

T1 and T3 dominate the other treatments, with the difference in yield for T1 creating the greatest net benefit to farmers (table 27).

Table 27. Dominance analysis of economic results (new trial), Illangama-Ecuador, 2011-2012.. Treatment definitions are the same than those in Tables 25 to 27.

Treatments	Gross benefit ($/ha)	Variable costs ($/ha)	Net benefit ($/ha)	Dominance
T1	8 915	3 233	5 682	Not dominated
T3	8 056	3 017	5 039	Not dominated
T2	8 016	3 153	4 863	Dominated
T4	4 192	2 624	1 568	Not dominated

T1 (i.e., current practices) provides the highest returns, calculated either on a total or marginal basis (table 28). It provides $298 additional per hectare compared to T3, but is also associated with higher variable costs.

Table 28. Marginal rates of return (new trial), Illangama-Ecuador, 2011. Treatment definitions are the same than those in Tables 24 to 27.

Treatments	Gross benefit ($/ha)	Variable costs ($/ha)	Marginal net benefit ($/ha)	Marginal variable costs ($/ha)	Marginal net return (%)
T1	5 682	3 233	643	216	298
T3	5 039	3 017	3 471	393	883
T4	1 568	2 624	0	0	

Main experimental results: Bolivia

The Bolivia project has made excellent progress on this task, establishing experiments on:

1. Direct seeding quinoa with oat cover crop.
2. Field testing of *Bacillus* strains for improving phosphorus availability.
3. Optimizing irrigation regimes for potato.
4. Forage variety trials, including forage mixes (in collaboration with CIF).
5. Prototype development for a high residue quinoa planter.

1. Effect of use of cover crop vetch (*Vicia dasycarpa*) as a component of a CA rotation, from the experiment at 15 de Octubre in Tiraque: This experiment was designed to determine the effect of *Vicia dasycarpa* as a cover crop and its impact on potato as the second crop in the CA cycle. We were unable to identify significant differences in potato productivity regardless of whether the vetch was incorporated into the soil or left as a groundcover. It is likely that the lack of impact was due to the short time between the end of the first cycle and the planting of potatoes (two months), during which the vetch could not decompose. In contrast, during the third part of the cycle, when biomass was being produced (vetch associated with oats), the trials where vetch had been established earlier produced more biomass, particularly oats. Another positive effect of the use of vetch was weed control and in subsequent trials, this effect is likely to increase in importance.

2. Evaluation of cover crops of vetch (*Vicia dasycarpa*) and vetch associated with oats (*Avena sativa*) as a component of CAPS (first year): The main focus was on dry yield of biomass and impacts on the soil during the first year of a CA rotation. We had parcels in Tiraque (Sancayani Alto and Waylla Pujru) and Anzaldo (Phinquina), where we compared findings to the traditional fallow. Treatments were: T1 traditional fallow; T2 vetch and oats to remove; T3 vetch and oats as cover crops. We evaluated crops yields and soil health indicators, with the latter currently undergoing analysis. The production data show yields of greater than 12 t/ha of dry mass, which is greater than that found in other studies (figures 12 and 13). During the same period we experimented in various seeding practices, including seed dispersion by hand, vetch by itself, and vetch in rows.

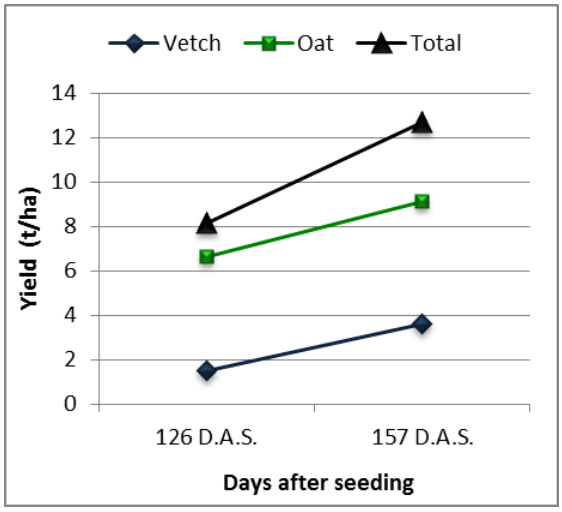


Figure 13. Biomass yield at Sankayani Alto for oat-vetch intercropping

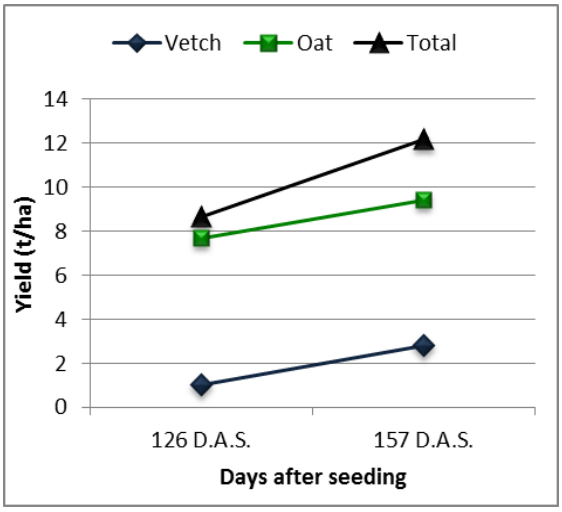


Figure 12. Yield in biomass at Waylla Pujru for oat-vetch intercropping

Economic analysis of T2 showed a net benefit (including all variable costs) of approximately USD 49 per hectare. The value of the forage for T3 needs to be measured in terms of its increment to production in subsequent cycles. Economic analysis of the different planting methods showed no significant difference.

Figure 14: Biomass yield in Sancayani Alto, Bolivia, 2012

3. Technical and participatory evaluation of systems of legume and cereal production as vegetative cover in two communities in Tiraque: The objective is to identify promising crops to include in a CAPS rotation. We examined three legumes (*Vicia villosa*, *Vicia dasycarpa*, and peas) and three cereal (oats, triticale and barley) species alone and in association. The technical analysis showed that the cereal species produced more biomass (wet and dry yield) than the legumes. Among cereals, oats were the highest producers. Oats were also most successful associated with *Vicia dasycarpa* and *Arveja* var. petit poa. Triticale produces the most biomass when planted in pure stands, but, in general more total biomass results when the cereals are planted in association with legumes. The participatory assessment showed that stakeholders were interested in producing

cover crops, but women prefer crops that can be sold or used to feed the family, while men were more interested in forage production. Both groups were interested in trying associated cover crops in their own parcels.

4. Effect of vegetative cover in quinoa production: We evaluated the impacts of mulch from cereal and vetch straw, measuring impacts in terms of plan height, seed head size, and cereal yields. Results show clearly that mulch improves soil moisture (especially important in moisture-stressed areas where the crop is grown). All measures, and particularly yield, were significantly higher when using the mulch (figures 15 and 16). Economic analysis is still being conducted.

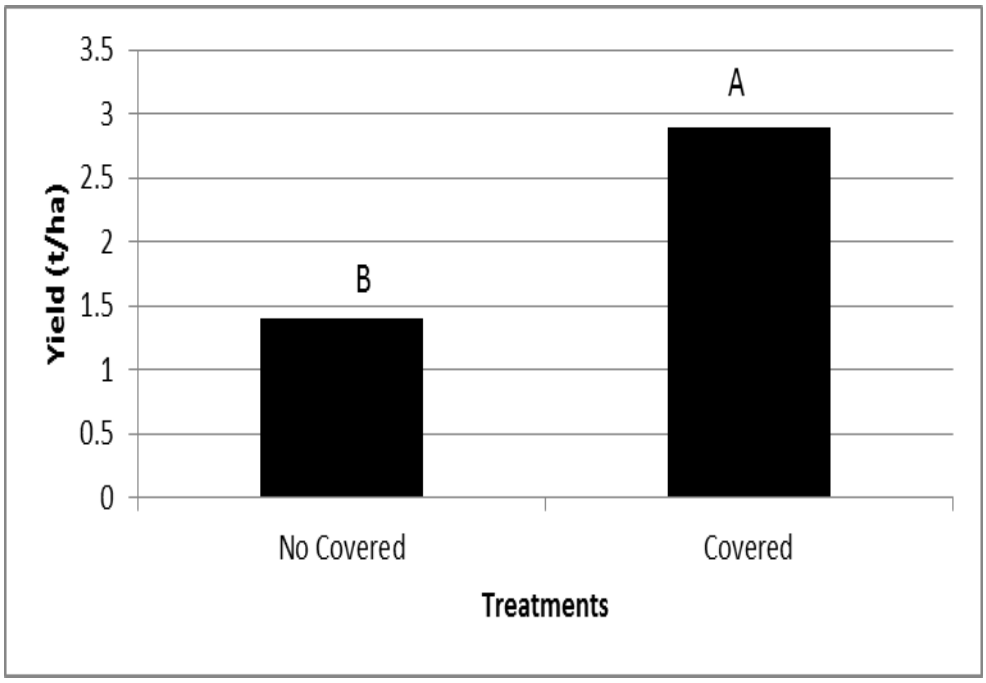


Figure 15. Effect of mulch on grain yield, quinoa, Bolivia, 2012

Figure 16. Effect of mulch on quinoa growth, Bolivia, 2012

5. Effect of the bacteria *Bacillus pumilus* as a solubilizer of phosphorus to improve availability in a potato crop, and effect on potato productivity as a complement to potato production systems: As the soils around Tiraque are notoriously phosphorus deficient, there was hope that *Bacillus* could be used to improve phosphorus availability. Our trial showed no significant effect of the bacteria on plant emergence, leaf development, plant height, or yield. We found high concentrations of the microorganism in the rhizoplane and rizosphere and not on the interior of the plant (roots, tubers, leaves and stems), and suspect that either the plant is resistant or competing local microorganisms prevented uptake by the potato. We are continuing to evaluate the phosphorus content from soil samples with the intent of seeing whether the bacteria has effectively solubilized it, but growth effects on the plants were not detected. We will continue with this trial in subsequent crop cycles.

6. Effect of three (alternative) frequencies of irrigation in potato cultivation: As irrigation water is scarce in the Tiraque area, this experiment was designed to measure the effect of lower-frequency irrigation on potato yields during the dry season (Mishka). Three treatments were established: T1—farmer practices (weekly irrigation); T2—bi-weekly irrigation; and T3—irrigation every three weeks. The main measured effect of the alternate regime was related to maturity; frequent irrigation leads to a two-week advance in tuber maturity. T2 and T3 plant growth lagged behind that of T1, but eventually the tuber was harvest ready and no yield effects were found. An economic analysis is proposed as farmers in the area note that market prices spike significantly prior to harvest and early availability may present an economic benefit.

Figure 17. Mishka potato with irrigation in Tiraque, Bolivia, 2012

7. Development of CA practices for quinoa in Tiraque: Farmers in the Tiraque area have become increasingly interested in planting quinoa in their potato rotations as quinoa prices have recently reached record highs, quinoa yields in the area are relatively high, and quinoa is a good candidate in a potato rotation. A key challenge for CA in small-scale quinoa production is seeding. Seeding tools for quinoa have been developed for the altiplano where planted areas are high and the topography is flat. In contrast, farmers in the hillside areas and inter-Andean valleys of Bolivia

have small extensions and much of the terrain is undulating. As a part of our CA package, we needed to adapt seeding techniques for quinoa under such conditions. This adaptation was comprised of two components: (i) agronomic experiments to identify the optimal seed depths under a direct seeding system; and (ii) development of a direct seeder. Our agronomic experiments were completed this year, and together with CIFEMA (the Centro de Investigación, Formación y Extensión en Mecanización Agrócola—a unit of the Universidad Mayor San Simón, and a SANREM partner), we developed a hand-held direct seeder and are evaluating prototypes for an oxen-drawn direct seeder (figures 18 and 19). We expect to have the oxen-drawn model completed by early 2013, and, together with CIFEMA, we are investigating models of commercialization of the seeders (figures 16 and 17).

Figure 18. Prototype for oxen-drawn direct seeder for quinoa, Bolivia

Figure 19. Hand-held direct seeder for quinoa, Bolivia

<u>Task 2.2.2:</u> Micro-liming as a method to improve phosphorus fertilizer availability in Andean soils (conducted in Ecuador)

The volcanic ash derived soils of the Andean region (Andisols and soils with Andic properties) typically have a large capacity to tightly bind phosphorus in forms that are not available for crop uptake. Resulting P deficiency reduces crop yields and contributes to soil degradation. Improving P availability and P fertilizer use efficiency is a critical component of CAPS for these soils. Kathleen Webber, M.Sc. student in Soil Science at Penn State began working on this issue for her thesis research with Stehouwer and in collaboration with Alvarado, Barrera and Valverde. The fundamental hypothesis being tested in this research is that a micro-liming approach can be used to improve P fertilizer-use-efficiency. Liming has been shown to improve P fertilizer-use-efficiency. However, the quantity of liming material required for traditional whole soil liming makes this practice logistically and economically impractical for high elevation Andean region farmers. The micro-liming approach applies the lime in a band together with P fertilizer placed below the crop row. Liming only the soil in the fertilizer band will require less than 1% as much lime needed to lime the whole soil volume.

Webber and Stehouwer travelled to Ecuador in March 2012 to discuss research plans with Alvarado, Barrera and Valverde, to collect soils from the two CAPS experiment sites for baseline analysis at Penn State, and to make arrangements for Webber to return to Ecuador to initiate a greenhouse experiment at INIAP's Santa Catalina station. Baseline soil analysis was conducted at Penn State on soils from the Illangama and Alumbre CAPS experiment. Analysis of the clay mineralogy showed a large fraction (25.9%) of the clays in the Illangama soil are amorphous and likely to have high P fixation capacity, while the Alumbre soil showed no amorphous clays.

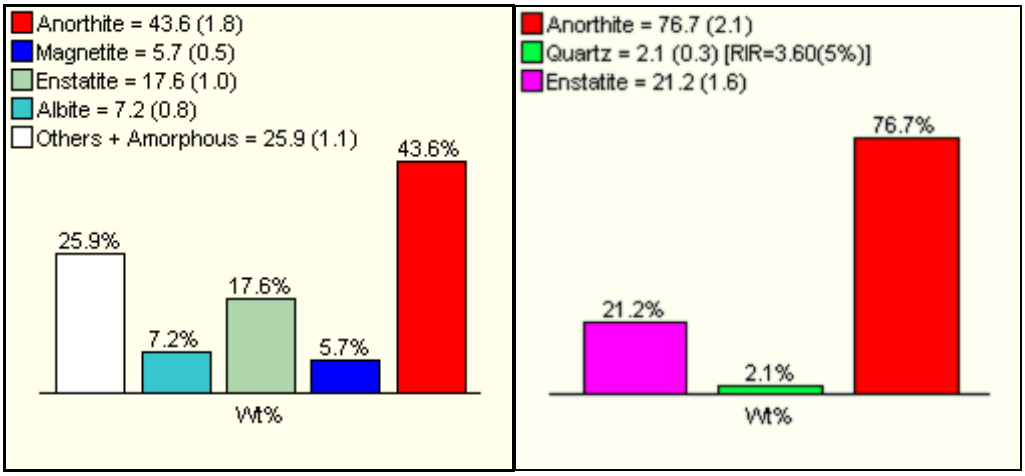


Figure 20. Clay mineralogy of Illangama (left) and Alumbre (right) soils

Webber returned to Ecuador on June 21 and stayed until August 21, 2012 to work on establishing a greenhouse experiment to test the micro-liming hypothesis. An intern, Mr. Danny Farias an undergraduate student at Universidad Central del Ecuador, was hired to work on the experiment with Webber. The experiment will also provide data for Danny's undergraduate thesis. After consultation with Alvarado, Barrera and Valverde we decided to use two Andisol soils in the experiment; 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 in a long-term liming study (the soil used in this experiment has never been limed). Characteristics of the two soils are given below.

Table 29. Characteristics of soils used in the greenhouse experiment in Ecuador.

Parameter	Unit	Soil	
		S. Catalina	Illangama
pH		5.2	6.4
P	ppm	62	11
K	meq/100g	39	0.11
Ca	meq/100g	3.8	14.7
Mg	meq/100g	0.71	1.5
Org. matter	%	11.2	9.2
Texture			
Sand	%	39	41
Silt	%	49	49
Clay	%	12	10
Class		loam	loam

Barley, which grows well in small greenhouse containers and is also an important regional crop, was used as the test crop.

Greenhouse containers were constructed (50 cm long x 30 cm wide x 30 cm tall, Figure 21). For each soil the following four treatments were applied to a 5-cm x 5-cm band of soil that ran the length of each container 5 cm below the soil surface: (1) no lime or P fertilizer, (2) lime with no P fertilizer, (3) P fertilizer with no lime, and (4) lime and P fertilizer. Barley was planted above the treatment band. All treatments were replicated three times. Two containers of each treatment were prepared so one container could be used for sequential soil sampling during the experiment, and the second could be used to measure plant growth and P uptake. Photographs of the containers and early barley growth are shown in Figure 22.

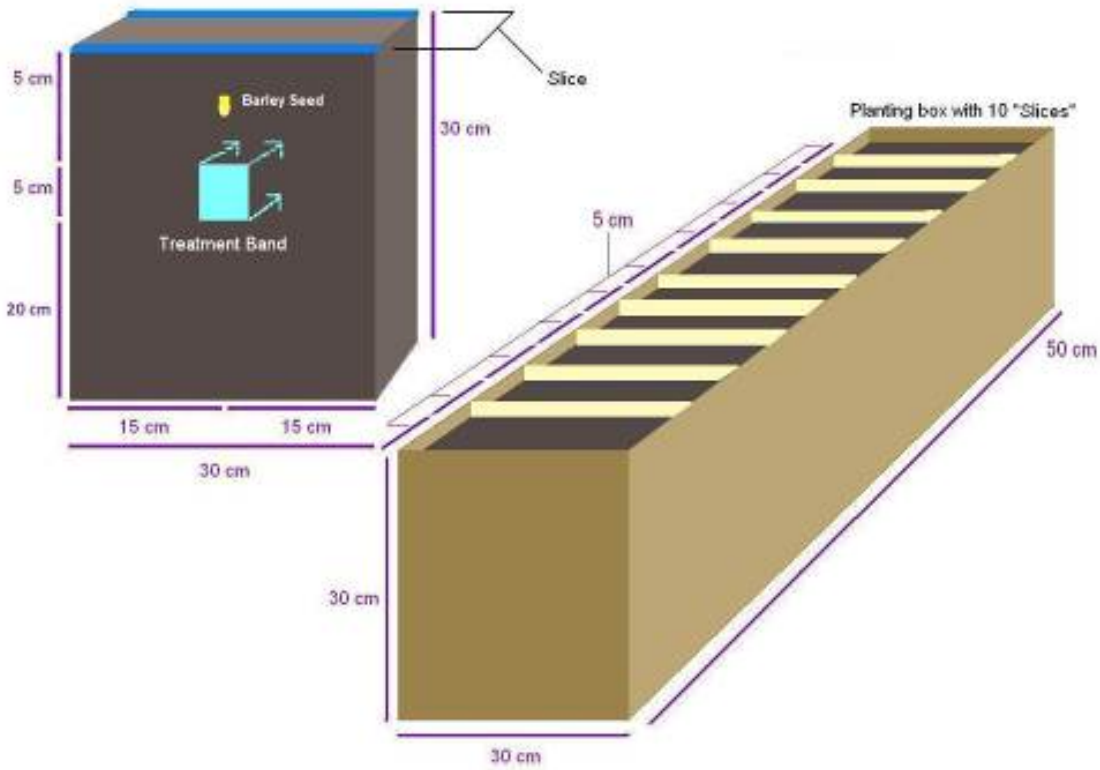


Figure 21. Design of containers used for the greenhouse experiment.

Figure 22. Barley growth at 37 days after planting. Darker green plants have both lime and fertilizer.

The experiment is in its very early stages at this time so no soil or plant analysis is yet available. Soils have been sampled two times by collecting a vertical cross section of soil. The soil cross section was then subdivided using the "cookie cutter" tool as shown in figure 23. Plant height data at the first soil sampling is given in figure 24 and suggest a very early response to the lime and P fertilizer treatments.

Figure 23. Cookie cutter soil sampling grid. Soil from emptied cells has been collected for analysis. Center empty cell represents the treatment band soil.

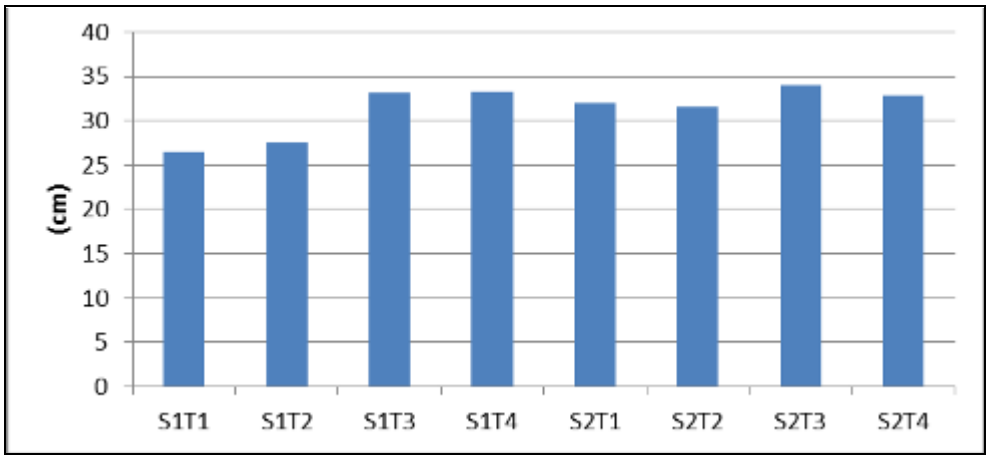


Figure 24. Barley plant height on August 15. S1, Santa Catalina soil; S2, Illangama soil. Treatments: T1, no lime or P; T2, lime no P; T3, P no lime; T4, lime and P.

The experiment will continue until November. Danny Farias will conduct soil sampling and analysis and plant sampling and analysis. Webber and Stehouwer will return to Ecuador in November to work on final sampling and data analysis.

<u>Task 2.2.3</u>: Complementary experiments: soil fertility enhancements and biological control of pests in CA.

Developing sustainable methods of enhancing crop nutrition is essential for achieving high yields with low environmental impacts. Use of microbial biofertilizers is one such method of enhancing crop nutrition. Microbial biofertilizers can either synthesize a needed plant nutrient, such nitrogen fixation by *Rhizobia*, or microbial biofertilizers can alter soil conditions to make plant nutrients

more available, such as how phosphate solubilizing bacteria provide phosphate to plants. Phosphate solubilizing bacteria make soil phosphorus more available to plants through the production of organic acids, phosphatases, or acidification through proton efflux. The most commonly studied genera of soil bacteria that are able to solubilize phosphate are *Pseudomonas*, *Rhizobia*, and *Bacillus*.

Penn State research for the SANREM CRSP has focused on *Bacillus* species able to solubilize phosphate (see description of field experiments in Bolivia, above). We focus on *Bacillus* because it is able to form environmentally stable endospores, which have a long shelf life when used as biological products. Also, our collaborators at Foundation PROINPA have the fermentation capacity and experience to produce *Bacillus* for commercial use. We have isolated *Bacillus* from *Chenopodium album* (lambsquarters, due to its close relationship to quinoa) in Pennsylvania and from quinoa from Ecuador and Bolivia. *Bacillus* isolates were obtained from roots, stems and leaves and identified to species or species group using 16S DNA sequencing. These isolates were then qualitatively tested for ability to solubilize phosphate using a standardized methodology.
On hundred and seventy-one *Bacillus* isolates from *Chenopodium album* were qualitatively tested for phosphate solubilization and 100 isolates (58%) were able to solubilize phosphorus. Three hundred and twenty-seven *Bacillus* isolates were tested from Ecuadorean quinoa plants and 204 isolates (62%) were able to solubilize phosphorus. 342 *Bacillus* isolates were also obtained from quinoa plants from Tiraque Province, Bolivia and 237 (69 %) isolates were able to solubilize phosphate. Mayra Claros visited Penn State during June 2012 for a SANREM traineeship. Ms. Claros' research at Penn State focused on developing a set of skills that could be used to improve and increase throughput in screening of *Bacillus* as plant growth promoting bacteria. Ms. Claros and graduate student Anna Testen screened 342 Bolivian isolates of *Bacillus* for chitinase production (good for biological control agents) and the ability to produce indole acetic acid, a plant hormone (good for plant growth promoting bacteria). These isolates will be transferred to PROINPA for further screening on quinoa, faba, and potato plants. Ms. Claros learned techniques to produce quality *Bacillus* inoculum and then inoculate plants with *Bacillus*. Rapid methods to screen for plant growth promotion by phosphate solubilizing bacteria were developed by Ms. Claros and Ms. Testen. Ms. Claros learned how to identify different bacterial stains and she became comfortable with molecular techniques to help identify *Bacillus* isolates to species. Ms. Claros also learned how to develop isolates of *Bacillus* that are easier to isolate from plants to measure the bacteria's ability to colonize the plant and promote growth.

The next stage of this research was to test the effects of phosphate solubilizing *Bacillus* on quinoa growth. We have begun data analysis of trials that examine the effects of phosphate solubilizing *Bacillus* on quinoa growth and nutritional status of the plant tissues. In these trials, we looked for plant growth promotion by a phosphate solubilizing isolate versus a non-phosphate solubilizing isolate with quinoa plants grown under phosphate limited conditions with one of four different phosphorus sources (iron phosphate, calcium phosphate, aluminum phosphate, and rock phosphate).

In growth chamber research, we also ran experiments to determine the ability of five pre-screened Bolivian *Bacillus* isolates (provided by our PROINPA collaborators) for their abilities to colonize quinoa roots and promote plant growth. We have typically used quinoa as a test species because

unlike most plants, it does not have mycorrhizae, so beneficial phosphate effects almost certainly are related to phosphate solubilization, or healthier roots. In addition, we simultaneously tested 4 commercially available *Bacillus* isolates for the same abilities. For neither the Bolivian isolates nor the commercial isolates, we did not observe significant plant growth promotion in these trials. In field trials with commercial isolates of *Bacillus* that are sold as plant growth promoters or disease suppressors, we also did not see significant growth promotion. To improve this research, either more screens need to be run in Bolivia under natural conditions or perhaps, we need a more genetically uniform line of quinoa.

Field Trials at Rock Springs, PA

This year H. Cheesman planted two experimental field trials evaluating several bacteria from Ecuador (and the industry standard fungicide Thiram) for effects on growth, root health, and plant nutritional status when applied to common beans (*Phaseolus vulgaris*), and in a separate test to fava bean (*Vicia faba*) with 10 seed treatments in each trial. The plots were randomized complete blocks with 6 replications of each treatment. The seed treatments compared the effects of an industry standard thiram fungicide, rhizobia and three strains of *Bacillus* (*B. pumilis*, GB34; *B. amloliquefaciens*, GB99 and *B. subtilis*, GB03/122). These treatments were applied alone and in combinations. Plants were analyzed for increased growth rates, yield weight, nutrient content, colonization (GB122 only), and nodule number, root and shoot disease. Other factors taken into consideration were number of internodes, emergence rate, plant height and shoot/root weights. These trials are still underway.

In the lab, roll towel experiments (seed rolled in absorbent paper to determine seedling growth effects without the presence of soil) were established to compare the field treatments listed above for germination percentage and seedling growth stimulation, in a controlled environment. This experiment indicated that Thiram decreased emergence rate, while GB34+Rhizobia significantly increased emergence in two experiments. GB-34 (a *Paenobacillus* sp.) is known for its ability to induce the defense systems of plants that have received GB-34 seed treatments. Future work includes determining overall root health, assessing plant growth parameters, and determining the status of the plant's nutrition.

<u>Task 2.3:</u> Create and follow protocol for measuring economic dimensions of CAPS.

These dimensions include fixed and variable costs of practices, productivity and profitability (including rotation effects and incorporation of new products), labor and time requirements, impacts on risk and variability, and gender roles. Each country team has been provided a template for collecting the needed data. As noted in the description of achievements in Ecuador under task 2.2 we are collecting cost data and already have some interesting results across the practices (see some of the results reported above).

<u>Task 2.4:</u> Adapt the Mexican nitrogen index tool to conditions in Ecuador and Bolivia.

Drs. Delgado and Gallagher visited Bolivia and Ecuador to establish protocols for collecting the data needed to calibrate the nitrogen index model (NIM). A version of this model is available in the programming language Java; farmers and extension agents in the US and Mexico use it to estimate plant uptake and losses of nitrogen in different cropping systems and thus develop nitrogen application recommendations. Data from experimental trials conducted during the prior phase of

SANREM were used to calibrate the model to represent conditions in the Bolivia and Ecuador sites. Our new results from the analysis of soils from our experimental trials are being incorporated into the prototype NIM. The index is continuously updated based on data from the field.

An activity conducted this year was used to validate the nitrogen index in Ecuador. Rosa Arévalo, a SANREM agricultural engineer used data from our maize trials in Alumbre, Ecuador, and compared actual measurements with predictions from the NI. Arévalo discovered that the NIM predicts well nitrogen needs, plant uptake and leaching. Total nitrogen in the system was 162 kg/ha/year; of this, the plant took up 54 kg and 44 kg were leached. The economic analysis from this experiment showed that the value of leached and residual nitrogen was $24 and $31, respectively. These results were compared to the NIM and the correspondence was high.

Development Impact

The results from the different CA trials in Ecuador provide substantial reason for optimism about the promise of conservation agriculture. In some cases, CA treatments are associated with superior returns compared to farmer trials, and in most cases they are at least equal. While measures of soil quality are not exhibiting substantial positive reactions to the CA practices, some evidence of positive impact may be emerging. In most cases yields of CA are at least as good as conventional practices and costs are lower. Evidence from the field (not reported here) shows that for the latest trials, CA yields are substantially higher. These results will be reported following termination of this cycle of harvest (end September, early October).

A high percentage (nearly 100%) of *Bacillus pumilus*, *B. subtilis*, *B. megaterium* and *Paenibacillus* isolates obtained in this study are able to solubilize phosphate, whereas members of the *B. cereus* group are weak phosphate solubilizers. This knowledge allows our collaborators to focus their efforts on groups of *Bacillus* that are more likely to be able to solubilize phosphate. By focusing on fewer species of *Bacillus* with desired traits, isolates can be screened much more rapidly with a greater chance of finding effective isolates.

In order to promote more widespread use of the NIM, SANREM in Ecuador has created a number of linkages, principally with the Universidad Estatal de Bolívar. These linkages allow us to use university resources to promote soil conservation and more efficient use of nitrogen in production units in Bolivar province.

Challenges and Responses

Partners in Bolivia and Ecuador have the knowhow and the necessary reagents to do the soil extractions and prepare the soils for the protocols outlined in Task 2.1. However, both are seriously behind in this task. For Bolivia, Saavedra-Rivera and González appear to be overwhelmed with the work load, although some progress was made during their winter season. However, the spring field work has recently picked up and Saavedra-Rivera has indicated that it is difficult to balance the field and laboratory tasks. Students are now being integrated into the work to help with the work load.

In Ecuador, as previously indicated, progress on processing the soil samples has been greatly hampered by 1) availability of knowledgeable laboratory personnel to process the soil samples, and 2) the lack of the necessary reagents needed to use the most efficient soil analysis protocols.

Arnulfo Portilla, under the supervision of Soraya Alvarado, has made considerable progress on the SANREM samples associated with his thesis project, but not the remaining samples. Portilla has now been hired on a full time basis to serve as the laboratory technician. Portilla is knowledgeable and dedicated, and should make up for lost time once he has a full time position with SANREM. In addition, a bacterial disease was detected on faba beans grown in the growth room. Investigation and identification of the bacterium is under way. Current possibilities are *Xanthomonas* or *Pseudomonas* species. In addition to the bacterial diseases *Fusarium* species were isolated from the vasculature of the fava beans as well as in necrotic areas on the root and stem. Leaf hoppers were also a major problem in the field with the hot and dry conditions so insecticides were applied to prevent further damage to the older tissues of these plants. Chocolate spot caused by *Botrytis cinerea* is presently developing in the faba beans.

Objective 3: Promote adoption of the most appropriate CAPS by identifying mechanisms to increase their profitability

Critical Research Accomplishments/Development Impacts

Task 3.1: Explore the potential for increased local input production.
Ecuador: In Ecuador, farmers have achieved a delicate balance between land use for farming and other alternatives. Over the years, there have been significant efforts in the project areas to introduce plans for reforestation of the more degraded areas. The analysis of vulnerability (to erosion and soil degradation) conducted in the prior phase of SANREM identified areas where reforestation was possible and areas where small-scale agroforestry systems could assist in retaining soils and provide inputs for fuel wood and stakes for perennial crops. These efforts will raise local incomes and make CA more likely to be profitable and environmentally sustainable. In the current year, we had an ongoing woodland-related output: continued operation of a nursery with funding from USAID in Mulanga (also the upper watershed). This nursery, funded with a $5,000 grant from the USAID Ecuador mission, is providing seedlings of native tree and bush species to aid in reforestation in the more vulnerable areas of the upper watershed.

In addition, three native hardwood species were planted in the past as part of a "silvo-pastoral" experiment by the SANREM team, in the Illangama Watershed. Growth and survival of this plantation was poor, and the community was not encouraged by these results. The poor performance was due in part to lack of care following planting, grazing by livestock, and possible damage from wind. Seven native hardwood tree and shrub species have been identified as appropriate candidates for future reforestation projects. Local stakeholders expressed a strong desire to work with native species, as their experience with pine has been uniformly bad. All species have been planted at various sites, and there are mixed results on their performance. Opportunities for producing saw log-grade hardwoods from planted native species in the Illangama watershed is limited, based on observations of growth rates and stem form quality in existing trees. Opportunities for native tree establishment for firewood production, creating windbreaks, protection of fragile sites, and to improve biodiversity are numerous.

Bolivia: The main focus of work to improve agricultural productivity and profitability within our CA system in Bolivia has been to further refine biological controls and biological inputs for improved productivity within CAPS. PROINPA (Bolivia) has a well-developed capacity (a bio-

control production facility) to produce biological organisms, but work is needed to refine the particular isolates. We are examining steps to use *Bacilli* from quinoa to control quinoa diseases. At Penn State, several experiments have been performed to isolate endospore-forming *Bacilli* from *Chenopodium quinoa* seeds. This work is ongoing. Isolates that are verified to form endospores will be checked for their ability to solubilize phosphate by utilizing the National Botanical Research Institute's phosphate growth medium. Cultures will be tested for their ability to colonize *C. quinoa* in growth chamber assays and promote growth of *C. quinoa* in a low-phosphate Andean proxy soil (actually a soil from the state of Washington with similar soil attributes to Altiplano soils). SANREM scientists are also evaluating the economics of PROINPA's potential for producing bio-inputs. Nadezda Amaya spent summer 2011 in Bolivia and conducted research to categorize potential bio-inputs in terms of their effectiveness in promoting plant growth, and lowering diseases; estimate market demand for bio-inputs at different levels-local and regional; and measure costs of production at different scales. She continued this work through 2011-2012. This research will inform decision makers about the appropriate scale of production for each of these inputs. She has completed a report on this research, which shows that for some products (particularly "biol"-a fertility enhancer), local production is economically effective. PROINPA has established a local "biol" processing plant in the Tiraque area.

Another component of our research is to lower production costs through more efficient use of irrigation. In Ecuador, we are experimenting with sprinkler irrigation, which makes for more efficient use of scarce water resources when compared to the flooding systems that are currently being used. We are evaluating the amortized cost of this investment. In Bolivia, farmers purchase "shares" of water from the irrigation scheme, and our vetch and oats trials are taking advantage of surplus (unused) water that flows through the canals and would be lost to the producer if it is not used. Both these activities are seeking cost-saving approaches to enhance the economic viability of CA.

Challenges and Responses

In both countries, labor availability is growing in importance as a constraint to profitable farming. Prices for a daily agricultural worker have nearly doubled since SANREM began its work in Ecuador and Bolivia in 2006. Growing labor costs are primarily due to outmigration of youth, but agricultural day laborers are in increasing short supply. In Bolivia, we are seeking labor-saving practices, such as the direct seeder of quinoa described above. These technologies will clearly improve the economic viability of CA. In Ecuador, our lower-till options are becoming increasingly viable as labor costs increase.

Objective 4: Design and evaluate mechanisms for disseminating results to similar areas.

Critical Research Accomplishments/Development Impacts

We are in the process of evaluating alternative means of dissemination of CA practices and CAPS. We will continue to do so in the upcoming period. Our primary mechanisms are: participatory research, field days, and short workshops aimed at farmers. We consciously identified local leaders

to participate in the research, and as participants adopt the practices, neighbors and others may adopt as well. We also conduct regular field days with participation generally exceeding 100 people. We are engaged in mass media outreach in both countries. In Ecuador, SANREM has sponsored a number of radio and television programs focusing on CA and watershed management. In Bolivia, we have contracted with local radio and television in Tiraque to broadcast messages.

In the current year, we will begin to collect data on the effectiveness of these practices. We plan to institute randomized control trials to measure how the different outreach measures contribute to farmer knowledge and diffusion of the technologies. We will also undertake choice experiments to gauge willingness to receive compensation for adoption of otherwise costly practices. We will take advantage of the entry of SANREM into the Anzaldo region of Bolivia to experiment with alternative outreach methods.

Objective 5: Evaluate overall impacts of the CRSP research program along several dimensions including soil health, productivity, economic, social and environmental.

Critical Research Accomplishments/Development Impacts

Soil health and productivity:

- Baseline soil samples have been taken on the farmer fields. Some of the analysis results are presented above; we will continue to conduct our analysis, some locally, some at Penn State, and some at Virginia Tech by the CCRA-9. We are following soil CCRA-9 protocols.
- Protocol for measuring erosion loss under different CA management practices has been established in Ecuador. We are evaluating data from the prior SANREM cycle and have improved our methods for erosion measurement for the current cycle.
- Training in the use of nitrogen index has been undertaken. This tool will be used by research teams to evaluate nitrogen needs in our research sites and to adjust nutrient application recommendations to changing conditions.

Economic and social:

- We have established protocols for collecting data on costs for all field experiments (in conjunction with the CCRA-6). These costs include fixed (equipment) and variable costs, including family labor use in cultivation and harvest. Preliminary data were collected and analyzed by undergraduate research associates from Virginia Tech during the SANREM internship program (May-June 2011, in Ecuador). Abigail Nguema (MS, Virginia Tech) completed an impact assessment linear programming model. This year's report contains a wealth of information on the economic viability of our CAPS (see details above).
- The project is collecting market data on input and product prices. Regular market surveys are being undertaken in both countries. These data will be used in the current year to assess how market risk affects profitability of different products and marketing decisions. In the current year, our LTRA published several papers on how risk and access to information affect production decisions (Larochelle and Alwang, *Journal of Agricultural Economics*; Larochelle, Alwang, and Botello, *Revista de Agricultura*; Castelhano, Alwang, Kuminoff and Botello, *Revista de Agricultura*) and market choice (Amaya and Alwang, *Agricultural Economics;* Amaya and Alwang, *Revista de Agricultura*). Findings of all these studies confirm

that risks are endemic in our study areas, that farmers adopt "costly" practices to manage risks, and that a key determinant of adoption of CA will be its impact on risk. The Amaya studies show clearly that access to information affects farmer marketing decisions, and, while traditional methods of obtaining this information persist, they are being supplanted by cellular information technologies.

- Regular participatory assessments are being conducted in areas where field experiments are being undertaken. For example, in the current year, our Bolivian partners, together with CIF (Centro de Investigaciones de Forages—forage research center at UMSS) undertook a participatory assessment of preferences for different forage types (figure 25). The purpose of this assessment was to identify culturally acceptable forages to include in our CAPS trials. Results (reported above) indicated a major difference in preferences by females for use and qualities of forages as opposed to males.

Figure 25. Participatory assessment of forages, Tiraque, Bolivia

Analysis of conservation agriculture knowledge and practices, Ecuador

Jointly with the IPM CRSP, we are in the process of analyzing a second set of baseline data for the Bolivar province in Ecuador. This household data set (419 total observations with about ¾ coming from Alumbre—see table 30) was collected by the IPM CRSP, but contains information on soil conservation and other CA practices. The preliminary analysis shows that women and men jointly make decisions about conservation practices, but substantial differences were observed in responses of women compared to those of men. Farmers in Illangama have more complete information on conservation practices compared to farmers in Alumbre.

Farmers in Illangama are also more likely to use conservation practices (table 31). These differences are likely to be due to the longer presence of SANREM and, more generally, INIAP in the upper watershed. INIAP only began to work with producers in the lower watershed in 2006 (during the previous phase of the SANREM project); it had been working in Illangama for more than 10 years.

Table 30. Knowledge of soil conservation practices, Alumbre and Illangama,Ecuador, 2012.

	Alumbre (%)		Illangama (%)		Total (%)		
Practice	**Knowledge**	**S.E.**	**Knowledge**	**S.E.**	**Knowledge**	**S.E.**	**p**
Strip cultivation	8.77	1.61	27.27	4.27	13.64	1.68	0.0001
Deviation ditches	10.39	1.74	37.27	4.63	17.46	1.86	0.0000
Contour planting	8.77	1.61	30.91	4.43	14.59	1.73	0.0000
Crop rotation	64.61	2.73	92.73	2.49	72.01	2.20	0.0000
Live barriers	34.09	2.71	68.18	4.46	43.06	2.42	0.0000
Reduced tillage	32.79	2.68	72.73	4.27	43.30	2.43	0.0000
Green manure	12.34	1.88	13.64	3.29	12.68	1.63	0.7319
Number of observations	**308**		**110**		**418**		

*Significant difference in test of means p< 0.01.

Table 31. Adoption of soil conservation practices, Alumbre and Illangama,Ecuador, 2012.

	Alumbre (%)		Illangama (%)		Total (%)		
Practice*	**Adopt**	**S.E.**	**Adopt**	**S.E.**	**Adopt**	**S.E.**	**p**
Strip cultivation	3.77	1.23	21.25	4.60	8.15	1.53	0.0004
Deviation ditches	5.02	1.42	31.25	5.21	11.60	1.80	0.0000
Contour planting	6.28	1.57	22.50	4.70	10.34	1.71	0.0015
Crop rotation	59.41	3.18	92.50	2.96	67.71	2.62	0.0000
Live barriers	24.69	2.79	63.75	5.41	34.48	2.67	0.0000
Reduced tillage	26.36	2.86	76.25	4.79	38.87	2.73	0.0000
Green manure	7.11	1.67	6.25	2.72	6.90	1.42	0.7873
No. observations	**239**		**80**		**319**		

*Significant difference in test of means; p< 0.01.

Our data show that, despite the participation of women in farming decisions, men were most likely to be responsible for the implementation of soil conservation practices (table 32). However, differences by gender were not statistically significant for the strip cultivations, use of live barriers, adoption of reduced tillage and use of green manures. Construction of deviation ditches and plowing on the contour require physical strength and aretasks usually performed by men (men almost always plow fields in Ecuador).

Table 32. Gender and adoption/performance of conservatuion agriculture practices, Chimbo-Ecuador, 2012.

Practice*	Man (%)		Woman (%)		Total (%)		
	Use practice	S.E.	Use practice	S.E.	Use practice	S.E.	p
Strip cultivation	10.11	2.20	5.34	1.97	8.15	1.53	0.1083
Deviation ditches	15.43	2.64	6.11	2.10	11.60	1.80	0.0061
Contour planting	15.43	2.64	3.05	1.51	10.34	1.71	0.0001
Crop rotation	75.00	3.17	57.25	4.34	67.71	2.62	0.0011
Live barriers	37.23	3.54	30.53	4.04	34.48	2.67	0.2130
Reduced tillage	39.36	3.57	38.17	4.26	38.87	2.73	0.8302
Green manure	7.45	1.92	6.11	2.10	6.90	1.42	0.6381
No. observations		**188**		**131**		**319**	

*Significant difference in test of means p< 0.01.

Environmental effects:

- The research team agreed on research protocol within soil erosion test plots. These plots include metal-demarcated boundaries, erosion collection points, and mechanisms for monitoring rainfall events. These trials had been established under the prior SANREM project to measure the relationship between weather events and soil loss, conditioned on management practices. The current SANREM team agreed that these experiments should continue. Preliminary analysis of some of these data was conducted this year, and will be completed in the coming year (2012-2013—see above).
- Dr. Flowers presented and discussed his efforts during the previous SANREM phase to monitor water quality using counts of macro-invertebrates. He explained that such measurement would be relatively inexpensive to continue and could be used to engage local stakeholders (particularly young people) in the project. The team agreed and Dr. Flowers worked to reinstitute the water quality monitoring program.
- The team in Ecuador has begun monitoring forest cover as a part of its environmental assessment. In the past two years, substantial cutting has occurred of old pine woodlots (planted in Illangama more than 20 years ago). The bare ground left from this cutting (reported in the prior year annual report) is highly vulnerable to runoff and leaching. One of our efforts in the past year was to educate farmers (the woodlots are communally held) about improved cutting and managing techniques. We have begun to monitor this form of environmental change.

Objective 6: Strengthen the capacity of government and non-government institutions to develop and disseminate CAPS in the Andean regions of target countries

<u>Task 6.1:</u> Conduct gender sensitivity training for all project staff. Collect data on participation rates by gender and by disadvantaged groups.

Gender sensitivity training was conducted during a workshop held in 2010. Recommendations from participants in this workshop were subsequently adopted by the research team. One clear problem is the imbalance between men and women in the research team (67% male, 33% female in Ecuador, see table 33). We are continuing to address this problem, but are constrained by conditions in local institutions. In Ecuador, we have hired an additional two female researchers and the team has continued to stress participation of females in meetings. The team has also entered into dialogue with the University Estatal of Bolivar to promote increased female participation in biological and agricultural sciences. The teams in both countries have already taken concrete steps to improve female participation in training events and this representation has grown in recent years. In Illangama, the women's inability to speak Spanish was identified as a problem and we have hired two bilingual assistants to address this problem.

Table 33. Indicators of females and males participation in SANREM CRSP-Ecuador, 2012.

Indicators	Number
1. Number of female scientists in research team	5
2. Males in research team	10
3. Women participating in short-term training	8
4. Men participating in short-term training	16
5. Female extension agents working directly with farmers	2
6. Gender-focused activities, current year	1

<u>Task 6.2:</u> Degree training

We are conducting degree training in two ways: (i) graduate training at US universities and (ii) undergraduate (honor's) theses for the degree of agricultural engineer.

Two female graduate students (1 PhD. from the U.S.; and 1 MS from Bolivia) completed degree work in Agricultural and Applied Economics at Virginia Tech during this reporting period. One female graduate student (MS from US) is in a degree program in Soil Science at Penn State. Two female graduate students (1 MS, 1PhD, both from US) are in a degree program in Plant Pathology at Penn State.

In the current year, we have engaged five undergraduate students in Ecuador: three from the Universidad Estatal de Bolívar for the degree "Ingeniero Agrónomo" (Juan Carlos Arévalo) and "Ingenieros Forestales" (Maricruz Suárez y Ruth Suárez); and two from the Universidad Central del Ecuador for the degree "Químicos" (Arnulfo Portilla and Danny Farías). They receive

training in CA practices and participate in field and laboratory work, depending on the assignment or thesis topic. In Bolivia, four undergraduate "tesistas" have participated in the project this year. Form 16 has further details.

<u>Task 6.3:</u> Nondegree training

We had several workshops and presentations to non-local audiences in Ecuador and Bolivia. See below.

Figure 26. Participants at INIAP-SANREM CRSP field day, Alumbre-Ecuador, 2012

Degree and nondegree training activities

Short-term training was provided to 598 men and 258 women through six field days, six workshops, five short courses, and three seminars. Six women and nine men were provided with degree training; ten Bachelors, three Masters and two PhDs. Some of these students also achieved important awards for their research:

- Hilary Cheesman and Anna Testen both received additional scholarship support from the Popp endowment for excellence in research ($1600 each).
- Anna Testen received a first place award in the biological sciences division, and a cash prize of $400 from the Gama Sigma Delta and College of Agriculture research competition.
- Anna Testen received third place in the University-wide graduate school research competition.
- Anna Testen, received Honorable Mention for her NSF graduate research fellowship program application.
- Catherine Larochelle, PhD, received Virginia Tech's award for best dissertation in January 2012. Three essays in her dissertation were from research supported by SANREM.

Publications, presentations, and other SANREM CRSP products

We have had a banner year in terms of published output. Most importantly, a special edition of the "Revista de Agricultura" (Bolivia) was dedicated to the SANREM project and its important findings; this edition contained ten articles. In addition, three journal articles were published, three theses completed, and eight posters/presentations made. In the popular media, Jeff Alwang and his work with the SANREM CRSP in Chimborazo, Ecuador was featured in a local NPR story
http://www.wvtf.org/index.php?option=com_content&view=article&id=2506:virginia-tech-around-the-world&catid=48:wvtf-news&Itemid=119

Networking activities

We have established important networks between participating scientists and our research team and local stakeholders. All participating U.S. scientists have established primary contact points with host-country researchers and are now engaged in collaborative research. An example of such collaboration is the training exchange that recently occurred between Dr. Delgado and the Ecuador and Bolivia research teams. In addition to scientific networks, each of our host-country teams has taken steps to build networks with local stakeholders. In Ecuador, a partnership has emerged between our research team, the Bolivar Provincial government, the Guaranda city government, the local university (where Carlos Monar, former SANREM researcher is now an academic dean) and local governments and farmer groups. We have established seven model farms where ongoing research is conducted. Neighboring farmers visit these farms for informational purposes or to participate in research activities.

In Bolivia, linkages between local farmer groups and the Tiraque municipal government have been solidified. Our professional linkages between PROINPA, CIFEMA and CIF have strengthened our capacity to evaluate different dimensions of the CAPS (notably, mechanization and forages). Within PROINPA, the project formed important linkages with the FONTAGRO-supported bio-inputs project, with SANREM taking leadership in the economic evaluation of bio-inputs.

Other networking activities:

- Víctor Barrera INIAP submitted a proposal to the Secretaría Nacional de Educación Superior, Ciencia y Tecnología SENESCYT to extend SANREM research under the name "Generación de alternativas tecnológicas para el manejo integrado de recursos naturales en las áreas de mayor vulnerabilidad y riesgo de la subcuenca del río Chimbo." Amount of proposal was USD 350,000.
- Víctor Barrera and Jeffrey Alwang presented to the McKnight Foundation a proposal entitled "Agricultura de conservación como una potencial vía para promover el manejo de recursos, incrementar la productividad y mejorar las condiciones socio-económicas en la Región Andina del Ecuador." This proposal was for USD 300,000.

- The team in Ecuador continues to use SANREM-produced knowledge to evaluate natural resource management activities in the Project "Manejo y conservación del capital natural que disponen las comunidades de Saraguro como mecanismo de adaptación al cambio climático". This Project is being conducted in Saraguro, Ecuador, with funding from the Ministry of Agriculture and UNDP.
- Víctor Barrera and Luis Escudero are conducting the project "Asociación de Desarrollo Comunitario San Francisco de la Bola de Oro", within the broader effort "Conservación del ambiente a través de la elaboración de fertilizantes orgánicos para la producción de cultivos en agricultura de pequeña escala". This project is being funded by USAID.
- Soraya Alvarado and Franklin Valverde submitted a proposal to the Secretaría Nacional de Educación Superior, Ciencia y Tecnología (SENESCYT). This project, entitled "Manejo adecuado de abonos verdes y microorganismos fijadores de nitrógeno dentro de sistemas de producción agroecológicos" was approved for an amount of USD 300,000.
- Soraya Alvarado submitted a proposal to the McKnight for "Integrated management of hillside soils in Chimborazo and Cañar." This proposal, for USD 300,000, was approved in the first phase of the competition.

Highlights

- We are advancing our knowledge relative to the feasibility and practicality of conservation agriculture in two sub-regions of the Ecuador highlands and in the Tiraque area of Bolivia.
- In Ecuador, the SANREM project has received substantial publicity and various organizations are looking to replicate the experience elsewhere. A field day in July was attended by three national news organizations.
- Our data indicate that conservation agriculture practices are at least as profitable in the short run as conventional alternatives, and improvements over time in soil health and reduced erosion will only increase their value in the future.
- Conservation agriculture is an effective means of reducing labor costs; these costs are increasing rapidly in Andean areas, and smallholders are desperate for technologies to substitute for scarce labor. Direct seeding of quinoa is now possible given SANREM-developed implements; these technologies save scarce labor and allow more precise planting at appropriate depths, even in mulched parcels.
- Both the Ecuador and Bolivia projects have successfully solicited grants from outside organizations.

Degree and nondegree training activities

We currently have five students (all female) engaged in SANREM-related long-term degree training. Two (US citizens) are seeking PhDs in Plant Pathology at Penn State, one is seeking an MS in Soil Science at Penn State and two are seeking PhDs in Agricultural and Applied Economics at Virginia Tech (one is Bolivian). All but one is receiving substantial co-funding from Departmental sources. We also have identified undergraduate honor's students in Bolivia

and Ecuador (one in each country, both women) who will conduct thesis research on the project.

We have had numerous workshops, seminars, short courses and field days, with a total of 604 (412 male, 192 female) attendees. Most of these trainings were directed toward farmer-stakeholders in our areas of work. Details are presented in form 17.

Publications, presentations, and other SANREM CRSP products

We have had a banner year in terms of published output. Most importantly, a special edition of the "Revista de Agricultura" (Bolivia) was dedicated to the SANREM project and its important findings; this edition contained ten articles. In addition, three journal articles were published, three theses completed, and eight posters/presentations made. In the popular media Jeff Alwang and his work with the SANREM CRSP in Chimborazo, Ecuador was featured in a local NPR story
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Networking activities

We have established important networks between participating scientists and our research team and local stakeholders. All participating US scientists have established primary contact points with host-country researchers and are now engaged in collaborative research. An example of such collaboration is the training exchange that recently occurred between Dr. Delgado and the Ecuador and Bolivia research teams. In addition to scientific networks, each of our host-country teams has taken steps to build networks with local stakeholders. In Ecuador, a partnership has emerged between our research team, the Bolivar Provincial government, the Guaranda city government, the local University (where Carlos Monar, former SANREM researcher is now an academic dean) and local governments and farmer groups. We have established seven model farms where ongoing research is conducted. Neighboring farmers visit these farms for informational purposes or to participate in research activities.

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Highlights

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- Conservation agriculture is an effective means of reducing labor costs; these costs are increasing rapidly in Andean areas, and smallholders are desperate for technologies to substitute for scarce labor. Direct seeding of quinoa is now possible given SANREM-developed implements; these technologies save scarce labor and allow more precise planting at appropriate depths, even in mulched parcels.
- Both the Ecuador and Bolivia projects have successfully solicited grants from outside organizations.

LTRA-8: Improving Soil Quality and Crop Productivity through Farmers' Tested and Recommended Conservation Agricultural Practices in Cropping Systems of West Africa

Principal investigator: P.V. Vara Prasad, associate professor, Department of Agronomy, Kansas State University

Host Countries: Ghana, Mali

Research team:

- Kansas State University: Department of Agronomy: Scott A. Staggenborg, Charles W. Rice, DeAnn Presley; Department of Agricultural Economics: Timothy J. Dalton, Kevin Dhuyvetter; Department of Plant Pathology: Karen Garrett; Department of Biology: Ari Jumponnen; Department of Sociology, Anthropology, and Social Work: Theresa Selfa; International Agricultural Programs: Nina Lilja
- Savanna Agricultural Research Institute (SARI): J.B. Naab, I. Yahaya; S.S. Seini, M.A. Askia AA: Spell in full the names of the collaborators if you can find them
- Wa Polytechnic: P.H. Momori
- Institut d'Economie Rurale du Mali (IER): M. Doumbia, K. Traore, P. Sissoko, A. Berthe, O. Samake

Research progress by objective

Objective 1: Evaluate local CAPS

This objective has been accomplished, summarized and reported.

Objective 2: Develop cropping systems

Objective 3: Foster and advance rapid adoption of local CAPS and integrated practices

Critical Research Accomplishments

Four on-farm mother tests were harvested and data were analyzed and results summarized for crop yields in 2011. These four on-farm mother trials were also planted in 2012 season.

- In Nyoli, there was no influence of tillage systems on stover yield of maize. Minimum tillage (pre-emergence herbicide and one hand weeding) produced the same yields of maize or soybean as conventional (tractor) or manual weeding (Figure 27). There were no significant differences among cropping systems: continuous maize, and maize following by soybean or maize intercropped with soybean produced similar stover yields.

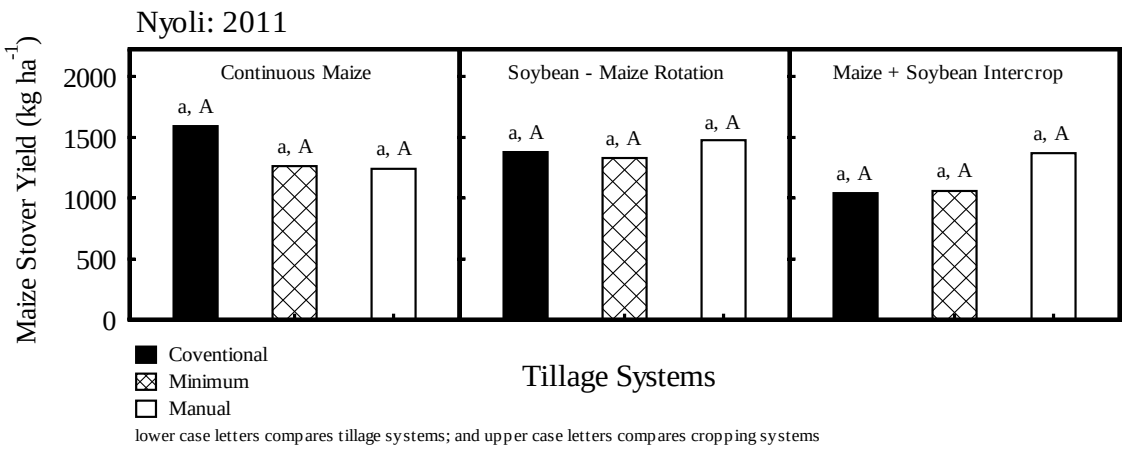


Figure 27. Impact of various cropping systems and tillage practices on stover yield of maize harvested in 2011 in Nyoli

- There was no influence of different tillage systems on grain yield of maize within different cropping systems (Figure 28). However, cropping systems had significant influence on grain yield, with continuous maize, and maize following soybean produced significantly higher yields than maize intercropped with soybean.

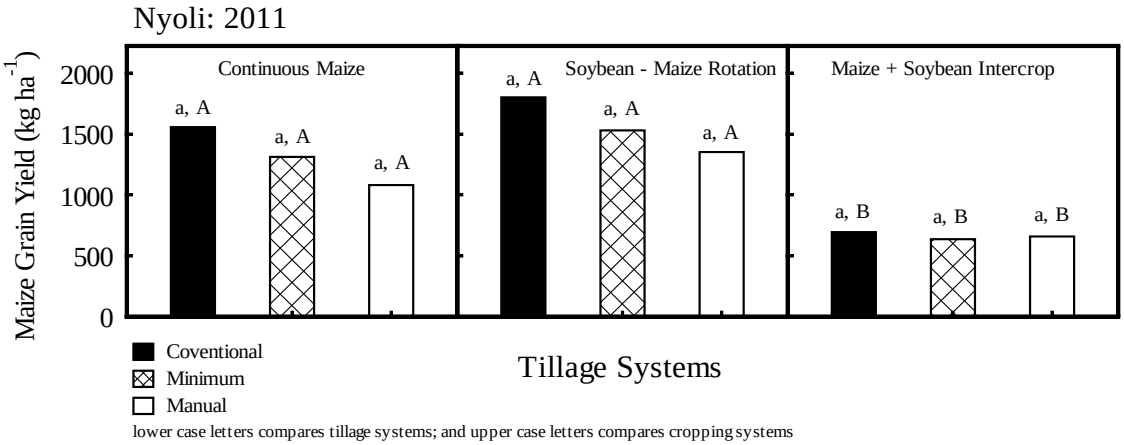


Figure 28. Impact of various cropping systems and tillage practices on grain yield of maize harvested

In Busa, there was no significant differences among tillage systems for a given fertilizer treatment or previous crop (Figure 29). However, maize following soybean were slightly higher in either conventional or minimum tillage systems. There were significant differences among various fertilizer treatments. For maize following soybean, application of compound fertilizer with complete nutrition (N, P and K; 37, 16, and 31 kg ha^{-1}, respectively) produced significantly higher yields than only P fertilizer or no fertilizer additions. Application of only P fertilizer (26 kg P ha^{-1}) produced higher grain yield of maize in both tillage systems, when compared to no fertilizer controls.

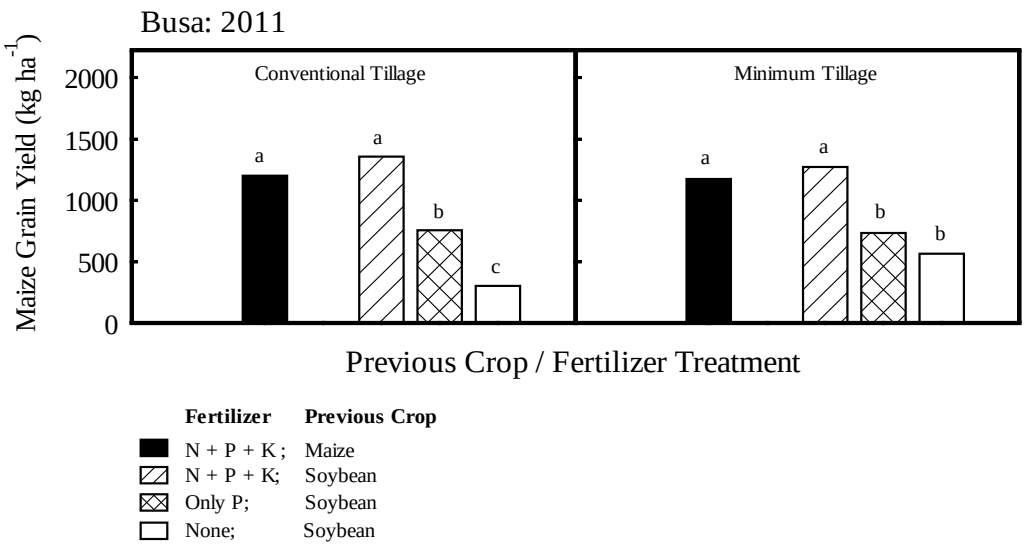


Figure 29. Impact of various tillage systems, fertilizer application and previous crop on grain yield of maize harvested in 2011 in Busa.

In Gbanko, there were no significant differences between conventional tillage and minimum tillage systems for either residue yield or grain yield (Figure 30). However, for soybean, both residue and grain yields were significantly greater in minimum tillage system when compared to conventional tillage system.

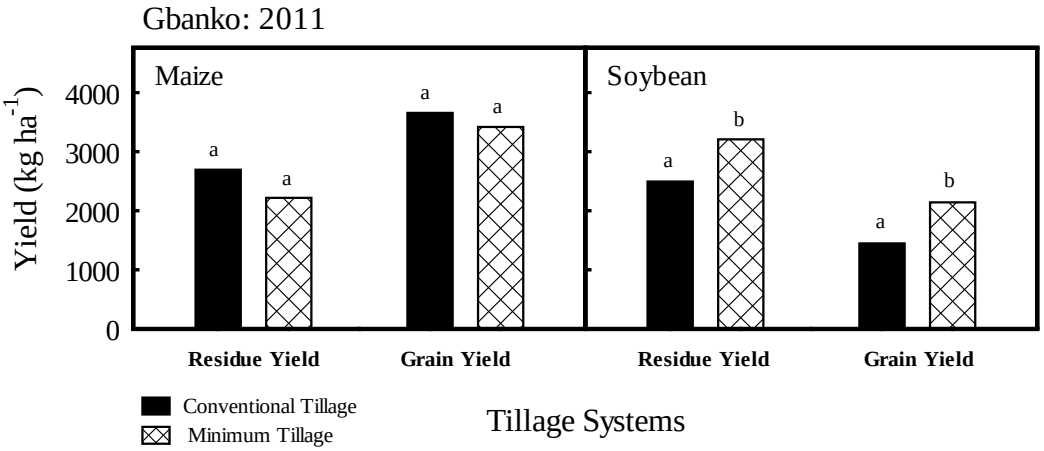


Figure 30. Impact of various tillage systems on residue (stalk) and grain yield of maize and soybean harvested in 2011 in Gbanko.

There were no significant differences in stover yield of maize under various water conservation methods (Figure 31). However, the response of grain yield varied significantly. Maize planted on tied ridges produced significantly higher grain yield than planted in flat beds. In the tied ridges systems, maize planted in tied ridges alone produced significantly higher than maize with grass or *Gliricidia* strips.

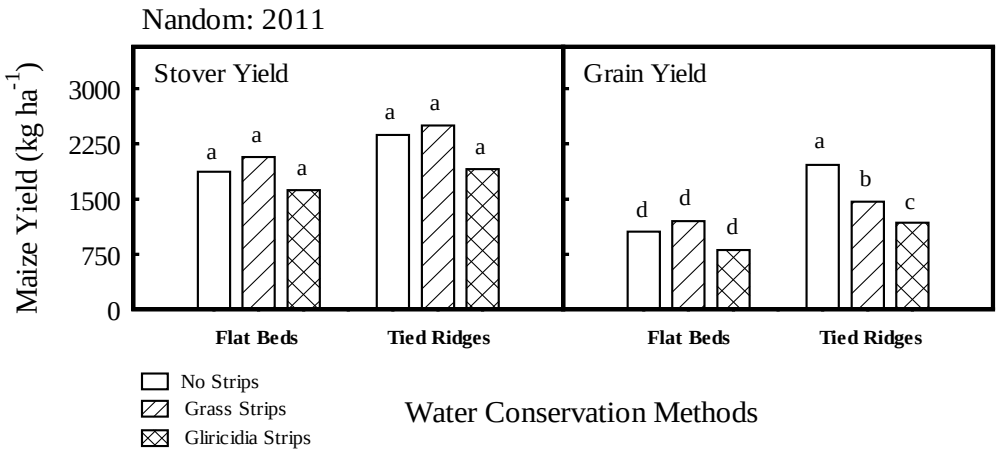


Figure 31. Impact of various water conservation methods stover and grain yield of maize harvested in 2011 in Nandom.

Development Impacts

Minimum tillage systems, crop rotations, and water conservation methods showed promise in mother tests in most locations. Similarly, application of complete fertilizer or P fertilizer in all cropping systems and tillage systems improved grain yield. This shows opportunities for enhancing use of these practices in the region.

Challenges and Responses

During 2011, only four on-farm mother trials were carried forward. The site in Sieyiri was taken over by the land owner due to water logging, and therefore, could not be continued. This field was located in a low lying area and due to high intensity rainfall, it was prone to flooding. The yield levels in all treatments were low.

Critical research accomplishments

Ghana: To foster and advance adoption of CAPS by farmers, sub-set of the mother trial treatments were selected by farmers and implemented in their own fields and communities. A total of 66 farmers tested components of CAPs during 2010. A total of only 42 on-farm trials were implemented in four villages during 2011.

- Minimum/reduced tillage and rotation with a legume crop, growing sole crops and following rotation, application of fertilizer and water management practice can help improve yield and would be adopted.
- The adaptation of Brachiaria as a potential solution to the challenge of permanent ground cover. Preliminary results in Mali show that Brachiaria can be established, but more research is needed to define the time of planting (in comparison to main crop). When planted at the same time, Brachiaria overtook the main crop. Relatively better growth of both Brachiaria and the main crop was observed when Brachiaria planting was delayed by two weeks after the main crop.

Mali:

- Minimum tillage or direct seeding plus one weeding/fertilizing produced the same yields as the conventional tillage (5 operations that disturb the soil; i.e., planting, weeding, fertilizer application on maize in Sikasso).
- Crop residues or biomass used as mulch produced an average of 26 percent yield increase over no soil cover treatment at the Cinzana Station.
- Biomass of sorghum (13 Mg/ha) was left as crop residues. This would undergo off-season, open grazing, and only about 15 to 20 percent would remain by next planting.

Development impact

Ghana and Mali:

- Minimum tillage and rotation with a legume crop showed promise and new farmers also tried these practices in 2011. Application of P fertilizer and water management practice improved grain yield and is being adopted.
- Preliminary results show that Brachiaria can be established, but more research is needed to define the time of planting (in comparison to main crop).

Challenges and responses

Ghana: Fifteen on-farm trials in the village of Sieyiri in 2010 were discontinued in 2011, because the sites selected by the farmers last year were prone to water logging.

Mali: Although *Brachiaria* shows potential for cover crop, time of planting relative to main crop planting needs further investigation.

Objective 4: Assess long-term effects of CAPS

Critical Research Accomplishments

Soil samples were taken again during the 2012 cropping season from both mother and baby trials to assess if there have been changes in soil carbon content due to adoption of CAPS. These data are currently being analyzed and reported later. In addition, new measurements on CO_2 and N_2O emissions were measured in 10 farmer's fields in 2011. These data are being summarized and will be reported later.

Development Impact

We are not yet ready to report any development impact as data are still be analyzed and will be reported later. Results from individual experiments are given in previous sections (Objectives 2 and 3).

Challenges and Responses

Initial main soil characters were analyzed and reported. In addition, samples are currently being analyzed. It is a time-consuming task as there is only one functioning soil laboratory in

Mali and in the Wa region of Ghana. There is a lot of backlog of samples in these laboratories from other experiments. However, the samples are being processed.

Objective 5: Modeling to predict impactspredict impacts of CAPS

No task was planned for this year of the project in both Ghana and Mali.

Objective 6: Assess the cost and benefits of activities

Critical Research Accomplishments

Cost-benefit analyses are on-going for the 2011 harvested cropping season baby trials to identify CAPS which can improve small holder farmer economic returns and will be reported in the next semi-annual report.

Degree and nondegree training activities

Degree Training Activities: Two students from Ghana started their PhD programs. They initiate their programs in spring 2012 and are currently in the process of developing their research and education program and details will be reported in the next year semi-annual report.

Nondegree training: Annual meeting, workshop, field day and farmer exchange visits were organized in Wa for training, capacity building of farmers.

- Annual meeting: This meeting was attended by 45 farmers (16 women). Brief results of various experiments were presented to the farmers and discussed. Benefits of CAPS identified were lower cost of cultivation, increased income, control of soil erosion and increased soil moisture.
- Workshop: A one-day workshop on farmer participatory monitoring indicators of CAPS was conducted. The main indicators identified were cost of production, yield, income, labor use and acreage under cultivation.
- Farmer exchange and field days: Field days were organized during the cropping season. A total of 61 farmers (16 female and 45 male) participated.

Publications, presentations, and other SANREM products

None for this period. As this research involves crop rotations – publication will be written when we have replicated results of full rotations.

Networking activities

Collaboration/integration of activities was initiated with the following projects/programs:

- Integrated activities of the project funded by INTSORMIL in both Ghana and Mali
- Started new project with Africa RISING Program of USAID in Upper East Region of Ghana to complement our studies. These studies are focused on efficient nutrient and water management techniques.
- Linkages were initiated with University of Ghana, AGRA, FARA, IITA and ICRISAT for opportunities for future collaboration and extend of our research and training activities.

- Visited USAID – Ghana Mission and West Africa Regional Mission and presented our objectives, project details and future opportunities.

Highlights

In Ghana, farmers from all regions, Busa-Tangzu (Wa Central), Nyoli (Wa West) and Nandom (Lowra-Nandom) showed interest in adopting components of CAPS (minimum or reduced tillage, crop rotation with a legume crop (groundnut, soybean or cowpea) and improved soil fertility (application of N, or P) and water management practices (tied ridges). We interviewed 118 farmers in the region, and found that 94 farmers have adopted and using these technologies in their own farmers (these include 48 farmers).Total expanded area this year was around 16 ha.

LTRA-9: Developing Sustainable Conservation Agricultural Production Systems for Smallholder Farmers in Southern Africa

Principal investigator: Neal Eash, associate professor and soil scientist, Department of Biosystems Engineering and Soil Science, University of Tennessee

Host Countries: Lesotho, Mozambique

Research team:

- University of Tennessee: Department of Biosystems Engineering and Soil Science: Forbes Walker; Department of Agricultural and Resource Economics: Dayton Lambert, Michael Wilcox
- National University of Lesotho: Department of Soil Science: Makoala Marake
- International Maize and Wheat Improvement Center (CIMMYT): Global Conservation Agriculture Program: Patrick Wall
- Growing Nations: August Basson

Research progress by objective

Objective 1: Integrate cover crops into CAS to protect soil from erosion, provide weed suppression or control, include crop rotations that provide forages for livestock, improve soil quality as measured by soil carbon (C), decrease risk and vulnerability to drought.

Critical Research Accomplishments

This past year, we conducted several un-replicated studies evaluating the effect of cover crops in reducing weed pressure as well as the effect of cover crops on the yield of subsequent crops. At our research site in Maphutseng, Lesotho, we found that where a mixture of wheat and vetch (*Vicia villosa*) grown in the winter preceding maize seeding, maize yields were approximately 1 Mg/ha greater.

In Mozambique research continues to evaluate cover crops, inter-cropping, and crop rotations. Due to the high termite populations at some sites we have evaluated *Tephrosia sp.* as a plant that

may reduce termite infestation level due to the lack of palatability of this forage to termites. Extract from this same plant is also being used to evaluate its potential as a foliar application on growing plants to reduce termite damage. Many plots in Mozambique cannot maintain the residue cover "requirement" for CA due to the termites consuming all of the crop residues that cover the soil. Once these residues are consumed the termites will resort to eating live tissue whether it is weeds or the growing crop. Researchers continue assessing the need to alter the rotation to cowpea and the sunflower intercrop to a maize/pigeon intercrop in the coming cropping season. These are important decisions that emphasize the importance of on-farm adaptation of CA practices throughout the region; failure to adapt CA locally will ensure its demise as a sustainable agricultural production system.

In Mozambique, the PI's are providing technical support to the on-station research at Sussendenga that evaluates maize population and N rates, residue cover, and sixteen different varieties of maize (hybrid and OPV). In addition, the PI's will work with CIMMYT to initiate relay/cover crops for weed suppression and consider how to best manage a high termite population site. This past year, several plow/ripper/strip till conversion for ox-drawn plows and ox-drawn planters were purchased as part of upscaling CA in the region.

Development Impacts

The Mozambique project is more advanced than Lesotho due to the five plus year head start on this research by CIMMYT. Our involvement will build upon this in-country experience by providing economic and agronomic support and analysis of their CA work and by incorporating the early successes from Lesotho. Ongoing farmer field trials will be used to assess the riskiness of CA conventional agronomic practices. Combined with analysis of the data collected from household surveys in March 2012, important insight into the reasons why farmers tend to adopt CA agriculture in some contexts more rapidly than in others will be gained.

We have developed the initial database upon which the dissemination of conservation agriculture technologies will be based as opposed to the anecdotal evidence prior to our research outputs. To this effect, one thesis is published and another is in the final stages. The carbon dynamics work of our project is breaking new ground in terms of methodology for real time carbon dynamics and will launch our efforts into climate change adaptation research.

Challenges and Responses

An obstacle to CA adoption in Mozambique it the high cost and/or availability of fertilizers and herbicides. Without herbicides weed control is all by hand labor some of which is usually hired. To overcome this obstacle, we are doing a substantial amount of research evaluating the nutrient-supplying and weed-suppressing potential of various cover crops and cover crop combinations. In Lesotho there has been some spontaneous adoption of CA due to hired laborers for weeding correctly assessing that CA fields have fewer weeds and thereby take less time to weed than conventionally tilled fields. Although our replicated plots evaluating cover crop N contributions were inundated with rats that consumed the maize on many plots, cover

crops added 1-1.5 tons per hectare when compared to maize produced under CA but without a winter cover crop. Lesotho CA adoption rates are increasing due to the strong research-based recommendations developed through this program. A challenge is to further the adoption rates through adequate upscaling and outreach efforts with current budget limitations due to Lesotho not being a Feed the Future country and subsequently not a high priority for USAID funding.

Objective 2: Determine the agronomic and economic fertilizer rate for maize in both the basin and machine no-till methods.

Critical Research Accomplishments

Fertilizer rate studies were completed in both Roma and Maphutseng sites in Lesotho. The Roma site was again used to train 25 students under the supervision of Dr. Marake. Students completed undergraduate projects in conservation agriculture and wrote four joint undergraduate theses in partial fulfillment of the requirements for their B.Sc Soil Science degree from the National University of Lesotho. It is anticipated that no changes to the protocol for this year will be needed so that at least two site years of data can be evaluated. Results thus far indicate that a maize target population of approximately 45,000 plants per hectare with 100-, 60-60- kg/ha of N, P_2O_5, and K_2O will achieve maximum yields of greater than 7 ton maize per hectare. This year we plan to include more soil types in the calibration to strengthen inferential power for more accurate fertilizer recommendations. A MSc. academic thesis will be completed on this work at the University of Tennessee in the academic year 2011/12. Maize yields were recorded up to 7 tons per hectare (same than Mg/ha in Figure 32).

In Mozambique, all sites were monitored by project staff and NARS partners. The sites are generally in good condition; however farmers struggled with two main problems: residue retention on CA plots and weed control (especially the second-hand weeding). Pre-harvest data was taken and all sites harvested in April-May 2012. The project has emphasized the importance of collecting high quality harvest data from the field, which was the main focus for further data collection and management skills training of extension officers collaborating with the project.

Development Impacts

Fertilizer recommendations generated by our Lesotho research are the basis for the stable yields found with CA. Like CA adoption elsewhere in Africa, numbers of farmers adopting are slowly increasing and will likely steadily increase over the next few years if adaptation is successful at the farm level. In Mozambique some spontaneous adoption is occurring which is often the result of input or equipment availability that is tied to the various communities associated with the project.

Challenges and Responses

Our solid start in Lesotho could blossom into a very successful CA adoption study if enough monetary support is provided to enable scaling up and outreach efforts. In Mozambique CA

adoption is already on the upswing but appears to be limited by the price and availability of needed inputs (seed and fertilizer).

Objective 3: Characterize the composition and contribution of N and C from legume/grass cover crops and determine the best species for maintaining soil residue cover until after maize crop harvest.

Critical Research Accomplishments

Different cover crop species continue to be evaluated in Lesotho. Specific grass legume combinations have been prioritized for up-scaling in the upcoming growing season. Carbon flux measurements were collected at the Lesotho site, starting in November 2010 under both conventional and conservation agriculture management systems. One M.Sc. thesis was completed analyzing the carbon-conservation agriculture data in the 2011/12 academic year at the University of Tennessee. In Mozambique, cover crop selection and evaluation continues.

Development Impacts

Cover crops are key to successful CA adoption in both Lesotho and Mozambique. Fertilizer N fixed by winter cover crops provide approximately 1-1.5 t/ha maize yield increase in Lesotho (which is 2-3 times the average maize yield) and have shown great promise in suppressing weeds (up to 90% of some species). Work is ongoing to determine the impact of other cover crops to suppress termite infestation so that soil residue covers remain in place until crop canopy occurs. Maintaining crop covers is important for crop production in areas of low rainfall and high temperatures due to their ability to reduce soil temperature and evaporative losses.

Challenges and Responses

The key to successful CA adoption is assisting farmers with adapting CA locally. In Mozambique, we will continue to support scaling up and other outreach efforts as well as continued efforts on best cover crop mixes for the various ecological zones. In Lesotho, we will continue our fertilizer calibration, plant population, and cover crop evaluation and upscaling as our budget allows.

Objective 4a: Determine the short- and long-term impacts of CAS on gender equity especially in terms of household income and economic impact and to involve women in decisions that impact their welfare.

Critical Research Accomplishments

Survey data (427 households surveyed) from Botha-Bothe, Lesotho (November 2010) are being analyzed at the University of Tennessee under the leadership of Drs. Lambert and Wilcox and some of that data are presented in Figure 33 and Table 34. The positive correlation of labor allocation along gender lines appears to be quite strong and there do not appear to be any differences with respect to labor demands along technologies used (conventional versus no-till practices). Another interesting finding (not reported in the table 34) is that women appear to be

the primary decision makers for fields that are rotated to leafy green vegetable plots during the winter months. Preliminary results also suggest that these fields, on average, tend to be relatively larger. Analysis of statistical associations with other household demographics and these farm resource variables is in progress. Students are also hard at work with the survey data from Mozambique (535 households) and preliminary results are reported below in Tables 35 and 36. Some follow up surveys have been conducted by Dr. Keith Moore at Virginia Tech and analysis of that data will be forthcoming shortly.

The baseline survey for Mozambique was completed in early 2012. Approximately 535 households completed surveys in northwest and west-central Mozambique and this data are currently being analyzed for inclusion in upcoming publications. Preliminary results include information on households and household heads. Most household heads are male (Table 35, see below). The mean head of household age for all four farming groups (conservation agriculture adopters, is above 40 years old, noting that the life expectancy in Mozambique is 50 years old (UNICEF 2010). On average, CA farmers were 45 years, compared to non-adopters (42 years). This difference is significant at the 5 percent level.

Educational attainment levels were similar among groups. Of the respondents practicing CA, 63 percent indicated that they had attended primary school. This frequency was not different from educational attainment reported by non-CA respondents (56 percent). The majority of respondents across all groups indicated that farming was their principal livelihood.

Specific agricultural tasks among heads of households were generally similar among CA adopters and non-adopters, with the only significant difference being the application of chemicals (Table 36, see below). Among CA-adopting households, 31 percent indicated that they applied chemicals, which was significantly higher than non-CA farms (19.9 percent).

Development Impacts

The direct and indirect effects of CAPS at the household level, especially as it pertains to gender equity, labor allocation and household welfare, is being examined through the initial baseline survey and – if funding allows – through follow-up surveying in Year 4 or 5. Adoption and the potential for subsequent dis-adoption is a function of many variables, including socio-economic and individual preferences. As a snapshot, the baseline research being conducted in Lesotho and Mozambique is also aimed at informing our host country partners so they can adapt their recruitment and training practices.

Challenges and Responses

The major challenge facing this aspect of the project is the ability to examine the effects CAPS adoption on households over time. To do this, a follow up survey is necessary. In addition, dissemination of research results needs to occur at the practitioner level, as well as through academic outlets. For these efforts to be realized, additional funding will have to be secured.

Objective 4b: Evaluate ways and means to improve fertilizer adoption rates among smallholder farmers, the degree to which market structure influences fertilizer use, and determine welfare implications based on price margins.

Critical Research Accomplishments

Field research during the current growing season will provide data to assist with understanding fertilizer economics in smallholder maize production. Preliminary secondary data, in the form of spot prices for key inputs and outputs in Lesotho, were obtained from contacts whose acquaintance was developed and strengthened during the trip in March. Survey data from Lesotho is yielding interesting results with respect to input use, productivity, and household well-being. A M.Sc. student is currently working on comparing the profitability and input use demand of households who adopted CA in Lesotho. In Mozambique, it appears that households who have adopted CA are more likely to sell maize in local markets, whereas non-adopters in communities with demonstration plots as well as communities that do not have demonstration plots are, on average, more likely to be net purchasers of maize. Reasons for these univariate comparisons will be investigated using econometric analyses. In addition, biological and economically optimal input rates have been determined using fertilizer N and P and plant population yield response data collected from the Maphutseng field trials. This information will be important for modeling changes in smallholder household welfare, given prevailing input and maize prices. Research in the coming year will further investigate these interactions.

Work on fertilizer calibration and correlation is not a fundamental part of the field research in Mozambique due to the field research legacy in nearby Zimbabwe. The research team plans to evaluate this issue further (including fertilizer economics) if the need is expressed.

Development Impacts

The baseline surveys conducted in Lesotho and Mozambique allow for some analysis of market-oriented issues that farmers are facing with respect to inputs and output. Both weigh heavily on the farmer's ability to successfully adopt CAPS. From a socio-economic perspective, successful farmers will have access to important inputs (fertilizer, herbicide, seeds, labor, etc.), use them efficiently and be able to meet the needs of the household through the enhanced productivity of their fields and the ability to market surplus output.

Challenges and Responses

Efficiency is key and requires research on both the economic and agronomic fronts. This means that our research themes need to be integrated so the response to our host county partners offers information on economically sensible recommendations that account for country-specific realities both on farm and in the marketplace.

Degree and nondegree training activities

One U.S. M.S. student has defended her thesis and a research paper will be forthcoming from this work; another M.S student will defend within the month. Two M.S. graduate students from

the University of Tennessee participated in these research efforts, and also managed on-going carbon analysis and fertilizer calibration/management studies. The students presented their work at the ASA meetings in San Antonio, Texas (October 2011) and one has completed her thesis with the other thesis defense scheduled in October 2012. Two Basotho, two Mozambicans, one Kenyan, and two U.S. citizens have also been recruited and began studies in 2012.

A number of field days and workshops (18) were held at Maphutseng, Lesotho by project cooperators to highlight the work that is being conducted on conservation agriculture. In Mozambique, our cooperators hosted 44 field days and numerous workshops (details on Form 17) that were well attended by extension personnel and local farmers. Overall more than 4500 farmers participated in training hosted by this project. The field days were attended by representatives from various UN organizations including the FAO and UNDP, Ministry of Agriculture and Food Security, and other NGOs. In Lesotho, considerable dialogue occurred with the Honorable Michele Bond, US Ambassador to Lesotho, regarding ways and means to upscale our CA research and outreach given the extent of the food shortage in Lesotho in the 2012 harvest season.

Publications, presentations, and other SANREM CRSP products

Social media postings regarding Lesotho research plots and severe drought generated activity on Facebook and Twitter.

Networking activities

We have maintained close contact with the U.S. Embassy in Lesotho. Drs. Marake, Eash, and Walker have had two meetings with Ambassador Bond. Dr. Marake has also provided briefs on the role of conservation agriculture on climate change adaptation to members of a team developing a climate change strategy for engagement in Lesotho through U.S. embassy resources. The ambassador and her staff were enthusiastic in their support for the ongoing work sponsored by the SANREM CRSP project and hope to visit the research site in Maphutseng again in the upcoming season.

The Mozambique research team collaborates with the IRMA project (Maize Resistance to Stem Borer and Storage Pests for Eastern and Southern Africa), WEMA (Water Efficient Maize for Africa), DTMA (Drought Tolerant Maize for Africa), and SIMLESA (Sustainable Intensification of Maize-Legume Cropping Systems for Eastern and Southern Africa).

Highlights

In spite of the extreme weather conditions in Lesotho, the stability of the conservation agriculture systems developed during this project stood the acid test of extreme weather events as record yields in maize were obtained in both on-station and on-farm trials and demonstrations alike. We found during our visit in July 2012 that yield averages ranged from 6 to 7 tonnes per hectare against the backdrop of reported disastrous crop failures nationally for the same period and regions of project operations.

We have made significant progress in Lesotho on both the agronomic objectives and are a long way into understanding the issues around plant population and fertility aspects as a basis for recommendations to farmers. The work thus far with cover crops has resulted in solid leads to explore these aspects for the legume effects as well as their weed suppression potential. The most prolific of the cover crops, grazing vetch, has the potential to respond to the livestock-crop interaction challenge in which farmers find it difficult to sacrifice crop residues given the opportunity cost of livestock feed.

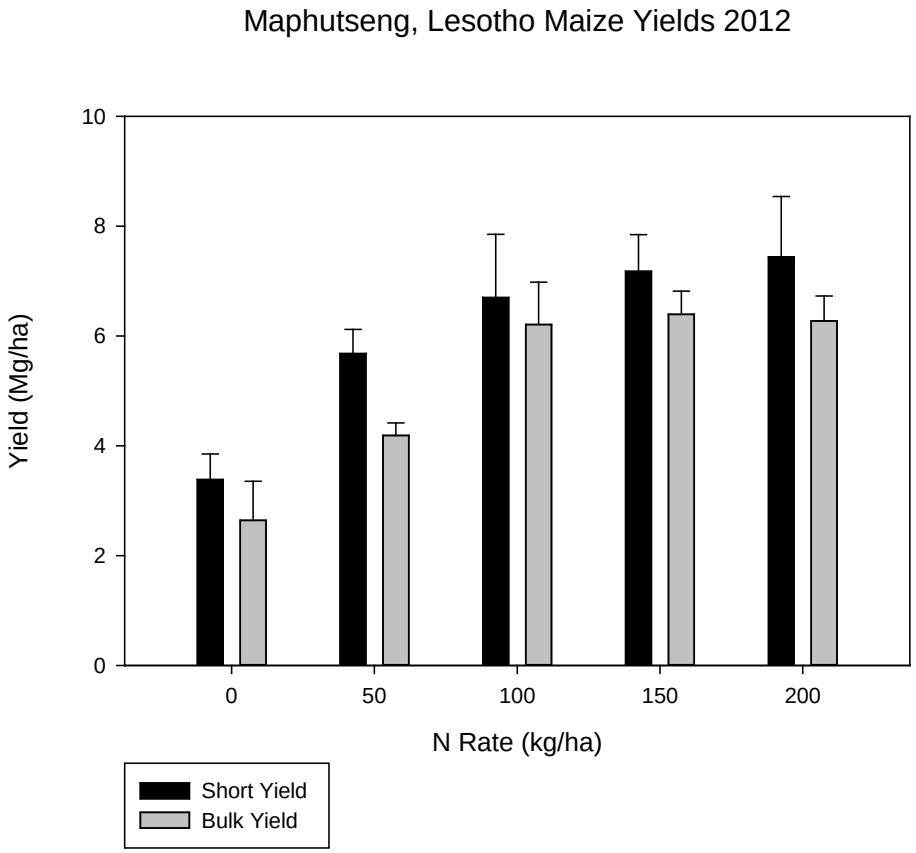


Figure 32. On-station maize yields (short and bulk) in Maphutseng, Lesotho for 2011-2012 season

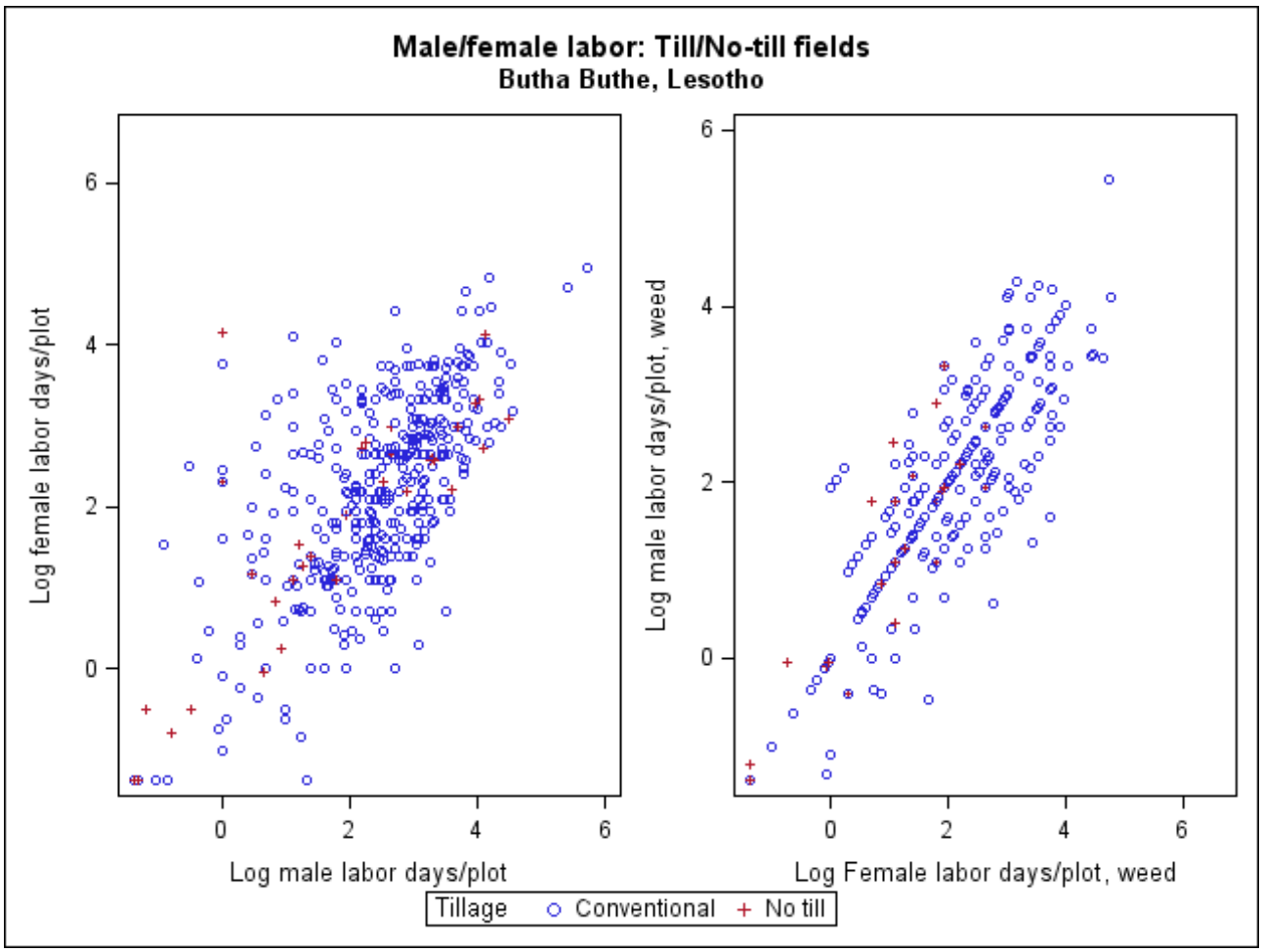


Figure 33. Estimated labor distribution by gender (total labors days per season per plot) in Butha Buthe, Lesotho

Table 34. Plot characteristics and labor demand under conventional and conservation tillage, Butha Buthe, Lesotho

	(1) Conservation tillage Mean	(2) Conventional tillage Mean	(3) All plots Mean
Plot area (ha)	0.45	0.77	0.75
Residue left on plot (1 = low, 4 = high)	2.17	1.43	1.49
Minutes walking to plot	9.75	39.1	36.5
Days after January 1 plot planted	304.3	303.5	303.6
Plot inherited through family (= 1)	0.41	0.50	0.49
Women's share, weeding labor	0.39	0.44	0.44
Men's share, weeding labor	0.33	0.33	0.33
Hired share, weeding labor	0.04	0.18	0.17
Women's labor (person days/plot)	15.62	14.4	14.5
Men's labor (person days/plot)	18.9	16.3	16.5
Hired labor (person days/plot)	2.13	11.4	10.6
Total labor (person days/plot)	45.2	44.0	44.1
Hired weeding labor (person days/plot)	0.93	6.8	6.4
Management decision of plot, male (= 1)	0.30	0.3	0.3
Maize price: M/kg	2.43	2.4	2.4
Wage index: M/day	29.6	46.6	46.4
Observations	66	674	740

Notes: "adopters" defined as household that had used no-till technology in previous or current cropping period.

Table 35. Head of household demographics in the provinces of Manica and Tete, Mozambique.

	Exposed Villages			Unexposed villages
	Conservation agriculture (CA) adopters	**Conventional farmers**	**Dis-adopters**	**Conventional farmers**
Head of household (HH) gender:				
Male	131 (86.1%)	167 (78.8%)	10 (66.7%)	102 (69.4%)
Female	21 (13.7%)	45 (21.2%)	5 (33.3%)	45 (30.6%)
N	152[1]	212[2]	15[3]	147[4]
HH age:				
Mean	44.65	43	41.2	40.8
Std Dev	12.69	13.92	14.38	12.66
Min	24	19	24	14
Max	91	85	72	67
N	139[1]	191[2]	15[3]	134[4]
Education head of household (HH):				
None	33 (22.1%)	55 (25.9%)	4 (26.7%)	40 (27.2%)
Pre school	19 (12.7%)	36 (17.0%)	2 (13.3%)	30 (20.4%)
Primary	85 (57.0%)	109 (51.4%)	8 (53.3%)	66 (44.9%)
Midddle School	9 (6.0%)	10 (4.7%)	1 (6.7)	11 (7.5%)
High School	1 (0.7%)	2 (0.9%)	0	0
College	1 (0.7%)	0	0	0
Technical	1 (0.7%)	0	0	0
N	149[1]	212[2]	15[3]	147[4]
Principal economic activity of the HH:				
Farm work	123 (81.5%)	162 (76.4%)	13 (86.7%)	111 (76.7%)
Other	28 (18.6%)	50 (24.6%)	2 (13.3%)	34 (24.4%)
N	151[1]	212[2]	15[3]	145[4]
Principal residence of the HH:				
This house	150 (99.3%)	211 (99.5%)	15 (100%)	146 (99.3%)
Other	1(0.7%)	1 (0.5)	0	1 (0.7%)
N	151[1]	212[2]	15[3]	147[4]

(CA) Is defined as practicing; no till, cover crops and field rotations on all or part of their fields
(1) CA farmers with usable responses
(2) Conventional farmers from villages exposed to CA with usable responses
(3) CA disadopters with usable responses
(4) Conventional farmers from villages unexposed to CA with usable responses
(N) Is total number of respondents for a given question and group

Table 36. Agriculture tasks among head of households in the provinces of Manica and Tete, Mozambique.

	Exposed villages			Unexposed villages
	Conservation agriculture adopters	**Conventional Farmers**	**Disadopters**	**Conventional Farmers**
Land preparation	127 (83.0%)	178 (83.2%)	13 (86.7%)	133 (89.9%)
Planting	123 (80.4%)	169 (79.0%)	13 (86.7%)	124 (83.8%)
Weeding	118 (77.1%)	169 (79.0%)	13 (86.7%)	122 (82.4%)
Apply chemicals	47 (30.7%)	48 (22.3%)	8 (53.3%)	19 (12.8%)
Bring crop from field	117 (76.5%)	161 (75.2%)	13 (86.7%)	115 (77.7%)
Dehusking	82 (53.6%)	124 (57.9%)	7 (46.7%)	82 (55.4%)
Threshing	83 (54.2%)	118 (55.1%)	8 (53.3%)	82 (55.4%)
Marketing	66 (43.1%)	90 (42.1%)	10 (66.7%)	72 (48.6%)
Tend livestock	16 (10.5%)	31 (14.5%)	2 (13.3%)	18 (12.2%)
N	153[1]	214[2]	15[3]	148[4]

(Conservation agriculture is defined as practicing; no till, cover crops and field rotations on all or part of their fields
(1)Total number of individuals who indicated that they practiced conservation agriculture
(2) Total number of individuals who indicated that they practiced conventional agriculture in a village that was exposed to conservation agriculture
(3) Total number of individuals who indicated that they practiced conservation agriculture, then abandoned the practice
(4) Total number of individuals who indicated that they practiced conventional agriculture in a village that was not exposed to conservation agriculture
(N) Is total number of respondents for a given question and group
Questions were binary with yes no response indicating participation in task

LTRA-10: Development and transfer of conservation agriculture production systems (CAPS) for smallholder farms in eastern Uganda and western Kenya

Critical Research Accomplishments

In November 2011, reflection workshops were conducted at each location of the project that were well attended by men and women opinion leaders of each community, along with on-station research station managers, constituting the core of our advisory groups. The workshops reflected upon first-year research activities, highlighted main learning points, and identified key problem areas. The workshops provided a means to resolve many of the underlying challenges identified from first year research activities. In February 2012, CCRA-8 Graduate Research Assistant Jennifer Lamb facilitated social network analysis (SNA) workshops at each research site to, among other things, obtain feedback from farmers and other service providers, explore strategies for promoting CAPS in the region, and share research results. These feedback workshops built upon the advisory committees constituted at the beginning of the project and provided additional contacts that will be very important in the processes of adoption and/or scaling up of CAPS (Lamb et al., 2012)

Development Impact

Reflection and Training Workshops revealed farmers' excellent understanding of on-going work in the way they took turns to accurately describe every step of research establishment, management, and basic data collection procedures. Field research staff, especially those without prior training in agriculture, also demonstrated excellent understanding of research activities accomplished during the first year of project implementation. This implied that ongoing CAPS research is building the capacity of farmers and support players to improveunderstanding of soil degradation issues and setting the stage for co-innovation and participatory evaluation of CAPS components.

Challenges and Responses

Challenges cited at reflection workshops included: 1) lack of adequate and/or appropriate tools needed to perform CAPS, 2) inadequate participation of host farmers in planning, establishment and maintenance of on-farm research plots and 3) insufficient information on correct herbicides to control weeds. These concerns were addressed partly during the Reflection and Training workshops and in subsequent interaction with farmers in each site. Farmers were exposed to guidelines for approved pesticide use in the East Africa SANREM project contained in the PERSUAP 1 and 2 documents developed by Research Associate Omondi in partnership with Research Associate Sikuku, Lead-PI Norton, and Dr. Mike Mulvaney. Safe use and handling of pesticides was re-emphasized, data collection protocols clarified and shared, and development, improvement, and testing of a new multifunction minimum tillage implement intensified throughout the year.

Objective 2: Define the traditional system and develop prototype CAPS for each area that build upon local knowledge, traditional practices, and address agronomic and socio-economiconstraints.

Critical Research Accomplishments

A detailed overview of the SANREM CRSP project (background, aims, and goals) as well as CAPS was revisited during the reflection and training workshops in each site, facilitated by Research Associates Emmanuel Omondi and Dominic Sikuku assisted by Research Coordinators of each sub-awardee. Components of CA were outlined as including minimizing soil disturbance, maintaining crop residue cover on soil surface, building soil organic matter, and using agricultural inputs precisely. The SNA feedback workshops facilitated by Research Associate Lamb in February 2012 revealed, among other important findings, the large disparity between the perceptions of farmers and agricultural service providers regarding their understanding of CAPS concepts. For example, popular assumption that farmers may not support the fact that tillage can degrade land because of their viewing tillage as being synonymous with farming was discounted by reports in Kapchorwa revealing that many farmers in the region were actually in agreement that tillage causes land degradation (Lamb et al., 2012). This implied that farmers may find CAPS and other new farming technologies more acceptable than they are frequently credited for (Lamb et al., 2012).

Development Impact

Reflection workshops revisited training on erosion and soil depletion processes as caused by conventional tillage practices and a detailed overview of CAPs. This encouraged participants to discuss workable solutions for evaluating and implementing CAPS. A total of four prototype multifunction implements (MFI) designed by a U.S. engineer, that would substantially increase the efficiency of, especially, minimum tilling operations, were shipped to East Africa in March and August 2012 and intensively tested in both countries using both donkeys and oxen. Tests revealed that the MFI exceeded expectations and will be playing a key role in all future CAPs operations. Use of donkeys for draft is not common at these locations but draft animal trainer Joshua Ouko of Manor House Agricultural Centre was able to harness and train local donkeys to pull the implement in a very short time. This impressed attending farmers who were apparently unaware that donkeys could be used in this capacity. One advantage of using donkeys over oxen is that they are much cheaper to feed and maintain. Each test was carried out as a co-innovation activity in which farmers, including women farmers, took turns operating the implement with various tillage, weed cultivation, and subsoiling attachments, followed by a facilitated discussion of possible improvements of the machine. Most noted possible improvements included soft, rounded handle bars and resistance to breakage by rocks, both of which were addressed in the two improved versions shipped in August.

Challenges and Responses

One major challenge cited across the board was inadequate participation of farmers in decisions regarding planning and execution of research design, management, and data collection and analysis. Reflection and SNA feedback workshops provided farmers with an opportunity to

freely express their concerns, challenges, and misgivings about first-year CAPS project implementation. More intensive training to equip farmers with skills needed to manage research work coupled with closer supervision by field research staff was undertaken during the course of the year.

Objective 3: Evaluate agronomic, ecological and economic sustainability of CAPS compared to traditional practices.

Critical Research Accomplishments

Soil sampling was undertaken in mid-January by Dr. Sikuku assisted by UW and Moi University students. Soils were sampled at 0-10and 10-30 cm from four spots randomly selected using a zigzag design. Samples were collected from plots receiving +N and –N treatments. Although land preparation was completed by end of February 2012, planting was delayed to mid-April due to a delay in onset of long rains in all study sites.

Farmers in each project site were quite satisfied with implementation of the second-year research work. A general consensus emerged, based on preliminary observations and results, that intensive tillage may not be as critical in growing maize and beans as originally assumed. First year project implementation preliminary results in Kenya indicated that traditional/conservation tillage tended to perform better than both conservation tillage practices. For example, in Trans Nzoia, preliminary on-station results, looking only at main effects of tillage and cropping systems, indicated that maize and bean grain yield in conventionally tilled plots were greater than those in no-tilled plots ($P = 0.024$ and $P = 0.0029$) respectively (Table 37). Similar results were obtained on-farm whereby maize yield in conventionally tilled plots were greater than those in no-tilled plots ($P = 0.017$) but no differences between tillage treatments were observed for bean yield (Table 38). In Bungoma, there were no significant differences between tillage practices for maize or bean grain yields from on-station yield analysis. Although bean yields in no-tilled on-farm plots in Bungoma were significantly greater ($P = 0.0204$) than minimum till and farmers' practice (Table 38), farmers in Bungoma and Trans Nzoia were generally not convinced that minimum or no-till was a viable option to conventional tillage. These results were partly attributed to weed infestation that were more prevalent on conservation tilled plots given that we were all still learning how best to manage weeds under the restrictions imposed by the limited availability and diversity of herbicide options. However, farmers in this region were all willing to do it again, especially on the understanding that the weed control and other challenges identified during the first year would be addressed and/or corrected in the second year. During reflection and training Workshops, Research Associate Omondi provided instruction on weeding and guidelines for approved pesticide use in the East Africa SANREM project. Attention was drawn to the participants on the fact that all pesticides that are USAID approved for this project are contained in PERSUAP 1 and 2 documents. Special emphasis was made on the fact that we are not promoting use of herbicides, but expect to minimize and/or eliminate their use altogether after sufficient residues are generated and appropriate cover crops established to manage weeds, improve soil fertility and increase crop yields without the need for herbicides.

Table 37. Comparing yield parameters between main effects of tillage practices in East Africa on-station trials; CT denotes conventional till; MT denotes minimum till; NT denotes no till. These preliminary analysis excluded effects of nitrogen top-dressing.

Treatment	Trans Nzoia, Kenya†		Bungoma, Kenya		Kapchorwa, Uganda		Tororo, Uganda	
	----------tons/ha----------							
	Corn†	Bean†	Corn	Bean	Corn	Bean	Corn	Bean
CT	4.40a	1.75a	4.31a	0.44a	1.80a	0.17a	2.00a	0.08b*
MT	3.77ab	1.61a	4.16a	0.47a	1.62a	0.20a	1.71a	0.18a
NT	2.98b	1.04b	3.44a	0.52a	1.43a	0.17a	1.91a	0.16a
P value	*0.024*	*0.0029*	*NS*	*NS*	*NS*	*NS*	*NS*	*0.095*

Means within the column followed by the same letter are not statistically significant (LSD, $\alpha = 0.05$)
* Significant at $\alpha = 0.10$

Table 38. Comparing yield parameters between main effect of tillage practices in East Africa on-farm; CT denotes conventional till; MT denotes minimum till; NT denotes no till. These preliminary analysis excluded effects of nitrogen top-dressing.

Treatment	Trans Nzoia, Kenya		Bungoma, Kenya		Kapchorwa, Uganda		Tororo, Uganda	
	----------tons/ha----------							
	Corn	Bean	Corn	Bean	Corn	Bean	Corn	Bean
CT	5.05a	0.68a	6.30a	0.06§b	3.89a	0.10a	3.29a	0.48a
MT	4.47ab	0.62a	6.62a	0.08§b	3.77a	0.18a	3.33a	0.48a
NT	3.97b	0.68a	6.28a	0.28§a	3.75a	0.10a	3.21a	0.65a
P value	*0.017*	*NS*	*NS*	*0.0204*	*NS*	*NS*	*NS*	*NS*

Means within the column followed by the same letter are not statistically significant. §There was significant season by tillage by cropping system interactions (P = 0.0039) for bean yield in Bungoma; thus data were analyzed separately by season, tillage, and cropping system. However, results shown are for season 2 as there were no differences between tillage practices for bean yield in season 1

Farmers in Uganda, on the other hand, observed either better performance of crops in conservation tilled plots at best, or no difference with traditionally tilled plots at worst, during first year research implementation, even though observed differences were not statistically significant (Table 37 and 38). In each area, however, there was a general consensus that potential savings from eliminating or reducing tillage was adequate incentive to continue this research. Farmers in all regions, except Kapchorwa, were quite happy with observed performance of *Mucuna* as a cover and/or rotation crop given the observed good yields of maize intercropped or grown in rotation with it.

Preliminary on-station results from Kenya revealed that maize and bean yields in Trans Nzoia (P = 0.0024 and P = 0.0001 respectively) and maize yield in Bungoma (P = 0.0004) were significantly greater in strip intercropped rotation plots that included *Mucuna* in the rotation regime (Table 39). There were no other statistical differences between cropping systems treatments for maize and bean yield from on-station plots. Apart from significantly greater bean yields in strip intercropped rotation plots compared to the other treatments, strip intercrop

rotation performance results were not impressive from on-farm preliminary results (Table 40). This was partly attributed to the aggressive nature of *Mucuna*; while its ability to suppress weeds and provide mulch was noted, unchecked, it also tended to cover and suppress maize and bean crops thereby affecting their productivity. In our most recent visit to East Africa in September 2012, it was proposed that *Mucuna* spacing be increased and/or inter-plant the cover crop between rows of maize at least two weeks after planting maize to minimize its potential adverse effects of maize yields. Despite all the potential problems observed involving *Mucuna*, all farmers, including those in Kapchorwa, expressed a desire and readiness to try *Mucuna* again. During our recent visit to Kapchorwa, different cover crop options were explored as *Mucuna* failed to perform as expected, especially in the cooler higher altitude farms in Kwosir sub-county. Annual vetch (*Vicia villosa* var. *villosa*) was proposed for immediate trials on *Mucuna* plots to replace failed *Mucuna* plants during second season relay cropping.

Table 39. Comparing yield parameters between main effects of cropping methods in East Africa On-station trials; ROT 1 denotes rotation 1; ROT 2 denotes rotation 2; CP denotes conventional maize-beans intercropping practice. These preliminary analyses excluded effects of nitrogen top-dressing.

	Trans Nzoia, Kenya†		**Bungoma, Kenya**		**Kapchorwa, Uganda**		**Tororo, Uganda**	
Treatment	**----------tons/ha----------**							
	Corn	Bean	Corn	Bean	Corn	Bean	Corn	Bean
ROT 2	2.65b	0.89b	2.73b	0.38a	1.66a	0.15a	1.79a	0.18a
ROT 1	4.26a	1.64a	4.45a	0.49a	1.51a	0.19a	2.00a	0.10a
CP	4.24a	1.87a	4.69a	0.58a	1.69a	0.19a	1.86a	0.14a
P value	*0.0024*	*0.0001*	*0.0004*	*NS*	*NS*	*NS*	*NS*	*NS*

Means within the column followed by the same letter are not statistically significant (LSD, $\alpha = 0.05$)

Table 40. Comparing yield parameters between main effects of cropping methods in East Africa On-farm trials; ROT 1 denotes rotation 1; ROT 2 denotes rotation 2; CP denotes conventional maize-beans intercropping practice. These preliminary analysis excluded effects of nitrogen top-dressing.

	Trans Nzoia, Kenya		**Bungoma, Kenya**		**Kapchorwa, Uganda**		**Tororo, Uganda**	
Treatment	**----------tons/ha----------**							
	Corn	Bean	Corn	Bean	Corn	Bean	Corn	Bean
ROT 2	4.38a	0.68a	6.70a	0.330§a	3.91a	0.20a	3.09a	0.53a
ROT 1	4.84a	0.62a	6.57a	0.001§b	3.85a	0.04a	3.38a	0.54a
CP	4.26a	0.68a	5.89a	0.001§b	3.66a	0.17a	3.36a	0.55a
P value	*NS*	*NS*	*NS*	*0.0001*	*NS*	*NS*	*NS*	*NS*

Means within the column followed by the same letter are not statistically significant

§ There was significant season by tillage by cropping system interactions (P = 0.0039) for bean yield in Bungoma; thus data were analyzed separately by season, tillage, and cropping system. However, results shown are for season 2 as there were no differences between cropping systems for bean yield in season 1

Follow-up meetings with host farmers in September 2012 also revealed that at least two host farmers in each site planned to scale up some of our CAPS treatments. A host farmer in Kapchorwa, Mr. Chris Kaptekin, grew corn on 6 acres of land that was not tilled this year. Although he later manually weeded the corn, this activity represents a substantial effort made

toward adoption of CAPS. One other farmer in Trans Nzoia, not directly associated with our research, learned about our activities and decided to grow 20 acres of corn using minimum till procedure. Others claimed to have stopped plowing on all or some of their maize fields, reflecting a general eagerness to drop this expensive and labor-intensive operation.

Development Impact

More inclusive and participatory planning, establishment, management, monitoring, and data collection in the second phase implementation of the study strengthened the foundation for a successful long-term project. Participating farmers that received rain gauges, notepads, and pencils for recording daily rainfall and reading the Tru-Chek rain gauges were quite enthusiastic about continuing to carry out these tasks.

Challenges and Responses

Delays in key management aspects like planting, weeding, and topdressing that may have contributed to poor performance of research crops especially in the second season of first year implementation, were attributed to insufficient participation of farmers in decisions regarding planning and execution of research design, management, and monitoring as well as inadequate supervision, especially in Kenya. During the Reflection and Training workshops, farmers were trained on the key aspects of CAPS, as well as timing of planting and various agronomic management aspects like weeding, top-dressing, herbicide application, and data collection. Supervision was also intensified uniformly in all study sites during the second phase of implementation. While host farmers managed farmer-practice treatment plots independent of SANREM field staff, no-till and minimum-till plots were managed in consultation with SANREM field and/or research staff. Farmers were also more involved in planning and executing research implementation activities. An advance planning program/schedule of activities including detailed research supplies and suggested time of acquisition were prepared by field coordinators in each site. All inputs for the following season were purchased well in advance. While strict adherence to instructions as prescribed and to constantly consult in case of doubts was emphasized throughout second year implementation, two isolated cases of farmers weeding no-till plots were noted.

Failure of *Mucuna* to perform as expected in Kapchorwa forced us to explore alternative cover crop options. Annual vetch (*Vicia villosa* var. *villosa*) was proposed for immediate trials on *Mucun*a plots. Seeds will be purchased from East Africa Seed Company in Kenya and shipped to Uganda before end of second season planting period. Other cover crop variety trials will also be attempted on small plots adjacent to our research plots in Kapchorwa. These will include lab lab beans (*Dolichos lablab*), other varieties of annual vetch (*Vicia* sp.), and jack beans (*Canavalia* sp.).

Ph.D. student Judith Odhiambo spent the fall and spring period on site monitoring trace-gas emissions once per month in Kenya on-station plots as well as collecting weeds data at all study sites. This coupled with other visits by NGO partners, students, and PIs, maintained a presence for continuing discussion of the research work. One major challenge noted in the first year was

uneven application among study sites of some practices, partly due to reliance on insufficiently informed hired labor coupled with inadequate supervision thereafter. This was remedied during one-week MFI-testing visit in February 2012 by Lead-PI Norton, Co-PI Ursula Norton, Sikuku, and Omondi in which field research staff were instructed to redesign the orientation of affected plots in a way that did not substantially affect their original layout and to note other plots that could not be remedied for future accounting in statistical analyses. Affected responsible NGO partners also agreed to increase contact and better management.

Degree and nondegree training activities

- Primary training involved graduate degree education for several students: two PhD and one MS at the University of Wyoming; two MSc at Moi University; and one MSc at Makerere University.
- Farmer training on CAPS and general research implementation strategies were conducted in November 2011 during reflection and training Workshops at each study site. A total of 28 men and 14 women participated in these workshops.
- Informal farmer trainings on the use of MFI were conducted during MFI testing in March and September facilitated by PD Norton, Engineer Norton, Joshua Ouko, Research Associates Omondi and Sikuku, and other field research personnel in Kenya and Uganda. A more formal training on animal draft power generally and use of MFI with oxen specifically was conducted for 16 ATU contact farmers (10 men and 6 women) and 4 ATU field staff persons (3 women and 1 man).
- In November 2011, Field Extension Coordinator (FEC) and Field Research Assistants (FRAs) of ATU conducted a farmer interaction/training on best agronomic practices to 9 men and 16 women in Kwosir and Kaplak in Kapchorwa County. The aim of this training was to enhance farmers' understanding of best agronomic practices and CA and safe use of agrochemicals. Field Extension Coordinator and FRAs also conducted a farmer interaction/training on data collection and record keeping to 10 men and 8 women in Molo region, and 4 men and 12 women in Kisoko region in Tororo County.
- In March 2012 FEC and FRAs of ATU conducted training on CA practices and farming as a business compared to farmers' current practices to 4 men and 23 women in Kisoko region in Tororo county. The aim of the training was to enhance farmers' understanding of the relationship between costs, income levels and profit across the tillage systems in CA in comparison with the farmers' current practices
- Other trainings conducted by ATU's FEC and FRAs in 2012 included the following:
  - Training on CA, FAAB, savings, mobilization, and soil fertility management and safe use of agrochemicals to 26 men and 37 women in Tororo in July 2012
  - Training on gender mainstreaming and CA to 2 men and 20 women in Tororo in July 2012
  - Training on soil fertility management and safe use of agrochemicals to 16 men and 13 women in Kapchorwa in July 2012
- Training enumerators and SANREM Field Research personnel on Marketing Systems research data collection was conducted by Co-PIs Eric Arnould and Melea Press, and a visiting Marketing Professor from Denmark, Dr. Sooren Askegard in August and

September 2012 at all research sites. Detailed plans for sampling, data collection and handling were devised for each project area during this training. The aim of marketing research is to explore specific market related factors that would encourage or inhibit farmers from adopting CAPS. This is expected to be achieved by exploring primary and secondary data. Primary data will be collected by questioning a sample of farmer groups and various marketing agents in the study area, while secondary data sources will include local, national, development projects, and producer organizations.

Publications, presentations, and other SANREM CRSP products

Ph.D. student Judith Odhiambo presented a poster reporting preliminary results of greenhouse gas emissions measurements at the 2011 American Society of Agronomy meetings in San Antonio, TX.Lead PI J.B. Norton presented a departmental seminar at the University of Wyoming reviewing the project and early results Newspaper articles on the MFI were published in the Waterloo Iowa Courier.

Networking activities

The University of Wyoming SANREM group of PIs, research associates, and graduate students meet regularly to discuss progress and related research. Lead PI Norton, Research Associate Sikuku, and on-site project partners participated in follow-up sessions present at each research site by Virginia Tech grad student Jennifer Lamb in which she reported and led discussions on results of her social networks analysis (SNA) research. These meetings had excellent participation and resulted in lively discussions of the SANREM project, CA, and how to implement change at each study area. The meetings broadened and strengthened engagement of local people in the project.

Highlights

- Reflection and Training workshops in November 2011 and SNA workshops in February 2012 brought over 100 men and women, creating broad understanding of and engagement in our East African SANREM CRSP research. This sets the stage for long-term co-innovation to develop adoptable CAPS based on participatory evaluation of tillage, rotation, and cover crop components;
- Agronomic, soil, and trace gas data were collected from the twenty research sites by the end of the first season research study. Analyses of these data are ongoing. Research study for the second phase was established in those same sites with help of participating farmers and local residents at each area, including soil sampling, tillage treatments, and planting. Clear communication of responsibility for managing and monitoring rainfall, weeds, and input activities continued to engage farmers and local workers in ways we think will support a successful long-term project.
- Farmers were re-introduced to weeding and guidelines for approved pesticide use in the East Africa SANREM project (PERSUAP 1 and 2) developed last October by Research Associate Omondi in partnership with Research Associate Sikuku, PD Norton, and Dr. Mike Mulvaney and approved by USAID. Issues of safe use and handling of pesticides

were emphasized and heightened awareness on the consciousness of the project on safety of users and the environment.

- Twenty research sites, including one on-station trial and four on-farm trials at each of four study areas, were established with help of participating farmers and local residents at each area, including plot demarcation, soil sampling, tillage treatments, and planting. Clear communication of responsibility for managing and monitoring rainfall, weeds, and input activities engaged farmers and local workers in ways we think will support a successful long-term project.
- Two prototype multifunction implements (MFI) designed by a U.S. engineer, James Norton of Iowa, that would substantially increase the efficiency of minimum tilling operations, were shipped to East Africa in March 2012 and intensively tested at on-farm and on-station sites in Trans Nzoia, Kenya, and Kapchorwa, Uganda. Performance of the MFI exceeded expectations and will be playing a key role in all future CAPs operations. Over 100 men and women attended the trials at the four sites and offered many suggestions for use and improvement of the implement. Based on these suggestions, Engineer Norton designed two additional MFIs that were shipped to East Africa in September and extensively tested at a research facility and one farmer group in Tanzania; Trans Nzoia and Bungoma in Kenya, and Tororo in Uganda. Tests in Tanzania were informed by a need to extend CAPS beyond our current project site locations and to identify other potential local manufacturers of the implement. Dr. Adrian Ares, the SANREM CRSP Director accompanied by Lead-PI Norton, Engineer Norton, Research Associate Omondi and other East Africa host research associates and staff participated in these tests that also attracted over 100 men and women.

LTRA-11: CAPS among tribal societies in India and Nepal

Principal investigator: Catherine Chan-Halbrendt, University of Hawaii at Manoa
Host Countries: Nepal, India

Research progress by objectives

Objective 1: Determine the set of CAPS for sustained productivity, labor, soil impact, gender equity and profitability

Critical Research Accomplishments

Nepal
Socio-economic surveys of at least 25% of all households in the project villages have been completed and the baseline databases of socio-economic profiles of farmers have been established. This data will be used to identify household composition, develop representative farm budgets, and provide supporting demographic information for further research.
The on-farm trials in three villages of Nepal are in their second year. By this reporting period, the summer season treatments (sole-maize with conventional tillage and sole-maize with strip tillage) are ready for harvest and rainy-season treatments (T1: sole-millet with conventional tillage, T2: sole-black gram with conventional tillage, T3: millet + black gram with conventional tillage, and T4: millet + black gram with strip tillage) are ready to sow. There was extreme drought at the time of maize planting in research villages. Farmers observed germination problems particularly in strip tillage plots. In general, crop-growing stages such as flowering and cob formation were slightly later in the strip tillage plot than in conventional tillage plots. Before conducting market surveys, it was important to analyze the marketing behavior of farmers. The baseline survey data in Nepal indicated that few market transactions were done by farmers. Rice (45% of farmers) and millet (42% of farmers) were major food grain purchased by farmers; while cowpea (48% farmers) and black gram (14% farmers) were major grains sold in the market. Most farmers neither sell nor purchase maize. Therefore, an increase in millet yield has the potential to lower farmers expenditures on food, as well as an increase in cowpea and black gram yield will enhance their income. The study also found that most marketing transactions (about 90%) occur in the local/village market followed by the town market. The next level of market survey in nearby towns is planned for next year.

The weather station and field sensor monitoring devices established in the villages are working properly. The data are being compiled and will be used to remove climate effects in the performance analysis of CAPS.

Crop yield, cost of production, labor and agronomic data from on-farm trials of the first year in Nepal, have been collected and analyzed. Although, the millet yield was significantly lower in intercropping than sole-crop, cowpea yield in intercropping was comparable to that in the sole-crop. Hence, farmers still find intercropping profitable. Analysis of Land Equivalency Ratio

(LER) for yield showed that millet + cowpea could produce an equivalent amount of cowpea and millet sole-crop yield using 20% less land. The major gain in LER was attributed to cowpea, because cowpea yields in millet + cowpea was about 75% of its sole-crop yield. The millet + cowpea system significantly increased total available protein to households, which is one of the main nutrient deficiency for people. Thus, results suggest potential for intercropping to contribute to improved nutrition. The yield of crops with strip-tillage was significantly lower than that with conventional tillage; hence minimum tillage may be the major factor constraining farmers' from adoption of CAPS in the near future.

Sole-cowpea with conventional tillage was the most profitable system due to low labor costs and the high market price of cowpea. Sole-millet was the least profitable of all treatments. Millet + cowpea with conventional tillage was the most profitable of the two intercropping practices. This reflects the reduced crop yields resulting from strip tillage, which was expected for the first year. Results suggest that CAPS can improve the livelihoods of subsistence farmers by increasing profitability.

The data on gender roles and their impact on agriculture system in Nepal have been collected through household surveys of approximately 50 % of the households. Preliminary results show that men and women tend to share the burden of agricultural labor, however, the control over agricultural decisionmaking and sales of crops tends to be somewhat imbalanced. On average the women surveyed only felt somewhat in control over decision-making related to the adoption of new agricultural practices, while control over land use decisions was considered as almost equal between the male and female. Women participate in a large proportion of household and agricultural activities; nevertheless, wage earnings and market sales remain predominantly male-dominated activities. In terms of community inclusion of women, 7% of women engaged in community leadership roles and 15% participated in savings groups. Since both men and women share the burden of agricultural labor, yet women disproportionately maintain household activities, the labor implications of CAPS treatments must be considered to ensure a balanced and feasible shift of labor demands for each gender.

India

Socio-economic surveys of all 60 households of the recently added village Talachampei have been completed. Household data related to demography, production resources, and agriculture practices and cropping system, labor availability, household income and market were collected and a database has been created. The database will be used as a baseline for comparison with future research to measure the changes in income and household consumption, as a result of CAPS implementation.

A field experiment was conducted during the rainy season of 2011 and post rainy season of 2011-12 at the Regional Research and Technology Transfer Station of Orissa University of Agriculture and Technology in Kendujhar. During thee rainy season, the experiment was laid out in randomized block design with four treatments:

- T_1: Conventional tillage with sole-maize,
- T_2: Conventional tillage with maize + cowpea,
- T_3: Minimum tillage with sole-maize,
- T_4: Minimum tillage with maize + cowpea, which were replicated thrice.

In the post-rainy season, residual effects of these four treatments (main plot) and direct effect of three cover cropping treatments at the sub-plot level, *viz*., no cover crop, mustard as cover crop, and horse gram as cover crop were studied in a split plot design with three replications. Analysis of on-station trial data showed that maize yield in the maize + cowpea system under minimum tillage was comparable to that of sole-maize under conventional tillage. Also, sole-maize produced comparable yield to that of maize + cowpea. Cowpea yield in maize + cowpea under minimum tillage was 24.4% less than that under conventional tillage. The highest net return of $403 per and per year was recorded from maize + cowpea with minimum tillage. Mustard was adjudged best among post-rainy season cover crops. With regards to soil physiochemical properties, maize + cowpea with minimum tillage followed by horse gram cover crop had small .although not statistical significant, positive influences on bulk density, pH, organic carbon, and nutrient availability.

The highest maize yield of 5.2 tons/ha was reported under MT-M+C which, remained at par to that of CT-M (control). Both treatments differ significantly from the rest of the treatments. As compared to the control, CT-M+C produced a yield of 4.7 tons/ha (a decrease of 8.8%), and MT-M produced a yield of 4.5 tons/ha (a decrease of 12.6%). Yield of cowpea on the intercropped plots averaged 775.5 kg/ha with conventional tillage and 675 kg/ha with minimum tillage, which were additional gains over the control with cowpea. There was a significant interaction effect of tillage and intercropping on maize yield. Intercropping had a positive influence on maize yield under minimum tillage, while conventional tillage was better with no intercropping.

In terms of labor requirement, minimum tillage reduced labor days by 30.8% during land preparation as there was only one plowing instead of two in conventional tillage. There was an additional increase of labor days for sowing of cowpea. All CAPS treatments showed an increase of labor days required for weeding and pesticide application over control except maize-cowpea intercropping under conventional tillage. CT-M+C and MT-M+C had higher increase of labor during harvesting of maize and cowpea, 156.5 and 143.2%, respectively. However, the highest increase of labor days per ha was in MT-M+C followed by CT-M+C, whereas MT-M showed 11.6% decrease in terms of total labor requirement as compared to control with profit of $387 per ha and per year. Among the CAPS treatment only minimum tillage with intercropping showed an increase in profitability of 9.7%.

The on-station weather data such as solar radiation, precipitation, maximum and minimum temperature and relative humidity have been collected and thedata set will be used to see the effect of climatic factors on annual crop growth and yield as well as for crop model calibration. UH has designed and field-tested a portable field device to measure water stable aggregates.

UH has trained 11 professionals (seven male and four female) from in-country partners and UH students on the method of using the device in field and data collection. The development of this device will be helpful for project soil research methods. Water stable aggregate measurements in villages will be conducted at the end of this year's cropping season.

Development impact

A major priority of this objective regarding dvelopemnt is testing and piloting new technologies on agronomic and economic basis. The project has is currently testing 15 new research technologies in the field, and four technologies have already been made available for transfer. The project found that with better integration of legumes in the farming system, and innovative intercropping, adoption of CAPS can actually increase yield and profitability from the first year itself.

- In Nepal, we have verified that appropriate adoption of CAPS has potential for increasing profitability of the maize-based hill farming system by $329.1 to $509.3 per ha and per by either yield increment (20% increase) or saving labor ($ 25.9 per ha and per). Since, most of the increased products are not sold, we can estimate that an increase in protein availability ranging from 182 to 213% is possible with implementation of CAPS. Since, protein deficiency is the major problem of the people in Nepal, the new farming system can reduce the deficiency.

- In India, the project showed the potential of increasing maize yield by 12% under minimum tillage with intercropping in addition to gain from cowpea. There was labor saving of $40.5 per ha and per year in sole-maize under minimum tillage versus conventional tillage sole-maize. We observed enhanced household income as well as consumption due to increased yield in maize and more specifically cowpea (as the market value of cowpea was almost double that of maize). Overall, we found that the best CAPS can increase profits by about $286.5 per ha and per year.

Challenges and responses

The project faced natural and human-made challenges during this year to accomplish these objectives. The main challenge we faced was increased variation in the weather. The project has farmers' field trials as major components of the research strategy for adoptive research; the germination of maize was lower because of drought. The problem of germination was higher in strip tillage plots. We responded that with gap filling, but the effects of the drought were visible even after that.

Collecting year-round weather information from established weather stations was also found to be difficult. For the initial two years, we have many intermittent points in the recorded data. Natural factors such as rainfall and animal intrusions in weather stations were major problems. Hence, we plan to fill the intermittent data with some imputed data based on government-established weather stations nearby the sites.

Another challenge was the spacing of crops in the intercropping treatments, which was not well established. Theroject focused on the common crops grown by the farmers and tried to introduce CAPS system, which were not practiced before. These combinations of new intercropping crops produced mixed results. In Nepal, prolific vegetation of cowpea had some negative effect on millet yield, and ultimately had to be replaced by black gram. Similarly, the farmers complained about the damage of cowpea plants due to closer spacing. As a solution, a new compact variety of cowpea was substituted in the villages and also a M.S. graduate student will work on spacing related issues in maize and cowpea intercropped systems to determine optimum spacing.

Objective 2: Explore stakeholder preferences for CAPS to promote adoption

Critical Research Accomplishments

Nepal

Three separate exercises using the Analytic Hierarchical Process (AHP) were conducted in three research villages to reveal the preferences of farmers, researchers (from Institute of Agriculture and Animal Science) and development workers (from LI-BIRD) on CAPS preferences. The hypothesis is that if stakeholders CAPS preferences are not aligned, adoption will be difficult. In terms of improved income as a goal, farmers rated sole maize-cowpea with conventional tillage the highest for two villages, and the second highest for one village. Development workers and researchers preferred sole maize- millet + cowpea intercrop with strip tillage to all others in terms of improved income. This met expectations for the researchers and development workers, as millet + cowpea with strip tillage is the only treatment that includes two of the three CAPS principles. Farmers at Hyrkrang and Thumka villages ranked sole maize -cowpea with conventional tillage much higher than other system, suggesting that the perceived advantages of intercropping or strip tillage have not been communicated well to the farmers. A higher preference for millet + cowpea with conventional tillage over strip tillage in terms of both improved income and soil quality in these villages indicates that farmers perceive conventional tillage as having more monetary and edaphic value than strip tillage. The study concluded that farmers, researchers and development workers show a preference for adoption of new production systems that can improve soil quality. However, the full benefits of legume intercropping and strip tillage may be unclear to village farmers. Moreover, labor savings is not a primary factor motivating the adoption of conservation agriculture production systems. It also suggested limited understanding amongfarmers and non-farmers about effectiveness of intercropping. Farmers were found to prefer short-term profits to sustainable production systems, which could be a challenge for the project in upcoming years.

The analysis of the institutional context, knowledge system and community organization, which are useful for the testing and promotion of CAPS in Nepal has been done by using Technology Network Analysis, Analytic Hierarchy Process (AHP), and Cognitive Mapping Tools. The network study was done to map the network through which farmers get information about new technology and new agriculture practices, to analyze how the network works for dissemination

of conservation knowledge and to determine how a farmer's position in the technology network affects her/his performance. To answer these questions, males and females from about 80% of the households have been surveyed with the semi-structured questionnaire in all three-project villages of Nepal and one village in India. Initial results indicate that farmer-to-farmer technology transfer is very important to the farmers in Nepal, while input suppliers, mostly agro-vet shops, NGO staff and development workers, were the major sources of new agriculture technologies in Indian villages. NGO staffs are the sole sources of conservation information to farmers. Moreover, the networks of male members of households were found to be far-reaching and stronger than the female members of the households. This information will be used to plan future activities.

India

A group of 15 farmers visited an on-station experimental site and learned about the concept of CAPS. The Department of Soil Conservation, Government of Odisha organized the trip. The farmers were enthusiastic about the minimum tillage concept.

Development impacts

Project used AHP and cognitive mapping to understand the decision-making processes of the farmers, and analyzed the differences between the development workers and researchers. These studies were useful for providing researchers and extension workers a glimpse into how their preferences and thought processes differ from the preferences and thought processes of the farmers. This will definitely help to bridge the gap in understanding about CAPS among the stakeholders for adoption. Moreover, the project has enabled researchers and development workers to use effective tools to understand the preference and perception of farmers, which will improve the effectiveness of technology development and dissemination in the long run. Two partner universities, one each in Nepal and India have been introduced to the concepts of CAPS. Moreover, a partner NGO in Nepal has built capacity to implement CAPS by conducting the action research project. The project has created a critical mass of about 20 institutional members to understand, research, improve and promote CAPS. Similarly, there has been interest from the government extension system regarding the technology being promoted by SANREM. The Department of Soil conservation, Government of Odisha organized an exposure visit for 15 farmers to learn about the concept of conservation agriculture.

Challenges and responses

Collecting information from researchers, development workers and farming communities using the same questionnaire items in order to compare their responses was challenging. The challenge was caused by logistical difficulties involved in securing translation, mainly during the focus group discussion and group survey. This problem was less severe after the enrollment of Nepalese and Indian students in the project. Similarly, use of visual aids prepared in the local language was also effective in improving communication and speeding up the information collection process in Nepal. Challenges were also faced in securing survey participants and maintaining respondent focus during the household surveys. Hence, changes in survey timing and procedure were made to improve the situation. Enumerators went to the houses at lunch or dinner times to finish the surveys.

Objective 3: Implement preferred CAPS on-farm for validation, impact on farm household welfare leading to policy recommendation

Critical Research Accomplishments

This project has maintained flexible and pragmatic approaches to revise and improve the CAPS treatments both in Nepal and India. The project used the results from previous on-farm trial data and preferences and feedbacks of farmers collected through AHP exercise to revise and improve the treatments in trials for on-farm validation.

Nepal

Cowpea was selected to intercrop with millet for the first year, and was replaced by black gram in the second year. The major reason for this change was shading issues experienced when cowpea outgrew millet. From this year, the modified treatments being tested in field are listed in the following table.

Table 41. Cropping pattern and tillage treatments

Treatments	Cropping pattern		Tillage
	1st season (March-June)	2nd season (July-October)	
T 1	Maize	Millet	Conventional
T 2	Maize	Black gram	Conventional
T 3	Maize	Black gram + Millet	Conventional
T 4	Maize	Black gram + Millet	Strip - tillage

About 28 farmers from three project communities are being provided with the knowledge and skills of the on-farm action research methodology. This training has been useful to improve the quality and reliability of the data being collected on farm.

IAAS-TU had conducted two research trials involving the tillage x fertilizer (full 3x4 factorial split plot design with 4 replications) and intercropping x variety (full 4x3 factorial split-plot design with 4 replications) trial. The tillage x fertilizer trial is designed to find the best fertilization practice for minimum tillage which has three tillage treatments; i.e., dibble, full plow and strip plow and four farmyard manure (FYM) rates (2, 5, 10 and 20 tons/ha) in subplots. The intercropping x variety trial has four intercropping combinations (maize + millet, maize + cowpea, maize + black gram and maize + green gram) in the first cropping season (April – July) crossed with three improved varieties of maize (Quality Protein Maize - QPM,

Manakamana – 1 and Arun – 2). This research will find out the best variety of maize suitable for different CAPS.

IAAS has also started an observational cover crop trial with 10-15 species in 5m x 5m plots. Selected species will be replanted and replicated in the fall to take advantage of residual moisture. The soil samples have already been collected, sent to ADSC/VT lab, and analyzed. The results of sample set analyses by the VA Tech soil lab are already available for comparison with LI-BIRD data.

India

The project assessed performance of CAPS based on key, economic, agronomic and soil quality indicators of on-farm trials in India. The assessment was done through the analysis of the first year data and focus group discussions. Data analysis indicated that compared to the control-sole maize with conventional tillage, maize and cowpea intercrop with minimum tillage produced about 9.7% higher profitability. The results of both on-station and on-farm trials showed that the yield of cowpea in maize and cowpea intercropping was an additional economic gain for the farmers. The soil data after the first year cropping season was collected and compared with the baseline. Although, it was too early to compare the effect of CAPS on soil nutrients and physico-chemical properties; maize and cowpea intercrop along with minimum tillage and followed by cover crop had positive influence on bulk density, pH, organic carbon, and nutrient availability of soil. Although, the actual changes were statistically not significant, the pattern of favorable changes in soil properties attributed to minimum tillage was visible.

In the Tentuli village of India there are 20 on-farm trials in their second year of CAPS implementation, while nine new plots from Tentuli and seven from Talachampei are in their first year of trial, each consisting of four treatments. The improved variety of maize 'Nilesh' and of cowpea 'Utkal Madhuri' are being grown in the treatments.

Table 42. On farm CAPS treatments in Odisha, India

Treatments	Season		Practice	Tillage
	1st season (June-October)	2nd season (November - January)		
T1 (control)	Maize	Mustard	Sole-crop	Conventional
T2	Maize + cowpea	Mustard	Intercrop	Conventional
T3	Maize	Mustard	Sole-crop	Minimum
T4	Maize + cowpea	Mustard	Intercrop	Minimum

The project facilitated gender-segregated focus group meetings (32 males and 38 females) in Tentuli village. Farmers mentioned that introduction of the improved maize variety 'Nilesh' and line sowing methods, resulted in three-fold increase in maize yield (12,500 vs. 35,000 cobs per hectare). Farmers were able to sell the first thinned two-week-old mustard in the local market as a green leafy vegetable (4 bundles at $0.22 each) to earn additional income. Intercropping of maize with cowpea had a great impact especially mentioned by male farmers, during the focus group meeting. According to them, though there was extra labor requirement in sowing and harvesting the cowpea, the additional yield and high cowpea market price ($273/ton, almost twice the maize price) made it worthwhile. Female members of the farm household particularly mentioned that getting three crops (maize, cowpea and mustard) instead of two (maize and mustard) from the same patch of land during the usual cropping season helped with fulfilling nutritional requirement of the family.

Continuous monitoring of on-farm trial plots in India to observe the effects of CAPS on weed, pest and disease was done. It was observed that there was more weed infestation in minimum tillage, but less in cowpea intercropped plots.

Development Impact

Intercropping has been found to have significant impact on income of households since yield of cowpea in maize and cowpea intercropping resulted in extra gain for the farmers. The gender-segregated focus group discussions in India gave us a glimpse of the magnitude of development effects arising from new practices in India. The participating farmers in India mentioned that introduction of the improved maize variety 'Nilesh' and line sowing methods, resulted in three-fold increase in maize yield (from 12,500 to 35,000 cobs/ha). Moreover, they mentioned that due to line sowing, mustard yields were also very good. Farmers were able to sell the first thinned two-week-old plants in the local market as a green leafy vegetable (4 bundles at $0.22 each), earning additional income. Though there was extra labor requirement in

sowing and harvesting the cowpea, the additional yield and high cowpea market price ($273 per ton, almost twice the maize price) made it worth the labor expenditure. The female farmers showed their excitement after getting three crops (maize, cowpea and mustard) instead of two crops (maize and mustard) from the same patch of land during the usual cropping season helping to fulfill family nutritional requirement.

In Nepal, the initiation of CAPS research by IAAS, which is the only government-owned institute for formal agriculture research, was significant. Agriculture scientists have acknowledged the need of more grounded and conservation oriented agriculture education in Nepal.

Challenges and responses

The on-farm trials in India faced problems with closer spacing of maize in cowpeas. As a strategy, a bushy variety of cowpea (Utkal Madhuri) was selected instead of the previous one (Hariyalli Bush) due to its damage in the intercrop rows of maize.

Integrating the principle of year-round soil cover has been found to be challenging in Nepal due to the geo-physical and socio-economic characteristics of the farmers. Lands remain fallow from November to April, which is the dry season, hence nocrop can be grown in this period. Moreover, the problem is worse because lands are not fenced and remain open for grazing during these months. For this reason, the project found it impossible to maintain year round vegetative cover. However, we saw the possibility of covering the soil through residue management. Hence, the project will try to integrate the crop-residue (of cowpea or millet or black gram) management practice in the CAPS treatments next year.

Providing enough incentive to maintaining the interest and support of communities in developing and improving CAPS was also found to be challenging, especially because farmers do not see direct benefits from the research projects now. Hence, some activities that offer direct incentives such as visits to demonstration plots will be provided to farmers that are involved in research.

Objective 4: To promote reflection, evaluation, and continuous improvement of implemented CAPS.

Critical Research Accomplishments

Nepal

The plan of organizing events with women's groups in Nepal was modified because of the unavailability of formal women's groups in the communities. Therefore, the field facilitators met with the women several times and discussed the relevance of CAPS for them. This informal method of discussion has enabled them to convey their feelings more effectively than in formal meetings.

In Nepal, soil samples collected from the plots prior to planting the CAPS trials (baseline) have been analyzed. Differences were found regarding soil nutrients across villages. Results indicated that soils from the different villages differed in nitrogen content, available phosphorous, available potassium, organic matter, bulk density and porosity. One of the soil characteristics that was similar across all villages was soil pH.

The initial effects of CAPS on soil primary nutrients, pH, and organic matter will be known by the first quarter of next year. Additional soil sampling and analysis will help to continuously monitor changes in the soil properties attributed to CAPS. In addition to the routine analysis planned in the first year, water stable aggregate measurements have been included beginning from this year on.

Table 43. Estimated average of the soil nutrient variables in Nepal by villages

	Village				
Soil nutrition	**Hykrang**	**Kholagaun**	**Thumka**	**p-value****	**Overall**
Nitrogen (%)	2.9 ±0.23*	4.5 ±0.23	1.9 ±0.13	<0.001	3.1 ±0.24
Available phosphorus (ppm)	70.5 ±7.88	203.3 ±33.08	10.3 ±4.91	<0.001	94.7 ±19.27
Potassium (ppm)	141.0 ±15.76	406.6 ±66.15	20.6 ±9.83	<0.001	189.4 ±38.53
pH' 1:2.5	6.7 ±0.18	6.3 ±0.09	6.7 ±0.13	0.14	6.6 ±0.08
Organic matter (%)	5.8 ±0.46	9.0 ±0.50	3.9 ±0.27	<0.001	6.2 ±0.47
Bulk density (g/cm3)	1.5 ±0.07	1.4 ±0.09	1.1 ±0.05	0.004	1.3 ±0.05
Porosity	0.4 ±0.03	0.4 ±0.04	0.5 ±0.02	0.004	0.4 ±0.02

* Indicate mean ± standard error of mean; ** indicate probability value of Fcal ≥ Fcritical

India
A focus group meeting was organized to discuss the CAPS trials and areas for improvement. The evaluation of the effects of CAPS on soil physical, chemical and organic properties has begun in India. Initial results indicate no significant effects of CAPS on soil organic matter and nutrient status.

Dr. Pravat Kumar Roul, host country P.I. had a presentation on the SANREM SMARTS activities to the Collector and District Magistrate of Kendujhar and other officials from the Agriculture and allied departments.

A significant amount of cowpea damage was witnessed on farm trial plots. The major reason mentioned by farmers during the focus group discussion was the close spacing of maize and cowpea. Hence, a master's student has initiated an on-station trial to estimate the optimum spacing for intercropping maize and cowpea.

Based on economic data collected from baseline and research plots, a farm-based profitability analysis and enterprise budgeting were carried out. A farm-based linear programming analysis is being developed to identify optimum combination of CAPS enterprises based on different production, consumption and marketing constraints in India and Nepal.

Development Impact
In India, the number of farmers willing to grow cowpea in a larger area has increased. The effect of maize and cowpea intercropping has been very effective. The Collector and District Magistrate in Kendujhar and officials from the Agriculture and allied departments visited the SMARTS Experimental sites. The Agricultural Technology Management Agency (ATMA) has already started to replicate the maize and cowpea with minimum tillage technology in 500 ha in Kendujhar using their own fund of 2.14 million Indian rupees only (Appendix 1). Also, there has been increased interest from the stakeholders about the CAPS. Altogether, 243 male and 175 female farmers from Nepal and India have been trained on different CAPS practices. About 44 farming households have started to pilot the CAP technologies in their fields, which will ultimately increase as the project progresses. In addition, there is a critical mass of students and researchers who have been trained with multi-disciplinary research skills for natural resource and environmental management.

Challenges and responses
Meetings with women's groups to discuss their need for and perception of CAPS were planned in Nepal but the lack of formalized women's groups in the communities led to modification of the activity.

Water stable aggregate of soil was found to be a useful variable to evaluate the impact of the CAPS on soil in short run. A new portable device has been developed at UH, which will be piloted and used in data collection in Nepal.

Objective 5: Build capacity of farmers, local NGOs and universities to scale up CAPS development for wider dissemination.

Critical Research Accomplishments

Nepal

To increase farmer knowledge of CAPS, and raise awareness about the importance of maintaining soil fertility and health, 40 farmers (15 female, 30 male) were trained in this reporting period. The training effectively transferred the knowledge and skills necessary to enable CAPS piloting and adoption. The initial effects can be visualized by adoption of intercropping practice in project communities and surrounding villages.

About 49 students and researchers, including 25 females, from universities and host-country research organizations were trained in conducting analytic hierarchical process (AHP), mental modeling, and CAPS in fall 2011. In addition, another 24 students, including 12 females, were provided with training on a technology network analysis tool, gender study tool and fuzzy cognitive mapping tools in June 2012. This training included in-house orientation followed by in-field (community) exercise for data collection. The evaluation of the trainings indicated that all three trainings were perceived effective by the majority of the trainees. The training effectiveness ratings were mostly very good.

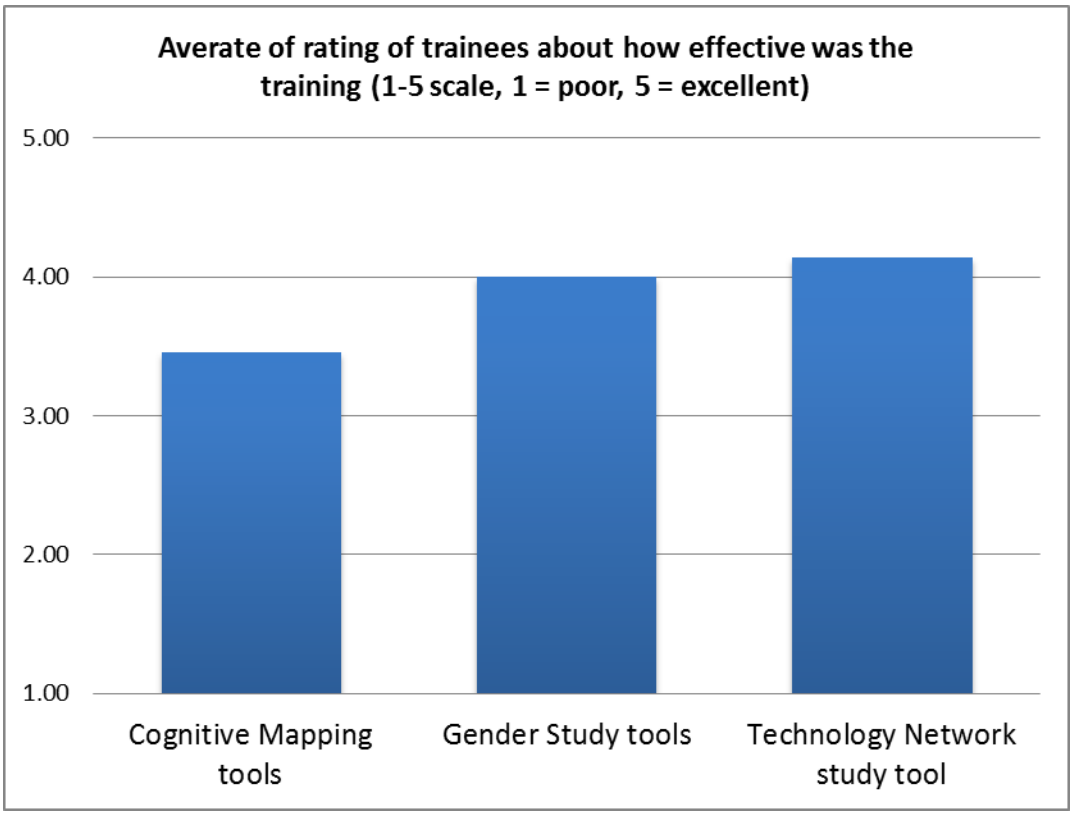


Figure 34: Training effectiveness ratings in Nepal
Note: 1 – poor, 2 = average, 3 = good, 4 = very good, 5 = excellent

A network of the universities; i.e., Institute of Agriculture and Animal Science (IAAS), and Institute of Forestry (IOF), and a development NGO (Local Initiatives for Biodiversity, Research and Development – LI-BIRD) were brought together in the CAPS research in Nepal.

India

- Training was conducted at the RRTTS Keonjhar with OUAT staff and scientists and local farmers in Tentuli to teach the principles of soil, water, and weed management as they relate to CAPS.
- Another training for 66 men and women farmers was conducted in Tentuli village on harvesting, post-harvest and crop residue management of cover crop mustard on 21st December 2011.
- The District administration and District Department of Agriculture were mobilized to implement maize-cowpea intercropping with reduced tillage in about 2,000 ha of potential maize area in Kendujhar district of Odisha, India. Accordingly, a project proposal has been submitted to the District Magistrate.
- About 44 participants (26 male and 18 female) were trained to use the water stable aggregate measurement tool, a technology network analysis tool, and a fuzzy cognitive mapping tool to assess the farmers' knowledge and mental model of adoption.

Specific to capacity building of the women, a literature review has been conducted regarding gender issues with respect to agricultural development and CAPS in both India and Nepal. The results of this review from the student class project have been completed and used to develop a gender survey for both countries. This will identify specific capacity building needs of women, which will be incorporated by the project in future planning.

Development impacts

A viable network of intradisciplinary researchers from IAAS and Institute of Forestry (IoF) and development workers (from LI-BIRD) has been established for research and development in conservation agriculture concepts and other intra-disciplinary issues of natural resource management.

The workshop organized by the project partners in India was successful in integrating CAPS into the plans of the government. Similarly, CAPS and its potential for climate change adaptation has been documented and shared through networks of NGOs in Nepal (Network for NGOs for Climate Change – NGOCC) and some members promised to pilot CAPS in their working areas. These are seen as the starting point for larger possibility of integrating CAPS in the agriculture development plans of research countries.

The collaboration of host country personnel with university of Hawaii faculty has led to other unforeseen collaboration as well. It has led to submission of two proposals, of which one was successful.

Challenges and responses

Because of very different geophysical, socio-economic and agriculture systems in project villages of India and Nepal, the cross-country comparisons and cross-country analysis have been found to be very challenging.

Training host country students and using them as data collectors have been regular practices in the project. Initial experienced showed that it might be helpful to organize a separate training session for students acting as enumerator prior to village workshops, to explain in greater detail what data is required and the significance of the research. That is why the project started to conduct full day training of the students before using them as enumerators from the summer of 2012.

Degree and nondegree training activities

Two students, one each from Nepal and India, have enrolled in the Ph. D. program in UHM from spring 2012, and another MS student has enrolled in fall 2012. In Nepal, four students, including one female, have been supported as research fellows (three in IAAS and one in IOF). In India, three students had completed their M.S. program on related CAPS activities and four new students have joined as research fellows. They are contributing to the overall project objective by conducting research trials in addition to the farmers-field trials.

Publications, presentations, and other SANREM CRSP products

Results from the research were highlighted through three posters and one oral presentation at the CTAHR Research Symposium in 2012 at UHM. Results of the fuzzy cognitive mapping exercise comparing farmers' mental model of CAPS with researchers' mental model; and papers analyzing data of two AHP exercise, one each from India and Nepal for same, were generated. One paper entitled "Comparative Economic and Gender Labor Analysis of Conservation Agricultural Practices in Tribal Village in India," published in International Food and Agribusiness Management Review. Moreover, about five working papers are being drafted which are expected to finalize by December 2012.

One project brochure has been developed in the Nepali language. The brochure communicates the basic principles of CAPS to the farmers and extension workers. A leaflet named "Sustainable management of Agro-ecological Resources for Tribal Societies (SMARTS): a conservation agriculture based participatory research in Kendujhar of Odisha" has been published and distributed in India; which included general information about the project and results of the CAPS on-station experiment. A video on water stable aggregate measurement has been developed and posted in YouTube link http://www.youtube.com/watch?v=S1GogaMk8l8 .

Networking

- The progress and outputs of the project have been shared with USAID Nepal. Technical advisors of LI-BIRD and IAAS regularly attended USAID meetings.
- The results of the CAPS and its potential for climate change adaptation were shared through the network of NGOs in Nepal; i.e., NGOCC (Network of NGOs for Climate Change) and some members of LTRA-11: CAPS among tribal societies in India and Nepal.
- The relevancy of the CAPS for improving the status of land transformed from shifting cultivation and livelihood of Chepang people was discussed in National Policy Workshop for Shifting Cultivation on October 2011 in Kathmandu. The workshop was attended by at least five members of the constitutional assembly, and chaired by the spokesperson for CA in Nepal.
- The in-country researchers accompanied by UH team visited and briefed about the progress, achievements and future plans of the project to USAID local missions in Kathmandu twice; i.e., first in January 2012; and then in June 2012. The team also discussed about how SMARTS can collaborate and complement other USAID funded projects in Nepal, specifically – HARIYO BAN PROJECT.

India

- OUAT organized one workshop on "Conservation agriculture" on 24th December 2012, where the Indian researchers presented a paper on "Sustainable tribal farming through conservation agriculture- SMARTS experience in Kendujhar."About 300 participants involving OUAT faculties & students, ICAR scientists, and Government of Odisha officials attended the workshop.
- In the Farmers-Scientists interaction section of "The Golden Jubilee Celebration of OUAT" host country researchers presented a paper titled "Soil Health Management through

Conservation Agriculture". Similarly, a bulletin titled "Conservation Agriculture", written in the local language was published and distributed to the participants. Highranking government officials, including the secretary of agriculture, researchers and scientists from OUAT, agri-input dealers and about 600 farmers from Kendujhar, Mayurbhanj and Deogarh districts of Odisha, attended the program.

- The SMART team including PI from UH and host country PI presented recent project activities, progress and future plans in India to USAID mission in New Delhi in June 2012. The program was attended by representatives from Cereals Systems Initiative for South Asia (CSISA) and officials from USAID. The team also discussed collaboration between SANREM and CSISA in Odissa. Major highlights of the discussion were:
    - Inclusion of the SMARTS project in CSISA stakeholder consultation to be held on the 10th of July in Bhubaneshwar in Odisha
    - Support in converting Conservation Agriculture materials – CSISA fact sheets and brochures into Oriya language for dissemination to all organizations in Odisha
    - Video documentation (through Digital Green) and sharing of CAPS practices that are being practised by farmers of Tentuli and Talachampei in Kendujhar.
    - sharing of the videos with Digital Green Odisha partners Pragati and Varrat, and planning for potential visits of other farmers Continuous cooperation between these two projects once CSISA starts its activities
    - Inclusion of SMARTS project into the CSISA newsletter e-mail list.

The research teams from Nepal and India visited Hawaii from 10-17 April 2012, for sharing and analyzing the progress of the project, share the findings, and plan for the future.

The researcher and students from UH participated and presented four papers resulting from the SMARTS research in the 22nd International Food and Agri-business Management Association symposium (IFAMA) – from 11 – 14 June 2012, in Shanghai – China. The platform was used for disseminating the outputs of the project to interested researchers, students and business communities.

Team members from India and Nepal attended a collaborative conference in Hawaii to discuss socio-economic and agronomic results of the project. It was discussed that there is very limited opportunities for comparing and contrasting the project results and challenges of CAPS in Nepal and India because of very different localities of collaborators and different crops and cropping systems. However, we consider the possibility of a joint conference in the future.

Highlights

1. On-farm research trials in Nepal indicated that second season millet+maize intercropping followed by first season of maize has potential to increase the overall yield and biomass. Minimum tillage was found to reduce the advantage of intercropping.
2. In India, tillage and intercropping had no significant effect on maize yield, both in on farm and on station trials. However, minimum tillage along with maize + cowpea, in

both the trials, had highest profitability as cowpea as an additional yield and having more market price than maize, provided more revenue to farmers.

3. Altogether 243 male and 175 female farmers from Nepal and India have been trained on different CAPS practices. About 64 males and 50 females were continued for longer-term trainings. Five students were supported to pursue graduated studies in UH, whereas other three students in host country received research fellowship from the project.
4. The initial results of adoption of CAPS have been observed in India. The Collector and District Magistrate in Kendujhar and officials from Agriculture and allied Departments visited SMARTS Experimental sites. The Agricultural Technology Management Agency (ATMA) has already started to replicate the maize and cowpea with minimum tillage technology in 500 ha in Kendujhar using their own fund of 2.14 million Indian rupees only.

LTRA-12 Conservation Agriculture for Food Security in Cambodia and the Philippines

Principal Investigator: Manuel Reyes, professor, biological engineering, North Carolina A &T
Research team:

Research progress by objective

The primary goal of this LTRA is to demonstrate that conservation agriculture (CA) principles which are defined as: practice of minimal soil disturbance, continuous mulching and diverse species rotations, constitute the best 'tool box' to create sustainable, permanent cropping systems for annual crop production under wet tropical conditions in Cambodia and the Philippines. Further that CA will reverse soil degradation, increase crop yield and profits and reduce the labor burden on women.

Objective 1: Gender - Pinpoint gendered limitations and advantages that can promote adoption of CAPS, and determine if CAPS will decrease labor burden on women in Cambodia and the Philippines.

Critical Research Accomplishments
Cambodia
Observations have been made regarding gender equity amongst farmers : (1) women's participation in field visits and training activities is between 30 and 45%. This level of participation demonstrates that a viable base to build upon and that we are poised to improve this percentage; (2) one of the two farmers' organizations is led by a woman; and (3) ten of 61 particpant households involved in the pilot extension network in 2012 are headed by women.

Philippines
In many aspects of agricultural production we find no gender bias between a women and men farmers, for example on the knowledge of use of cover crops, but differences in farming

knowledge may differ in other areas such as the application of tillage practices. While women are knowledgeable of soil types and make decisions based on soil quality, men tend to have more knowledge of implementation tools for land preparation and favor the availability of tractor or draft animals in making decisions.

The Gender CCRA team found that women do not normally participate in land preparation at all, and men were completely responsible for draft animals.The average female household participation in planting activities was similar to that for men. Land preparation was male dominated with no women participating in land preparation, spraying of herbicide, plowing, harrowing and furrowing. The female participation was limited to liming and fertilizer application. In postharvest activities female participation was higher than for males.

Development Impact

We can assume that since handweeding is done bywomen in both countries and would be replaced by herbicide spraying in CAPS, it appears that labor burden on women will be reduced.

Challenges and Responses

The gender scientist has become very busy and cannot continue to work in the project. A new gender scientist was contracted and will continue gender research in both countries.

Objective 2: Identify field- and farm-level CAPS that will minimize smallholder costs and risks while maximizing benefits and adoption in Cambodia and the Philippines.

Critical Research Accomplishments:

Cambodia

The economic assessment showed an increase in the Gross Profit Margin (GPM) for a type of CAPS known as a Direct seeded Mulch based Cropping system (DMC) with CAPS, yield increased.

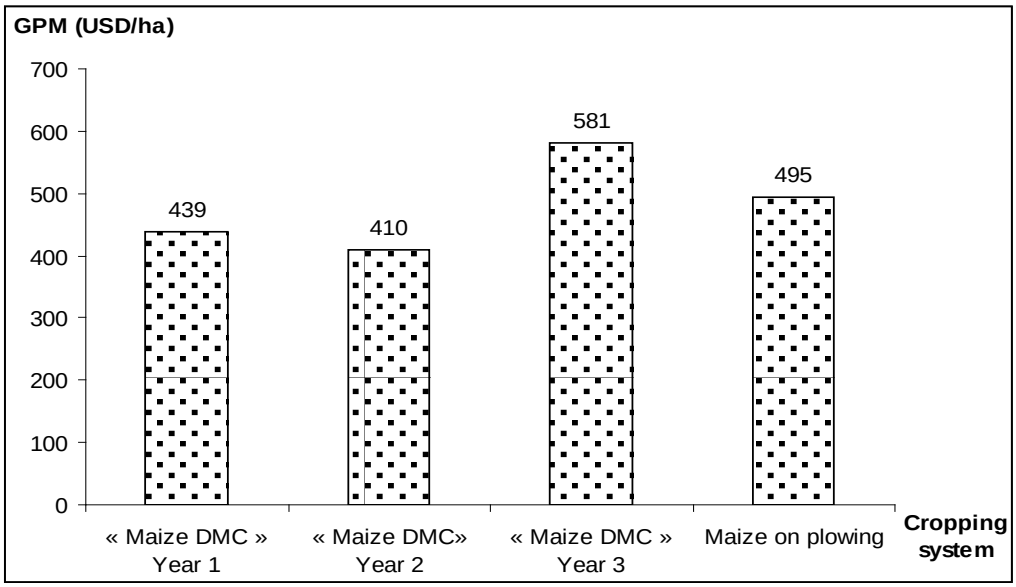


Figure 35. Increase in dollars per hectare employing DMC

From year 1 to year 3 while expenses decreased because of labor and fuel savings from no tillage and decrease in weed pressure. The GPM on CAPS is slightly lower than traditional plow-based ones during the first two years.

Philippines

Maize and cassava cost and returns analysis of the two crops were conducted with 14 farmer-cooperators for maize and six for cassava under farmer-practiced plowed system.

- Maize gross sales was $5050 per ha and per year, and cost of production was $1234 per ha and per year for a net income of $3816 per ha and per year

Capital outlay for maize was very high; hence farmers gravitate to cassava which can be grown in poor soils.

Development Impact

It was shown in Cambodia that the CAPS gross profit margin will be higher than that for plow-based systems by the third year. There is potential for CAPS adoption in Cambodia if subsidies can be provided to augment CAPS low yield in the first two years as soil capital is being restored.

Challenges and Responses

There were problems again in the 15 households participating in the farmer-managed experiments in the Philippines. Replacements were done in the set of farmer cooperators since some farmers plowed and others gave up participation in the study.

Objective 3: To quantify the effectiveness of SANREM-supported farmer groups in training knowledge leaders, being a means of knowledge transmission, and facilitating network connections leading to widespread adoption of CAPS; and to find out whether a microcredit approach and a method to facilitate access for mechanized direct seed drilling and spraying can be successful in promoting adoption of conservation agriculture in Cambodia.

Critical Research Accomplishments:
Cambodia:
Gross profit margin of CAPS was less than plow-based in years 1 and 2 but greater than that in plow-based by Year 3. There was a severe rain deficit during the first part of the 2012's cropping season and farmers saw that CAPS was more resilient to drought compared with plow-based system. There was a doubling of CAPS pilot extension participation from 31 families on 59.5 ha in 2011 to 61 families on 149 ha in 2012 in two project villages, Boribo and Pechhangvar. Spontaneous extension happened in a third village, Aukhmum. There were five families who witnessed CAPS in Boribo and Pechhangvar and then moved to CAPS and purchased CAPS seeders for 75 more hectares.

Two CAPS farmer organizations (FOCAPS) were formed. FOCAPS were trained to weekly monitor market price of maize and grow cover crops for seed production. FOCAPS members have clearly expressed their preference for cover crops *Cajanus cajan* and *Vigna umbellata*, to replace the first introduced and poorly performing cover crop *Stylosanthes guianensis.* Contracts were signed and agreed between FOCAPS and Seed Asia for a six-month maize seeds credit purchase. The initial plan for an improved credit access by connecting the bank system with FOCAPS through a production contract with a buyer did not materialize since FOCAPS membership was still small. In 2012, as well as 2010 and 2011, a key incentive for CAPS was that most inputs in pilot extension have been pre-financed with PADAC's cost-shared internal revolving funds. This situation may undermine the self-financing capacity of the pilot extension program in 2013 and 2014, since PADAC operations end in March 2013.

Philippines:
As a trusted information source, vendors of agricultural products ranked next to agricultural researchers who farmers trusted the most. Agricultural researchers initiate interaction with farmers while farmers initiate interaction with vendors. Farmers interact with vendors of agro-chemical products to procure seeds and chemicals and for information on farm inputs like fertilizers, pesticides and herbicides which are the most costly inputs. The most common location farmers receive advice from vendors is the store.
Additional observations:

- All respondents strongly agree that land is a heritage to be preserved for future generation, farm income shall be reinvested to grow the business, and farm production is necessary to feed the family.
- Respondents are uncertain on using crop residues only to be fed to livestock which suggests that they perceive other uses for crop residues.

- Respondents tend to believe that inorganic fertilizer is best in improving soil quality.
- Subsidy in farm inputs is a key incentive in CAPS participation in farmer-managed studies.

Development Impact:
For Cambodia, it is quite remarkable that in less than three years farmers have not only allowed but adopted conservation agriculture practices in a region that was heretofore heavily committed to plow-based agriculture. There is a noticeable favorable change in attitude towards CA among the households of three Battambang villages. Convinced about CAPS, farmers in Aukhmum village invested in buying their own Vencetudo no-till planter and even agreed to develop plots where varying CAPS options will be demonstrated. They are willing to rent the Vencetudo to other farmers who will adopt CAPS. Another farmer in Aukhmum, who is not yet in CAPS, fabricated a sprayer used by SANREM and developed by ACIAR and PADAC at less than half its cost. In addition, the number of farmers using CAPS doubled in Boribo and Pechhangvar villages whereas one farmer in Boribo purchased a Fitarelli no-till planter. But the adoptiondynamic is still weak and a very difficult cropping season like this drought of 2012 can "unhinge" bubbling pioneer farmers' convictions.

Challenges and Responses
For many small farmers, access to information and training are not sufficient to adopt CA. We must develop an integrated approach combining technology with improved access to CAPS inputs and credit that will be considered an investment in soil capital restoration. We must also secure land ownership. For the Philippines, researcher-managed trials showed improvement in soil quality with equal maize yield between CAPS and plow-based systems. This is an initial step in convincing farmers to adopt CAPS. However, like Cambodia, provision of no-tillage machinery, availability of production inputs and CAPS credit incentives are needed for CAPS adoption.

The initial plan for an improved credit access by connecting the bank system with FOCAPS through a production contract with a buyer did not materialize since FOCAPS membership was still small. In 2012, as well as 2010 and 2011, most inputs in pilot extension have been pre-financed with PADAC's cost-shared internal revolving funds. This lack of PADAC subsidy may undermine the self-financing capacity of the pilot extension program in 2013 and 2014, since PADAC operations will end in March 2013.

Objective 4: Soil Quality, Crop Yield and Biomass - Assess soil quality and measure crop yield and biomass from conservation agriculture production systems and compare them with soil quality and crop yield and biomass from conventional plow-based systems in Cambodia and the Philippines.

In describing treatments for *researcher and farmer-managed CAPS* the following notations were used:

'/' is relayed cropping with planting dates varying,

'+' is planted side by side with the same planting dates

Critical Research Accomplishments

Researcher-managed:

Cambodia

Researcher-managed demonstration plots, established in 2009 and 2010, were maintained and monitored at two places in Boribo village on black soil with limestone and on land considered by farmers as degraded. These demonstration plots are not replicated and the aim is to adjust CAPS to Battambang conditions; they are also a showcase of CAPS technologies for farmers. CAPS were implemented on 0.2- to 0.4- ha plots split with two levels of fertilizer application rates. Two cultivars of maize hybrids were sown to select new varieties to replace the "old" cultivars, yield of which is 25% less than new hybrids. Yield of maize, rice, soybean and cassava were measured (Tables 44 and 45). No yield is available for either plots in 2012 due to the harvest season commencing in November 2012.

In parallel with the SANREM-CRSP pilot extension process, PADAC is renting and directly managing two plots; the first (2.0 ha – Table 44 and Photo 1) was initiated in 2009 (4th cropping season under CAPS management) and the 2nd (1.5 ha – Table 45) in 2010. In 2011, a complementary demonstration plot was opened, on the request of the Provincial Department of Agriculture, in the neighboring Pailin Province (about 50 km from the project base in Rattanak Mondul), another region of intense upland cultivation development.

In 2011, to improve the demonstrative value during farmers' fields visit, a plow-based maize mono-cropping system (farmers' reference) was introduced in these two demonstration plots with an emphasis done on CAPS-based cassava system in anticipation of a high probable shift to this crop in the coming years due to high prices.

Table 44. CAPS-based crops succession implemented on the first demonstration plots in Boribo, Cambodia

Yield in	2009		2010		2011		2012	
	F1	F2	F1	F2	F1	F2	F1	F2
Bi-annual rotation Maize // Soybean	Bio p. Mil / Maize + Brach r.		Brach r. / Soybean + Sorgho + Stylo		Bio p. Mil + Stylo / Maize + Stylo + C. och.		Stylo / Soybean + Sunflower + Stylo	
	4 065	5 070	1 325	1 335	3 700	4 910		
	Bio p. Mil / Soybean + Stylo		Bio p. Mil + Stylo / Maize + Stylo		io p. Mil + Stylo / Soybean + Sorghum + Sty		Sorghum regr. + Stylo / Maize + Stylo	
	2 045	2 200	3 240	4 760	1 950	2 180		
Maize monocropping	Bio p. Mil / Maize + Stylo		Stylo / Maize + Stylo		Bio p. Mil + Stylo / Maize + Stylo + C. och.		Stylo / Maize + Stylo	
	3 575	5 565	2 645	3 855	2 955	5 580		
Bi-annual rotation Maize // Cassava	Bio p. Mil / Maize + Stylo		Cassava + Stylo		p. Mil + Stylo / Maize + Stylo + Eleu. + C.		Cassava + Stylo	
	4 060	5 350	21 580	19 350	3 495	5 680		
	Cassava + Stylo		Bio p. Mil + Stylo / Maize + Stylo		Cassava + Stylo		Bio p. Mil + Stylo / Maize + Stylo	
	13 020	13 290	3 185	4 650	16 550	16 215		
Cassava monocropping	Cassava + Stylo		Cassava + Stylo		Plow x Maize		Plow x Maize	
	11 750	13 525	20 995	20 755	4 480	5 655		

Fertilizers levels:	F1	F2	F1	F2	F1	F2	F1	F2
Maize:	69-34-30	113-85-60 + S	69-34-30	113-34-60 + S	70-30-30 + S	116-64-60 + S	70-30-30 + S	116-64-60 + S
Soybean:	23-34-60	23-85-90	23-34-60	21-34-72 + S	24-30-30 + S	24-64-90 + S	24-30-30 + S	24-64-90 + S
Cassava:	69-34-60	90-85-90 + S	69-34-60	90-34-90 + S	70-30-60 + S	93-64-90 + S	70-30-60 + S	93-64-90 + S

kg/ha (14% moisture for maize and soybean grain; in peeled, chopped in blocks and sundried for cassava). Bio-pump millet = 60-70 days biomass production of pearl millet (*Pennisetum typhoides*), Brach r.= *Brachiaria ruziziensis*, Stylo g. = *Stylosanthes guianensis*.

Table 45. CAPS in crops succession implemented on the second demonstration plots in Boribo, Cambodia.

	2010		2011		2012	
	F1	F2	F1	F2	F1	F2
			Plow x Maize 4445	5185	Plow x Maize	
Maize monocropping	Bio p. Mil / Maize + Stylo + V. umbellata 4210	4150	Stylo / Maize + Stylo + V. umbellata 4130	4595	Stylo / Maize + Stylo + Cajanus c.	
Bi-annual rotation Maize / Cassava // Cassava / Maize	Bio p. Mil / Maize + Stylo + C. cajan 3565	3570	an / Maize + Eleu. + C. och. / Cassava + V. 3465	4405	Cassava / Maize + Stylo + Cajanus c. early: 3490 late: 7070	early: 3290 late: 7690
			C. cajan / Maize + Stylo + C. cajan 3845	5220	an / Maize + Eleu. + C. och. / Cassava + V. 600	830
Bi-annual rotation Maize // Rice	Bio p. Mil / Maize + Stylo + V. umbellata 4200	4125	V. umbellata + Stylo / Rice + Stylo 2295	3565	Stylo / Maize + Stylo + Cajanus c.	
	Bio p. Mil / Rice + Stylo / V. unguiculata 2305	2510	Stylo / Maize + Stylo + V. umbellata 4635	5130	V. umbellata + Stylo / Rice + Stylo	
Bi-annual rotation Maize // Soybean	Bio p. Mil / Soybean + Sorgho + Stylo 1770	1730	rowth Sorgho + Stylo / Maize + Eleu + Cajan 4820	5850	ajanus c. + Stylo / Soybean + Sunflower + Sty	
			rowth Sorgho + Stylo / Soybean + Sorgho + S 2075	2185	ghum regr. + Stylo / Maize + Stylo + Cajanu	

Fertilizers levels:	F1	F2	F1	F2	F1	F2
Maize:	69-34-30	116-85-60 + S	70-30-30 + S	116-64-60 + S	70-30-30 + S	116-64-60 + S
Soybean:	23-34-60	21-85-72 + S	24-30-30 + S	24-64-90 + S	24-30-30 + S	24-64-90 + S
Cassava:	69-34-60	90-85-90 + S	70-30-60 + S	93-64-90 + S	70-30-60 + S	93-64-90 + S
Rice:	45-34-30	67-85-60 + S	70-30-30 + S	93-64-60 + S	70-30-30 + S	93-64-60 + S

V. umbellata = Vigna u. (Rice bean), C. cajan = Cajanaus c. (Pigeon Pea), V. unguiculata = Vigna u. (Cowpea), V. radiata = Vigna r. (Mungbean), Rice sc = upland Rice short cycle varieties (90 to 105 days), mc = medium cycle (110-125 days)

Figure 36. Demonstration Boribo I - plot 1a, Soybean on a poor pearl millet cover at 28 DAS (52 mm rainfall since sowing)

Farmers have clearly expressed their preference for a cover with *Cajanus cajan* and*Vigna umbellate* cover crops, the two proposed alternatives to replace the poorly and irregularly performing *Stylosanthes guianensis* on the neutral soil of Rattanak Mondul (Mollisol); preference was due to smaller competition with maize and the possibility to acquire income. Control of the *Cajanus* cover is simple and mechanical sowing in this "woody" cover doesn't present any major problems as well as acts as very efficient weed control.

Philippines

Researcher-managed demonstration plots of10 m x 20 m (0.02 ha) in size, were composed of six different cropping patterns and land management practices including the farmer's practice which serves as control in two fertility levels. The experiment is a strip-plot design with six treatments and four replications. Both undisturbed and disturbed soil samples were collected at three depths (0-5 cm, 5-10 cm and 15-30 cm) in December 2010, April 2011 and September 2011 for soil quality assessment. The soil samples were analyzed for bulk density, soil organic matter, soil nitrogen, soil phosphorus, soil pH and infiltration characteristics. The residual soil moisture content was also measured using time domain reflectrometry during the dry period. In

addition, solute transport studies and crop modeling under CAPS and conventional plow-based systems commenced. The CAPS plus control treatments are:

T1: Maize + *Arachis pintoi* followed by maize planted alongside established *Arachis pintoi*. Before planting, weeds are sprayed with glyphosate at the rate of 720 g active ingredient per hectare two weeks before planting. The maize was dibble planted at 70 cm x 20 cm, making around 72,000 plants per hectare. *Arachis pintoi* cuttings were planted in-between rows of maize spaced at 25 cm apart.

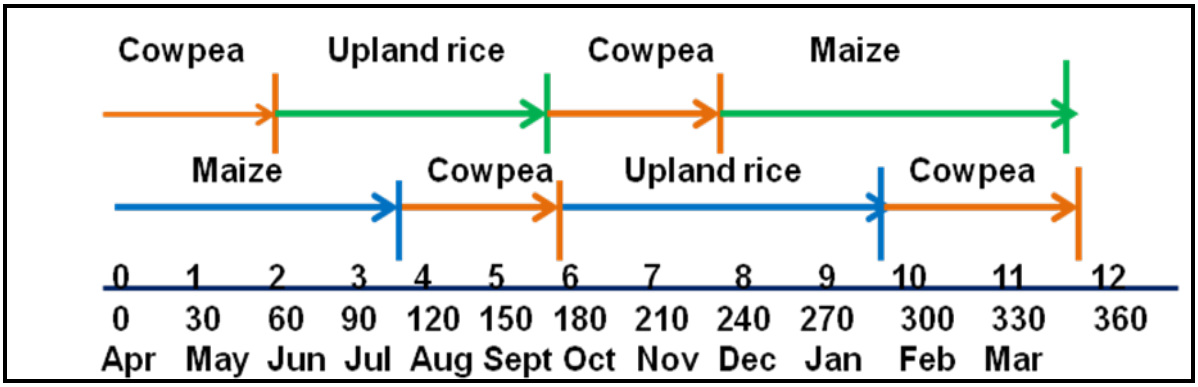
T2: Maize + *Stylosanthes guianensis* followed by *Stylosanthes guianensis* fallow. Maize is established similar to T1. *Stylosanthes guianensis* seeds are drilled in between rows of maize and thinned to 10-15 plants per linear meter.

T3: Maize + cowpea/upland rice + cowpea followed by maize + cowpea/upland rice/cowpea. The land is prepared similar to T1. Maize is established in double rows 30 cm apart with 20 cm between plants, followed by two rows of cowpea at 30 cm apart with 10-15 plants per linear meter.

T4: Rice beans/maize followed by rice beans/maize. Maize is established similar to T1. Rice bean is established two weeks prior to maize harvest.

T5: Cassava + *Stylosanthes guianensis*. Land preparation is similar to T1. Cassava cuttings are planted in furrows 100 cm apart and 50 cm between plants, making 20,000 plants per hectare.

T6: Farmers' traditional practice Two times plowed by animal drawn moldboard plow and two times harrowed by animal drawn spike-toothed harrow after every plowing.



Maize grain yields with CAPS treatments were generally similar to those in the plow-based system. Maize + *Arachis pintoi* showed higher total biomass among the treatments with maize as main crop. Cassava with *Stylosanthes guanensis*, however, ranked first in total biomass compared with five other treatments with maize as main crop. *Stylosanthes guianensis* and *Arachis pintoi* were found to be promising legume cover crops. Year 3 maize grain yields with CAPS treatments were generally the same as those in the plow-based system. Maize + *Arachis pintoi* showed highest total biomass among the five treatments with maize as main crop. S*tylosanthes guianensis* and *Arachis pintoi* were found to be promising legume cover crops.

Indications that soil quality improved in CAPS is based on the following findings:

- The soil bulk density in all CAPS treatments in February 2012 ranged from 1.02 to 1.24 g/cm^3 for all soil layers. Although the soil bulk density values varied erratically with depth for each individual CAPS treatment, the average soil bulk density for all CAPS treatments generally increased with depth.
- The soil organic matter at the researcher-managed site generally decreased with soil depth for all treatments in February 2012 regardless of fertility level, as in previous years.
- The soil organic matter at the uppermost soil layer (0 to 5 cm) in February 2012 ranged from 4.8% for T6 (plow-based) to 6.5% for T5 (cassava + stylo) for fertility level Fo and from 4.11% for T6 (plow-based) to 6.42% for T2 (maize+ stylo-stylo-fallow).
- For the uppermost soil layer (0 to 5 cm), the soil organic matter for all CAPS treatments T1 to T5 remained generally higher than for treatment T6 (plow-based system) for both fertility levels in February 2012.
- For the middle and lowermost measured soil layers (5 to 15 cm and 15 to 30 cm), the soil organic matter did not exhibit substantial differences for all CAPS treatments including the plow-based system in February 2012.
- The soil nitrogen at the researcher-managed site did not differ substantially for all CAPS treatments including plow-based system for all soil layers and for both treatments in February 2012.
- The soil phosphorus in CAPS treatments T1 (maize + *Arachis pintoi-Arachis pintoi*) , T3 (maize + cowpea-upland rice + cowpea) and T4 (maize + rice bean-maize + rice bean) all exhibited much higher levels of phosphorus than T6 (plow-based system) at the uppermost soil layer (0 to 5 cm) for both fertility levels in February 2012.
- The soil pH in CAPS treatments T1 to T5 proved to be generally higher than in treatment T6 (plow-based system) for the uppermost soil layer (0 to 5 cm) for both fertility levels, with T5 (cassava + stylo), T2 (maize + stylo-stylo-fallow) and T3 (maize + cowpea-upland rice + cowpea) as the top treatments that exhibited the highest soil pH.
- The soil bulk density varied erratically for all CAPS treatments between year 1 and year 3 with some CAPS treatments exhibiting an increase, while others showed a decrease in value for this parameter. However, the differences in bulk density values between year 1 and year 3 for all CAPS treatments are minimal.
- Regardless of fertility level, the average soil organic matter at the uppermost layer (0 to 5 cm) for CAPS treatments T1 to T5 increased from December 2010 to February 2012, while the organic matter for the plow-based system decreased for the same period.
- The highest increase in soil organic matter at the uppermost soil layer (0 to 5 cm) was exhibited by CAPS treatment T5 (cassava + stylo) for fertility level F0 with the level of 5.7% in December 2010 increased to 6.5% in February 2012. For fertility level F1, the highest increase in soil organic matter was exhibited by treatment T2 (maize + stylo-stylo-fallow), with organic matter increasing from 6.0% in December 2010 to 6.4% in February 2012.

- Under the plow-based system, the soil organic matter at the uppermost soil layer (0 to 5 cm) decreased from 5.9% in December 2010 to 4.8% in February 2012 and from 5.6% in December 2010 to 4.1% in February 2012 for fertility levels F0 and F1, respectively.
- The soil nitrogen at the uppermost layer (0 to 5 cm) in February 2012 did not differ substantially from the December 2012 baseline conditions. However, the soil nitrogen under plow-based system for the same soil layer decreased from December 2010 to February 2012 for both fertility levels.
- Soil phosphorus for all treatments at the uppermost soil layer (0 to 5 cm) increased from the baseline level in December 2010 to that in February 2012 except for treatment T5 (cassava+stylo).
- The average soil phosphorus for CAPS treatments T1 to T5 in February 2012 was higher in February 2012 than in December 2010, with the highest increase exhibited by CAPS treatment T3 (maize + cowpea-upland rice + cowpea) for both fertility levels.
- The soil phosphorus under plow-based system also increased from December 2010 to February 2012 for both fertility levels. However, the increase in soil phosphorus for plow-based system was not as high as in the CAPS treatments on average.
- The soil pH at the uppermost layer increased from December 2010 to February 2012 for CAPS treatments T2 to T5 for both fertility levels.
- The soil became more acidic for plow-based system from December 2010 to February 2012, with pH decreasing from 5.1 to 4.3 and from 5.3 to 4.4 for fertility levels F0 and F1, respectively.
- Reduction in soil acidity was highest in treatments T5 (cassava + stylo) and T2 (Maize + stylo-stylo-fallow) for fertility level F0 and in treatments T2, T3 (maize + cowpea-upland rice + cowpea) and T5 for fertility level F1, with pH registering as high as 5.5 to 5.9 in February 2012 compared to 4.7 to 4.9 in December 2010.
- Regardless of fertility level, the soil organic matter at the uppermost soil layer (0 to 5 cm) under plow-based system (treatment T6) continued to consistently decline over the last two years based on five soil samplings performed at the site from 2010 to 2012.
- The soil organic matter at the uppermost soil layer (0 to 5 cm) for the CAPS treatments (T1 to T5) did not differ significantly from their December 2010 baseline level for both fertility levels. However, the average organic matter for all CAPS treatments T1 to T5 increased from December 2010 to February 2012.
- The soil organic matter at the middle soil layer (5 to 15 cm) in all CAPS treatments including plow-based system generally decreased over the last two years. However, the plow-based system exhibited the highest temporal decrease in organic matter under fertility level F1.
- The temporal variation of soil organic matter at the deepest soil layer (15 to 30 cm) did not exhibit a well-defined pattern for both fertility levels for all CAPS treatment with the exception of treatment T2 (maize + stylo-stylo-fallow) whose organic matter steadily increased over the last two years for fertility level F1.
- The soil organic matter content at the deepest layer (15 to 30 cm) under plow-based system (T6) generally declined since the beginning of cropping in December 2010

regardless of fertility level. In contrast, the organic matter under CAPS treatments, T1 to T5 in February 2012 did not differ substantially from their December 2010 baseline level.

- TDR measurement of residual moisture content at the researcher-managed site during the dry period in February 2012 showed that the CAPS treatment T1 to T5 plots have significantly higher residual moisture content than the conventional plow-based system T6, with treatment T2 (maize + stylo-stylo-fallow) exhibiting the highest residual moisture content level.
- Model simulations using DSSAT-CERES of the maize crop were performed under a scenario of increasing and decreasing soil organic matter content and soil nitrogen for conservation agriculture production systems and conventional plow-based systems. Simulation results showed that maize yield would increase under conservation agriculture production system with increasing amount of soil organic carbon and total soil nitrogen at sowing.
- DSSAT-CERES model simulations also indicated that crop yield would increase by 5.5% to 10.2% under conservation agriculture production systems when both organic carbon and total nitrogen are increased by 30%. On the other hand, model simulations under conventional plow-based system showed that crop yield would be reduced by as much as 24.4 to 28.5%.
- Solute transport model simulation showed that the peak solute concentration would decrease by 9.6% and the time-to-peak would be delayed by 3.1% under CAPS represented by a scenario of 30% increase in soil organic carbon over 10 years.
- Solute transport model simulations showed that minimal changes in peak solute concentration and time-to-peak would result under conventional plow-based system assuming a 3% decrease in organic carbon content over the same period.
- Solute transport studies suggest that soil nutrients from fertilizer application would tend to be retained at a relatively longer time under conservation agriculture than under conventional plow-based systems, thereby maximizing nutrient uptake by upland crops.

Farmer managed

Cambodia:

The farmer-managed treatments in Cambodia are:

T1 (CAPS): Pearl Millet/maize + *Stylosanthes guianensis*

This treatment is based on successful CAPS developed by PADAC in Kampong Cham which commenced in 2004. After one year, it was found that T1 may not be suited for Battambang possibly because of the highly basic soil derived from limestone limits growth of *Stylosanthes guianensis*. Adjustments will be made based on results from researcher-managed studies and farmer inputs.

T2: Traditional plow based

The CAPS subsample of 15 farms has been randomly chosen prior to 2010's cropping season among farm households who decided to adopt CAPS on a part of their land. Another subsample of 15 one-ha plots from surrounding farms practicing conventional agriculture were chosen as well.

Within each of these 30 reference plots, four "permanent" sampling spots of 50 m^2 (5 m x 10 m) were randomly chosen and marked with stones. This network of plots evolved quite rapidly during the first two years due to farmers' decision. In 2012, the sample seems to finally stabilize at nine and eight plots for CAPS and plow-based systems, respectively (cf. Annex for monitoring data on crops, yields and biomass inputs).

Figure 37. CAPS-based maize at # 30 DAS on a farmer's reference plot in Boribo Village, Cambodia

The harvest occurred from November – December 2011, long after the date of crop maturity, as farmers preferred to dry the grain on plants and delay the harvest in order to get better prices. In 2012, one of the plow-plots grown with cassava in 2011 has been "converted" back to maize in 2012 and one plow-plot shifted from maize to cassava; all CAPS plots remained cultivated with maize in 2012. Harvest of the 2012 cropping season will start in November-December 2012 for maize and January-February 2013 for cassava. Yields obtained on the double reference plot network are presented in the Table 46 below which is the average of the yields measured on the four 50 m^2 fixed sampling subplots. Maize biomass inputs have been also measured on the sampling subplots right after the 2010 and 2011 harvests and prior to the 2011 and 2012 maize sowing.

The yield trends observed on this limited subsample are consistent with those observed on the pilot extension network conducted with farmers which began in 2009.

Table 46. Crop performances and main biomass inputs on the farmers reference plots network in 2010 and 2011 for plow-based (PLOW) and CAPS based (DMC) systems.

		2010						2011					
		Cycle 1		Cycle 2				Cycle 1		Cycle 2			
	Village	Crop	Biomass	Crop	Biomass (11/11-10/12)	Yield	moy.	Crop	Biomass (7-9/05)	Crop	Biomass (25/10-29/11)	Yield	moy.
PLOW	Pechhangvar			Maize	2403	2727				Cassava		7800	
	Pechhangvar			Maize	4958	2983				Cassava		6900	
	Pechhangvar			Maize	3277	1600	2800			Maize	2051	1345	2305
	Pechhangvar			Maize	3729	3999				Maize	1701	3264	
	Boribo			Maize		2208	4140			Maize	2126	3092	2877
	Boribo			Maize	3388	5393				Maize	1672	3150	
	Boribo			Maize	4246	4078				Maize	2377	2223	
	Boribo			Maize	4547	4880			1,193	Maize	4172	3041	
DMC	Pechhangvar	Millet		Maize	4478	3970	3446	Stylo	1793	Maize	2606	3434	4072
	Pechhangvar	Millet		Maize	3936	2760		Stylo	1210	Maize	2092	2937	
	Pechhangvar	Millet		Maize	3429	2679		Stylo	3097	Maize	2113	5040	
	Pechhangvar	Millet		Maize	3595	3615		Stylo	5634	Maize	3178	5568	
	Pechhangvar	Millet		Maize	4315	4206		Stylo	1288	Maize	2049	3379	
	Boribo	Millet		Maize	3561	2080	2465	Stylo	2185	Maize	2736	4241	3514
	Boribo	Millet		Maize	4430	2123		Stylo	3645	Maize	1297	2750	
	Boribo	Millet		Maize	5987	3399		Stylo	1409	Maize	1819	3326	
	Boribo	Millet		Maize	3569	2258		Stylo	7532	Maize	2137	3738	

Philippines

The farmer-managed treatments in the Philippines need to be reset hence there were no results obtained.

<u>Kitchen or small studies:</u>

Cambodia

Several small single-plot studies were being conducted to assess growth of cover crops also for seed production.

Philippines

In a nitrogen, phosphorus, and potassium (NPK) omission experiment, we found that no application of N resulted in a reduction of maize yield up to 67%, omission of P resulted in 59% reduction, and omission of K caused 21% reduction. The results suggested that N is the most limiting nutrient, followed by P and K. In a NPK addition experiment, we found that the optimum rate of N application was 120 N kg/ha, and the P optimum rate was 20 kg/ha. Different varieties of "Adlai" were evaluated. We found that the Kiboa variety produced the highest grain yield and total dry matter yield, followed by Ginampay, and Tapol. Our results

showed that Adlai has a huge potential for CAPS for sloping degraded acid upland soils which are in many parts of the Philippines as well in many Southeast Asia countries. We evaluated different cassava cultivars. We found that Rayong 72 cultivar from Thailand had the highest yield both in fresh roots and aboveground biomass, followed by VISCA 4 which was developed from Visayas State University (VSU) in the Philippines. Other promising varieties were Lakan and local yellow gold.

Development Impact

There is some evidence that CAPS can increase yield, and improve soil quality compared with plow-based system.When continued two more years, there is a potential for CAPS to be recommended as a robust replacement to plow-based agriculture.

Challenges and Responses

In both countries, CAPS adoption is in its infancy and is in a fragile situation. Deliberate actions must be done to protect the positive impact that CAPS has been showing to the plow-based farmers' world. Governments and international funding agencies should be provided with biophysical and socio-economic results and action items to promote CAPS adoption by providing incentives such us low interest rates for farmers who will adopt CAPS.

Degree and nondegree training activities

Three students, one from Cambodia, one from the Philippines and one from the U.S. are pursuing Ph.D. degrees in Energy and Environmental Systems at North Carolina Agricultural and Technical State University. In addition, two Philippine nationals completed M.S. degrees in Land and Water Resources, and a third is pursuing a Ph.D. degree in Land and Water Resources at the University of the Philippines Los Baños.

31 nondegree trainings were held with 445 women and 559 men (total 1004) in attendance. Thirty of the nondegree trainings were mainly related to Conservation Agriculture with Trees conducted in the Philippines with farmers, local government officials, ecclesiastical leaders, scientists, faculty, politicians, and extension staff as the audience. Conservation agriculture training was held in Cambodia for farmers.

Publications, presentations, and other SANREM CRSP products

The SANREM Phase III team was able to launch three books. For this two M.S. theses were completed as well. Nine oral presentations were given in several scientific meetings in the USA, Europe and the Philippines. Nineteen posters were presented by the team as well and several abstracts.

Networking Activities

- Meeting with the Claveria Landcare Association (CLCA) on integrating CA on their farms
- Meetings with United Rubber Producers Association (URPA) on conservation agriculture with trees using rubber trees

- Xavier University Sustainable Agriculture (XUSA) Research Collaboration particularly on socio-economic components of CA
- Launching of 'Vegetable Agroforestry Systems in the Philippines' book at the University of the Philippines Los Baños, January 2012
- Launching of 'Holding their own: smallholder production, marketing and women issues in Philippine agroforestry' book at De La Salle University, Philippines, March 2012
- Launching of 'Vegetable Agroforestry Systems in Indonesia' book at Bogor Agricultural University, Bogor, Indonesia, June 2012
- Soil and Water Assessment Tool workshop, June 2012, Bogor, Indonesia
- Scientific committee of the Third International Conservation Agriculture Conference in Southeast Asia, Hanoi, Vietnam, December 2012
- Implementation of CAPS for urban vegetable production study at the NCA&TSU and several high , middle and elementary school campuses in North Carolina

Highlights

- In Cambodia, Year 3 yield of maize in CAPS is higher and production inputs were lower than in plow-based system resulting in a higher gross profit margin for CAPS .
- In Cambodia, CAPS pilot extension participation increased from 31 to 66 families with area in CAPS increasing from 59.5 to 225 ha with five households in a village purchasing their own no-till seeder.
- In the Philippines, organic matter in the soil's top 5 cm increased by 0.6% under CAPS while organic matter decreased by 1.5% in the plow-based practices from 2010 to 2012.
- "Adlai" (***Coix lacryma-jobi*** L.) has excellent prospects for CAPS in sloping degraded acid upland soil in the Philippines.
- CAPS studies have been implemented for urban vegetable production at the NCA&T and several K-12 campuses at North Carolina through funding provided by USDA.
- From SANREM phase III results, three books were published and launched.

Cross-cutting Research Activities (CCRA) program

Economic Analysis and Impact CCRA

Principal investigators: Michael Bertelsen, George Norton

Research progress by objective

Objective 1: Identify the costs and benefits of CAPS in cropping systems/practices and related animal and forestry sub-systems

Critical research accomplishments

Regional programs gathered data on input costs and yields of the CAPS, as well as costs and yields for current practices or traditional agricultural methods. Evidence from Ecuador and Cambodia indicate positive economic benefits from adopting CAPS, and in those and the other sites, data continue to be collected and analyzed. In West Africa, data are being collected by

economists at KSU to assess profitability of reduced tillage, cover crops, and rotations for maize, beans, sorghum and millet in the northern region of Ghana. Some cost and yield data exist for cover crops, tie ridges for water management, intercropping for sorghum, millet, and brassicas. In Southern Africa, costs and yield data for maize cover crops and no-till have been collected in Lesotho and Mozambique by economists at UTK. Baseline surveys were completed in Lesotho and Mozambique. In South Asia, yield and labor use data have been obtained for rotations and intercropping by economists at the University of Hawaii and a format was provided to them for collection of additional cost of production and yield data. In Bolivia, costs and yield data were gathered for experiments on quinoa, habas, and potatoes with direct seeding, cover crops, and rotations. In Ecuador, cost and yield data were collected for potatoes, maize, habas, barley, beans with cover crops such as oats and vetch, rotations, and reduced tillage. Results from a linear programming model provided information on the optimal set of practices for two sub-watersheds. In the Philippines, cost and yield data are available for researcher-managed trials and are being collected on farmer-managed trials with an emphasis on maize, cowpeas, rice and beans. Practices include cover crops, reduced tillage, and rotations. In Cambodia, maize and cassava are the primary crops and some cost and yield data are available. In Haiti, a baseline survey has been conducted but the data are not yet summarized.

Development impact

Budget data will be an input into subsequent economic impact assessments. They will be used for assessing the profitability of specific CAPS elements for somecrops and cropping systems, the optimal sequencing of CAPS elements, and overall impacts of the CAPS in the various regions.The profitability of the CAPS will help guide future policies with respect to conservation agriculture in the specific countries.

Objective 2: Identify optimal CAPS in each cropping system being researched and sequencing of CAPS elements

Critical Research Accomplishments

Based on the crop budgets elaborated for the FY 2011 analysis of CAPS in Ecuador, a standardized LP model was developed and made available to other regions. A graduate student at KSU from Ghana who will use the budget data from the SANREM site in northern Ghana to conduct a linear programming analysis similar to the one completed in Ecuador. A graduate student at Hawaii will also conduct an analysis for Nepal.

Development Impact

SANREM is developing and disseminating sustainable agricultural technologies, such as water-deviation ditches, cover crops, minimal tillage, and crop rotations to improve the livelihoods of rural households in the seven study regions. The primary objective of the economic impact study is to evaluate the effects of the practices introduced with respect to farm income, to value the carbon sequestered, and to identify the optimal mix of conservation agriculture technologies for farmers in the study area.

Challenges and Responses

The biggest challenge is that the CAPS experiments in the various regional programs are not far advanced and hence there are limited data yet from the on-farm treatments, either in terms of input costs and yields or in terms of organic carbon differences or soil loss. To get around that problem, in Ecuador we combined additional farm level survey data on cost of production with data from partially completed experiments. We will also be making projections of benefits under alternative adoption scenarios for preliminary impact assessments as there is limited adoption to date.

Objective 3: Identify broader economic and social impacts of wide-scale CAPS adoption

No tasks were planned this past year, but an economic surplus analysis was designed to provide estimates of broader economic impacts. This coming year, the analysis will make use of budget data and projections of adoption of CAPS by producers in various countries on the project to provide ex ante assessment of market level economic benefits.

Objective 4: Identify any policy changes required to bring CAPS adoption in each cropping system

No tasks planned or undertaken this past year. This will be a future topic if the profitability of CAPs indicates that additional payments for environmental services are needed.

Degree and nondegree training activitiesnondegree training activities

A master's student, Barry Weixler-Landis, began working on the project in August 2012 and will complete a Master's thesis on the project over the next two years to assess economic benefits of CAPs and constraints to adoption in at least one regional program.

Publications, presentations, and other SANREM CRSP products

Nguema, Abigail, "Two Papers Evaluating the Economic Impact of Agricultural Innovation," MASTER'S thesis, Virginia Tech, Blacksburg, VA, September, 2011.

Networking activities

Collaboration was initiated with each of the regional projects in order to ascertain and assemble all available data on input costs and yields for the CAPS under investigation.

Highlights

Collaboration with each of the regional programs to assemble available data on input costs and yields for the CAPS under investigation. A simple crop budget template was circulated in order to develop the standardized data set necessary to conduct an overall economic impact analysis of SANREM Phase IV.

Gendered Perspectives for Conservation Agriculture: Local soil knowledge and crop-livestock rotation

Principal Investigator: Maria Elisa Christie

Research progress by objective

Objective 1: Document differences in men and women's knowledge, beliefs, and perceptions of soil quality

Critical research accomplishments

Philippines: Building on the experience with Bolivia, the research design and methodology were revised for implementation in the Philippines. Soil samples were collected by local partners in both countries from men and women's plots identified in our research, using the protocol of the CCRA-9. Sampling is complete and samples are pending shipment to the US. The Gender CCRA research protocol addresses gendered soils knowledge, beliefs and perceptions of soil, soil management practices, and gendered spaces from local men and women smallholder farmers. A gender dimensions analysis framework (GDF) used in USAID projects was also used to collect, inform, and analyze data. Outputs include a data analysis model for combining qualitative with laboratory techniques, as well as a prototype for current Gender CCRA research. This prototype includes descriptive and in-field methods documents for mapping community soils knowledge by gender on a satellite image; household interview and participatory mapping on farm resources, practices, and soils; GPS mapping of household plots identified by farmers; and for a community, gender-separate FGD on men's and women's activities, including information related to CAPS.

In February, the PI made a visit to the site in the Philippines to test and adapt the research template and assess existing literature and data. A key activity during this visit was training of the local team for summer fieldwork later. The PI conducted a FGD with several activities at the community level and a household visit, including separate interviews and participatory mapping with the man and the woman of each household. She also interviewed farmers at the SANREM test plots in the Philippines.

We have adapted the mapping gendered landscapes methodology from Bolivia to field work for the Philippines and other LTRA research sites, producing a research prototype for correlating gendered spaces with gendered soil knowledge, beliefs, perceptions, and management practices. We have also reviewed previous soils research in the Philippines from a gender perspective in order to build on previous SANREM soils research and identify gaps in research. Related to this task, we have obtained multiple data points to test a qualitative GIS model.

The following criteria whereas established for selecting research sites in the Philippines: safety, accessibility, relevance to the smallholder farming community, and availability of secondary

GIS data. Three barangays were identified but after further planning and due to the time-intensive process of implementing the full methodological package, research was carried out in only two: Rizal and Patrocenio. These two sites were selected in part due to their geographic differences. The altitude in Rizal varies from 730-841 meters, while in Patrocenio the altitude ranges from 475-505 meters. In Rizal, households were located along the main road with the farms located off the main road. In Patrocenio, both the houses and farms were located on the same land off the main road. The dominant crops planted in both are maize, bananas, sweet potato, vegetables, and cassava. Some farmers also planted upland rice.

Table 47. Soil descriptions by women and men in Claveria

Descriptors	Translation
Tambok	Fertile
Sustansyado/sustantia	Fertile/substance
Domay	unfertile
Umaw	Unfertile/acidic
Niwang	Unfertile
Pula-pula	Red
Dili maayo	Not good
Maayo	Good
Itom	Black
Pabrika	Black
Igo igo lang	Normal
Bughaw	Eroded
Patag	Flat
Bakilid	Rolling
Acidic	Acidic
Walay nada	Not Good/unfertile
Yellow/dalag-dalag	Yellow
Minous	Less growth

This chart is a list of all the soil descriptions that men and women from household interviews in Claveria, the Philippines, provided when asked to describe the different soils on their farm.

While selecting the sites was straightforward, sample selection at the farmer level was more complicated. Scientific approaches to "random sampling" came up against the realities of obtaining access to research subjects who fit our criteria. In order to know which farmers were appropriate to interview, where they lived, and to save time walking long distances from farm to farm, we went to the Barangay Council for assistance in selecting informants from our list. We explained to the council members that our criteria for respondents were based on the following: smallholder farmer that had their own land even if they were also hired labor, an adult man and woman in the household, they were not at the Focus Group Development (FGD) we held prior to the household interviews, and they were not SANREM farmer cooperators. We

had already obtained a list of farmers for each barangay through the Barangay Nutrition Scholar for 2011. It was created from a population survey with occupational data from which we obtained the names of those who listed their occupation as "farmer." The list was then randomized in Excel using the =RAND() function. With the Barangay officials, we went down the list systematically, one-by-one from the top, and eliminated the farmers not fitting the criteria we established. The research team discussed each name before eliminating it order to ensure that this was according to our criteria and not for other reasons. Once that was done, we had one of the officials escort us to the houses that fit our criteria and introduce us. This was deemed necessary to reduce suspicion and increase the likelihood of farmers speaking with us. Mary Harman's fieldwork in the Philippines during July and August 2012 continued the research started by the PI in February. The PI also carried out a site visit in July to support student research and discuss methodological and logistical concerns. ICRAF provided team members and transportation which allowed the work to be conducted efficiently and in the local language. Activities included two FGDs; one in each of the two barangays selected, household interviews, and field visits. In both focus groups, participants discussed different community soil types and mapped them on a satellite image. They also discussed socioeconomic activities and changes in soil and agricultural practices over time. Outputs included men and women's community soils descriptors and maps on satellite imagery, activity charts, and timelines (see Table 48).

These were similar to items that we obtained in Bolivia last year, but with responses that situate them in very different contexts. Preliminary findings from the FGD indicate that men describe soil quality based on physical properties, while women describe soil based on use. This is possibly correlated with gendered practices where men are responsible for land preparation while women mainly plant, weed, and prepare the product for sale or consumption.

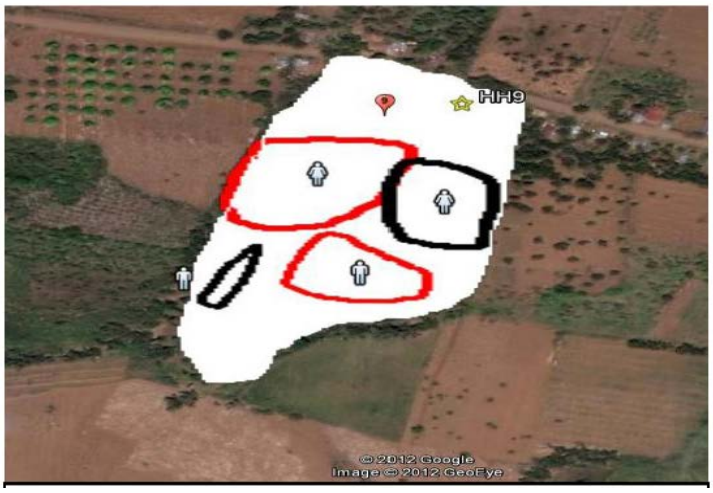


Figure 38. GPS data from Google Earth for household #9

In the household interviews, the men and women discussed community and farm-level soils through soil samples, pictures, participatory mapping, satellite maps, and field visits. Outputs included gendered descriptions of soil quality, participatory maps, and GPS data of the "best" and "worst" soil locations as indicated by men and women separately in each household

Initial analysis indicates that men and women both relate to soil quality through plant growth, but men generally designated field crops as either best or worst while women focused on horticultural crops. While they have local names for their crops and grasses, they said they did not have names for soils. They have only classified their soils based on color, fertility, and quality (good or bad) and used many descriptors, but not names per se. In addition, both men and women farmers were aware of and concerned about the changes in soil quality in their community.

Soil sampling has just been completed in the Philippines. Samples were taken from each man and woman's best and worst soil as per farmer selection. CCRA-9 will perform the soil fertility analysis and ICRAF will perform the texture analysis. These results will then be joined with the household, gendered soil descriptions to determine patterns and correlate local and scientific knowledge.

We made changes in the research methods to adjust to the Philippines site. Changes were also made to questions in the methods to allow for more discussion about describing and managing soils at the community and farm levels.

Table 48. Local soil quality indicators grouped by gender in Claveria

Rank	Men's Group	Women's Group
1	Color (black)	Land use a. Agricultural land – (para sa umahan) b. Residential land - (para balayan)
2	Topography (flat)	Topography a. Plain (patag) b. Rolling (hanayhay) c. Sloping (Handig, bakilid)
3	Distance to water (close to water is fertile)	Soil Quality (fertility) a. Fertile – good vegetative growth b. Not fertile – not good vegetative growth
4	Presence of organic matter (presence of weeds is fertile)	Color a. Black b. Red
5	Presence of pests (presence of pests is unfertile)	Type of vegetation
6	Presence of rocks (presence of rocks is unfertile)	Growth of plant in the soil (yield & production) a. Not good soil, corn have yellow colored leaves, poor yield
7	Color (red color is unfertile)	

For the community FGD on mapping soils, we changed three questions: 1. "How would you classify this soil?" 2. "Please describe your classification." and 3. "What do you cultivate here?" to 1. "How would you classify this soil?" 2. "How would you describe this soil?" and 3. "What do you use this soil for?" We also added an opening question "What is soil?" For listing soils, we also changed the question "What is this soil type?" to "What is the name of this soil?" in order to avoid language translation barriers, and to eliminate technical jargon or misinterpretation among farmers and researchers. We also included the soil sample discussion questions in the household interviews and added a local soil quality indicator exercise. In the FGDs, we also asked farmers to list the criteria by which they judge soils in their order of importance. We asked: 1. "What are the indicators of soil quality?" 2. "What is the most important indicator of soil quality?" 3. "What is the next most important indicator of soil quality?"(See Table 49). We adapted the household interview and mapping method from Bolivia to include the questions listed above as well as more questions to obtain information on decision-making on planting, tilling, and harvesting at the household level by gender. We asked

more questions about knowledge and practices related to CAPS. This adapted methodology was tested in the Philippines in February and executed in the summer. Adapted methods for mapping community soils were successful.

Bolivia: Outputs from the men's and women's FGDs on local soils in the community included: a list of descriptions of two soil samples ("good" and "poor"), a list of local soil types, their rating, description, and uses, and a hand-drawn map of the previous list of soil types over a satellite image of the community. Findings from the FGDs indicate that men and women describe the soil quality of soil samples based on biological, physical and chemical soil properties. Both men and women agreed that the soil sample (Soil A) lighter in color and moisture was "less" than the soil sample (Soil B) with darker, black soil and higher moisture content. The women's group indicated Soil A was a poor soil because (in order of importance) of its poor health (has diseases, chemicals, and pests: *rosario* and *gusano*), low fertility (not virgin soil; becomes less with fertilizer), low productivity and crop performance (especially related to potatoes), and its dry, clay-like structure and texture. Men indicated Soil A as a poor soil because of (in order of importance) its hard, dry structure, erodability with rain and wind, higher stone content, and lack of ability to irrigate and cultivate certain crops (especially potatoes). One man also expressed that Soil A was not necessarily a poor soil because of the higher stone content, which allowed the soil to maintain moisture "for planting."

Both groups of men and women also agreed that Soil B was the better soil, focusing on soil health, color, or structure. Women explained Soil B was better or good in quality because of its color (black), good health and purity, high fertility and ability to produce well, especially with potato seeds (*It gives good seeds.*), and its fine texture and structure (not clayey or chalky.) Men designated that Soil B as better because of its black color, good fertility and health, and good structure in terms of retaining moisture, resistance to erosion, and high organic material content. One man noted that Soil B was not necessarily better because it "could have diseases, which is 'bad' for planting potato seeds". Two men also disagreed with the black soil color, describing the soil as more brown, which means the soil is dry or can no longer produce oca, fava beans, potatoes, or barley.' Both men and women also indicated that this soil was only found in the nearby, higher altitude mountain community (Los Andes)—a factor which would later become important in choosing the best soils for soil sampling at the household level.

Men and women classified soil types based on color, texture, stoniness, structure, and moisture and structure. Men described the soil quality of the soil types largely based on the soils' structure (ability to hold moisture, irrigate, and work, smoothness, organic material content), crop performance (ability to grow certain crops, especially the potato), productivity (ability to produce in the rainy or dry season), texture (clayey or gravel-filled), and color (black or yellow). Women also described many of the same properties when judging the soil quality of the soil types, noting the soils' color (yellow, black, white), productivity (good or poor yields, use in rainy/dry season), stoniness, and structure and water infiltration (ability to irrigate).

Table 49. Soil quality indicators in the village of Rizal.

Rank	Men	Women
1	Crop performance (*The potato does not perform well. We have to plant other crops.*)	Crop performance (*I can only plant onions. It does not produce potatoes.*) (*It gives good potato seeds.*)
	Productivity and yield (*It produces well.*)	Productivity and yield (*It produces well, but only in intervals.*)
	Soil structure and stability (*It maintains moisture, and has organic material. It is soft and not hard for plowing.*)	Soil structure and stability (*The earth is hard, chokes the plant. It rains and turns hard. It does not have organic material.*)
	Fertility (*It is good earth, virgin soil.*)	
2	Presence of stones (*It has stones and does not maintain moisture or manure.*)	Presence of stones (*It has stones and little earth.*)
	Color (*Here, on top, it is always black soil. But underneath is yellow soil and stones. When we are working the land, the yellow soil and stones are coming out.*)	
3	Geography (*This is for planting in the mountains, only seasonal. It is only for producing potato seeds.*)	Fertility (*It does not produce without fertilizer.*)
		Color (*In the black soil we produce potatoes.*)
		Texture (*It does not have sand. It never turns to clay. It is loose.*)
4	Water infiltration (*It wets and dries quickly after irrigation. The moisture does not grab.*)	Water infiltration (*The earth turns hard and slick after irrigation in the rainy season.*)
	Moisture (*It has the best moisture, 1-3 months.*)	
	Texture (*It is chalky and clayey. It depends on the preparation of the soil.*)	
5	Seasonality (*It does not produce in rainy season.*)	Seasonality (*We use it in the dry season and it produces well.*)
	Workability (*It is smooth for plowing.*)	Geography (*It is in the mountains. It is not contaminated. Virgin soil.*)
	Erosion (*The water after rain takes away the soil.*)	
	Climate (*It produces a little less here because it is colder.*)	
6	Organic material (*It has organic material from the ox and sheep.*)	Moisture (*It maintains moisture.*)
	Depth (*The soil is not very deep because underneath there are stones.*)	Water availability (*I can only plant in the rainy season because I do not have irrigation.*)
	Topography (*It not cultivatable. It has little moisture and major slope.*)	Organic material (*It has organic material and so it is good.*)
	Health (*It is healthy earth.*)	Depth (*It produces little because underneath there are stones.*)
		Health (*It does not have diseases or pests (gusano).*)
		Plant indicator (*In the rainy season it rots the plants and seeds.*)

Outputs from the household visits include, from both men and women, participatory maps of soil types and resources used at the household level, descriptions of soil types, soil quality indicators for soil types, soil samples and GPS data of the best and worst soils, and descriptions of farming and livestock-related practices.

At the household level, men and women listed 21 different names for soils or soil types, classifying soils based on color, stoniness, texture, structure, moisture, quality, and use. Like the focus group, men and women described the quality of the soil types based on many of the same soil properties, such as crop performance, productivity and workability, and geographic location. The top indicators of soil quality for men included crop performance, productivity and yield, soil structure and stability, soil fertility, presence of stones, and color. Women's top indicators were the same, but with differences in rank or description: crop performance, productivity and yield, soil structure, and presence of stones (Table 49).

Men and women generally perceived the best soils based on color (black), location in Los Andes, good structure, fertility, lack of stones, crop performance and productivity related to potatoes (and other crops), good moisture retention, or organic material content. Of the eight households with couples, seven chose the same best soil. Soil sample analysis show that these soils, compared to the worst soils, are larger in plot size, higher in acidity, and ranged from loam to silt loam textures. On the other hand, men and women also described the best soils as easy to erode, susceptible to colder temperatures, or having limited seasonal use. Men and women's choice of best soil also showed differences in men and women's access to good soils. For example, in household nine, both the man and woman perceived their best soil as a so-so/poor soil in terms of quality, but explained it was the best soil to which they had access. Men and women generally perceived the worst soils based on color (yellow, yellowish black), sandy, clayey, or gravelly texture, high stone content, structure (hard and dry), poor top soil depth, difficulty to work (plow or manage weeds) related to irrigation and rain, need for fertilizer, low productivity and crop performance, and low moisture content and water infiltration. Compared to the best soils, men and women from four households chose different worst soils. In addition, one widowed woman chose her worst soil as a plot she rents to graze her sheep on crop cover, and another married woman chose her worst soil as the community pasture land in Los Andes. Soil sample analysis shows these soils were smaller in plot size and less acidic, with textures ranging from sandy loam, clay loam, and loam, when compared to the best soils. While the worst soils picked by men and women were similar in ranking, name, and description, one household's worst soils description and ranking more closely aligned with farmers' perceptions of best soils. This perhaps is an indication of differential access to quality soils, wealth, or soil management practices.

Development impact

These gendered ways of knowing soils and the landscape serve as points for knowledge integration for localized CAPS. What is important to recognize is that men and women farmers are very knowledgeable of the landscape and the different ways to manage it based on different

soil types or soil quality, or diminished access to land, labor, or animals. Researchers can learn from farmers as well as find innovative ways to situate CAPS in local contexts including gender. Men and women are highly aware of the importance of adding nutrients and organic material to soils to improve soil quality, structure, or moisture content. Men and women also are aware of soil erosion, especially related to their best soils. Many of men and women farmers' interests to care for their soils align with the CAPS framework to improve soils quality, which could provide a starting point for researchers and farmers to discuss CAPS.

Development impacts include a raised awareness of SANREM and conservation agriculture for farmers in the Philippines site and a raised awareness of gender concepts in agriculture and qualitative research for host-country institutions. The research conducted this summer in the Philippines was crucial in building relationships with non-SANREM farmers and allowed us to introduce SANREM and bring awareness and curiosity to the farmers about gender and conservation agriculture. We were also able to give back knowledge to the farmers by giving them geospatial information of their community, farms, and households such as satellite imagery and farm size.

Lessons from the field in the Philippines include: trainings should be adapted to encourage more women; trainings need to acknowledge that women have less access to technical information; and men and women's knowledge, beliefs, and perceptions need to be documented in order to address soil issues.

Challenges and responses

Many of the challenges experienced pertained to the interdisciplinary nature of the research, specifically using qualitative methods within a quantitative, bio-physical team environment. We were able to overcome these somewhat due to the commitment,quality and openness of the teams in both LTRA 7 and 12 and their being open to try a new approach.

This CCRA puts a lot of demands on host country institutions, and is dependent on them providing transportation and support for translation and note taking. This is very time and labor-intensive. Training of the field team and discussion and reflections among team members each day is necessary to focus on what is essential and build on patterns discerned. Translators and note-takers are essential to collecting data on local knowledge of soils because it is dependent on literal transcriptions of informants' descriptions. This is particularly an issue in cases when other team members do not speak the local language. Two alternating note-takers are recommended in order to have enough time for writing notes and reflecting—which is difficult to do during, day after day, field work to make the best use of a short time in the host country. Tape recording has also proved beneficial from fieldwork in both Bolivia and the Philippines in gathering data on local knowledge, beliefs, and perceptions.

Obtaining university IRB approval to work with non-US institutions that lack human subject policies was a tremendous challenge, as was obtaining approval for tape-recording interviews. Much time was spent this year in both host countries and the US to get the required online

training by co-PIs and signatures from the administration in host countries. This was an issue both before and after fieldwork. For future research involving human subjects (not soil sampling, for instance), we recommend beginning the process early and keeping careful records. Oral approvals by our subjects are acceptable as long as we fill one out for each individual after they understand that their participation is voluntary and anonymous, and give permission to be tape recorded and photographed. In the case of the FGDs one read aloud and agreed to by all participants is sufficient. Providing training on this in February during the preliminary fieldwork in the Philippines helped prepare for the extended research in the summer.

In addition, accessing relevant and secondary GIS data was difficult and proved that collaboration with other LTRAs and institutions is necessary for ancillary data. Even obtaining Google Earth imagery necessary for our work was difficult due to the cloudy weather in the Philippines and impacted the selection of sites. Furthermore, data variability in Bolivia revealed challenges and illuminated assumptions that needed to be addressed. This realization was particularly helpful towards using GIS data in the Philippines and planning for future work in other sites.

Objective 2: Document the gendered nature of crop-livestock interaction with respect to the conservation objective of maintaining the crop residue cover on the soil

Critical research accomplishmentsresearch accomplishments

In correlation with Research Objective 1, we obtained two culturally appropriate photographs showing crop-livestock interaction in the Philippines site, tested them during the trip in February and used them during July and August 2012. This served to elicit perceptions of the impact of animals on land. One is a picture of a local male farmer furrowing a plot with a cow; the second is of a chicken grazing in a field of grasses (*Arachis pintoi*). We asked the farmers "What is going on in this picture?" Most of the farmers responded with general answers such as naming the animal and what it was doing, yet they were not mentioning any connections between the animals and the soils/crops. We decided to add the questions: 1. "Do these animals affect the soil?" and 2. "If so, how?" Most of the farmers claimed that cows help cultivate the soil while chickens help fertilize it with their dung. Thus, both animals were beneficial and neither was associated with damage to the land.

Gendered access to resources, including animals, is spatial. In the Philippines, men have access and control over cows and the local water buffalo (carabaos), which are mainly situated on the farm. Women have access to cows, pigs, and chickens which are mainly situated within the house lot. In Bolivia too, we found that using geospatial techniques to 'map' gendered soils knowledge and space helped show patterns in men's and women's resource and livestock use and decision-making practices. Gendered soil knowledge and space is unique and situated. It has mutually informed the different ways men and women make or define their livelihoods and spaces in the landscape, both practically and symbolically.

In the Philippines, crop-livestock interaction is important to farmers and has become a legal issue. An ordinance now fines farmers from pasturing on other's land. This has resulted in farmers finding a place on their own land for this activity. However, this could mean loss of valuable cultivation space and increases labor for men since they now have to tie up and observe their livestock to prevent them from eating their own crops, as well as any crop-cover. In the Philippines, it was observed that access to water linked to elevation has an impact on the type of livestock used for farming. For example, in the Barangay of Rizal, which has an average elevation of 800 meters, all of the participants used cows to prepare their land. In Patrocenio, which has an average elevation of 450 meters, all of the participants used carabaos for land preparation. In both villages, they claimed their choice between cows and carabaos was based on whether they had easy access to water since carabaos need water to wallow in every few hours.

In the research in Bolivia, we had found that sheep—usually women's assets—created gendered sense of place, and that grazing land was included in women's perceptions of soils. We found this reflected in participant observation and the hand-drawn maps. Women frequently mentioned differences in soil types in relation to ability to pasture, tie animals to eat crop cover after harvest or during fallow, or crops produced to feed animals. Men also mentioned the ability to pasture animals, but not with the same priority as women. However, men (and some women) frequently mentioned the use of animal manure for improving soil quality and crop performance. Men and women also described different soil types in context with crop rotation and fallow period.

Findings from the household soils descriptions, participatory maps, and participant observation indicate that the gendered differences in ranking and description of soil quality indicators for soil types were related to gendered farming and livestock practices, and gendered spaces. (This was reflected by men and women both verbally in interviews and visually in hand-drawn maps.) In this case, women were primarily responsible for planting seeds, pasturing, splitting the crop harvest for food and market, fuel for cooking, selecting seeds, and caring for the plants during season, or applying fertilizer. In relation, women generally described soil quality based on their ability to plant in it, it providing good yields, or its use to pasture sheep. Men were primarily responsible for tilling and preparing the land, designing crop rotation, applying fertilizer, and harvesting crops. Similarly, men described soil quality based on its irrigation, growing and producing specific crops with different locations, soil types, tilling practices, and various crop rotations. Thus, gendered management practices influence the ways both men and women know of and spatially use the landscape and different soil types, and is important to understand these dynamic relationships between gendered practices and soils knowledge, and soil types and spaces for CAPS implementation.

Development impact

The CAPS framework for improving soils with crop rotation and crop diversity aligns with men and women's perceptions of using crop rotation for soil management practices. In terms of diversifying a crop rotation, men and women will most likely be open to CAPS-proposed crops

for many reasons related to desire to diversify crop rotation for improved yield or market income.

However, scientists and farmers have different perceptions about maintaining permanent crop cover and minimum tillage. On the local level, women (and men) use the crop cover to feed animals, and men use plowing for work and soil management. (For example, men plow soils that are too moist or clumped in order to loosen and aerate it for planting.) The CAPS recommendation for controlled grazing of eating the crop-residue at certain times—or not at all—might affect women's access to and control over animals or decision-making power in the household. However, findings show that many women have created their own ways to pasture animals, such as using a grass border around the plots for pasture, or using community pasture land. On the other hand, women also might be more supportive of fallowing plots as a means to feed their sheep. Researchers will need to be aware of—and integrate--both men and women's ideas and needs of pasturing animals with CAPS.

Challenges and responses

Flexibility is required in qualitative research in order to follow up on initial findings and increasing understanding of the research questions in the site context. In the Philippines, we found that focusing on soils knowledge alone may leave out important gendered, agricultural knowledge pertaining to crops and grasses that could be relevant to conservation agriculture. As a result, the team recommended including questions about the relationship between soils and plant growth to determine if there are any gender differences in that context. This is similar to the situation in Bolivia where initial research found that asking informants to classify soils based on "what it produces" among other things would leave out pasturing, which was an important gendered consideration regarding land use and access to assets. We encountered several other challenges relating to access in both Bolivia and the Philippines.

During the fieldwork in the Philippines, accessing participants and secondary data was difficult even with the help of LTRAs and host-institutions. As with the indigenous council in Bolivia, in order to conduct research in the Philippines, we needed permission from village leaders and to pay courtesy calls to local government units. It proved that collaboration with local government units is necessary with international research, especially when it comes to knowledge access and relationship building. The challenge is how to do this without introducing bias in the sample. This too is a challenge of qualitative, social science research which is different from that faced by bio-physical scientists.

SANREM must recognize that it does not operate in a vacuum and that previous development efforts and social interactions affect our project. Other obstacles affecting our access were linked to outside interventions prior to our research. For instance, some farmers in the Philippines were reticent to allow soil sampling on their land, saying that the government had done the same five years ago and they were still waiting for results. Prior experience with host-country institution ICRAF also affected how farmers reacted to us. CAPS initiatives must identify and take into account previous initiatives in the site and ascertain farmer's experience, beliefs and

perceptions of these. In the case of the gender CCRA research in the Philippines and in coordination with the Soils CCRA and the ICRAF, farmers were assured they would receive soil sampling results; this is critical and has been planned for February of the coming year. Keeping our word about and providing results of mapping and soil analysis will build trust that may increase farmer receptivity to CAPS recommendations.

CAPS and gender research must address the fact that farmers are most concerned with the short-term costs and benefits. Short-term benefits must be addressed and stressed in terms other than soil in order to increase adoption. Food security must be ensured in conjunction with increased soil quality.

In both Bolivia and the Philippines, farmers accessed land through a variety of different arrangements and often did not have long-term control or decision-making power over practices implemented there. These must be understood and taken into account if farmers are expected to make the long-term investment that CAPS requires. Access to land as well as land use differs by gender so this requires qualitative research talking to both women and men. One additional challenge to this research is that it includes a large amount of data and coordination, on one hand, combining the qualitative with the geo-spatial mapping, and also combining the ethnographic descriptions of soils with the lab results. It also requires physical effort as the researchers walk the perimeter of the farmers' plots (0.8 to 6.0 ha. in the Philippines) on steep slopes—while taking GPS points at the same time as carrying out observations and unstructured interviews talking with the farmers. Here, translation proved a difficult challenge that was not always overcome.

In the coming year, we have developed a new objective and will reduce our scope to focus on one of the elements proposed by CAPS, minimum tillage, and not include soil sampling as part of our research. This new, third objective, will be linked to the second objective and will look at access to assets for plowing, including animal-traction and motorized plowing. Coordination has begun with the Technology Networks on this objective to develop a short survey for the Gender CCRA and also analyze existing survey data.

Degree and nondegree training activities

Graduate student Keri Agriesti is making progress toward her degree in Geography; she has finished analyzing most of the data and is finishing writing her thesis. It focuses on gendered soils knowledge and gendered landscapes for CAPS in Sangk'ayani Alto, Bolivia. Further data analysis will be required for comparison of soil laboratory analysis to local knowledge. Graduate student Mary Harman has completed one year of coursework and fieldwork in the Philippines. Her thesis focuses on using a mixed-method approach to studying gendered knowledge, access to resources, and agricultural practices in relation to conservation agriculture in the Philippines. She has begun her second year of coursework and data analysis.

Graduate student Daniel Sumner was recruited by and is partially funded by SANREM, with the university supporting his tuition and fees with a portion of his salary being paid by another

project. He will be working on a master's degree in geography and will focus on the tillage component of conservation agriculture in Cambodia drawing on cultural ecology and masculinities theory to consider changing gender roles and perceptions. He began coursework in August and is preparing to work in Cambodia with LTRA-12 in FY 2013. He has already met with the team at NC A & T, began background reading on the site, and drafted a short survey instrument to gauge gender roles in tillage in all SANREM LTRAs.

Undergraduate student Sara Diaz carried out an Undergraduate Research for credit in Geography on the Andes, gender, and potatoes. Her research contributed to the case-study in Bolivia and to a professional presentation.

Nondegree training activities consisted of a qualitative methods workshop in February 2012 in the Philippines for ICRAF staff to prepare them for Gender CCRA research. In addition, a geospatial techniques training was conducted with the ICRAF staff in the Philippines during August 2012 to train them on how to use hand-held GPS units and open-source GIS software. These trainings will help host country partners further explore conservation agriculture using both qualitative and quantitative methods in their efforts to implement CAPS in the Philippines.

Publications, presentations, and other SANREM CRSP products

SANREM received much attention through the Virginia Tech website this year. There was a Spotlight on Virginia Tech's home page of SANREM graduate student, Keri Agriesti, during the month of February, including an article and photos from her field work. It is titled, "Graduate student researches gender roles in the Bolivian Andes" and can be accessed at: http://m.vt.edu/spotlight/impact/2012-01-09-bolivia/gender-roles.html. There was a feature of SANREM graduate student, Mary Harman during the month of July on the Outreach and International Affairs website. It is titled, "Mary Harman: Putting gender studies on the map." This story may be accessed at: http://www.outreach.vt.edu/Story.aspx?StoryID=634
In addition, seven posters and papers were presented at professional conferences and Virginia Tech's Women and Gender in International Development (WGD) Discussion Series.

Networking activities

The Gender CCRA raised awareness of the importance of women's work in agriculture in the research community and in the Philippine research team, ICRAF.

Farmers in Bolivia were provided with the results of their soil analysis. In the Philippines, devolution of research data including soil analysis results and recommendations is planned for the coming fiscal year.

The SANREM CCRA organized and obtained leveraged funds for bringing two outside speakers to Virginia Tech for presentations attended by the SANREM ME and students and faculty from several departments. Dr. Antoinette WinklerPrins was a visiting scholar in January (2012) and gave a talk addressing soils and gender titled, "Urban Homegardens in the Rainforest: Women and the Circulation of Plants in an Amazon City." She was funded by OIRED/SANREM, the Geography department at VT, and the Women and Minority Artists and

Scholars Lecture Series (WMASLS). Dr. Dianne Rocheleau was a visiting scholar in March for a special Women's Month event. She gave a talk titled, "Gender, Environment, and Development: Toward a World in which Many Worlds are Possible." She was funded by OIRED/SANREM, the Geography department at VT, WMASLS, and Women's and Gender Studies.

Highlights

Preliminary findings from the FGD in the Philippines indicate that men describe soil quality based on physical properties while women describe soil based on use. This is possibly correlated with gendered practices where men are responsible for land preparation while women mainly plant, weed, and prepare the product for sale or consumption.
This research is a novel approach combining qualitative and geospatial methods to explore gendered concepts in conservation agriculture.

Initial analysis indicates that men and women both relate to soil quality through plant growth, but men generally designated large crops as either best or worst while women focused on smaller crops. While they have local names for their crops and grasses, they said they did not have names for soils. They have only classified their soils based on color, fertility, and quality (good or bad) and used many descriptors, but not names per se. In addition, both men and women farmers were aware of and concerned about the changes in soil quality in their community.

Technology Networks

Principal Investigator: Keith Moore

Research progress by objective

Objective 1: Identify the knowledge and attitudes (technological frames) concerning agricultural production practices held by actors in the network

Critical research accomplishments

Preliminary analyses of the Kenya and Uganda data indicated that there were no consistent patterns of correlation among the responses with respect to Conservation Agriculture (CA). Respondents saw each of the three principles of CA as independent concepts, indicating that a conservation agriculture technological frame is not-fully formed amongst survey respondents. However, there does appear to be a weak set of correlations for these indicators within the Lesotho data where CA introduction is more advanced. The following section summarizes these findings for Kenya and Uganda. The analyses of the Lesotho data set are not yet complete.

Factor analysis has been used to identify underlying perspectives on agricultural production held by farmers and service providers in research communities. In the Kenya and Uganda sites, items for the Conventional and Risk Averse Agriculture technological frames were found to provide more coherence when analyzed together as evidence that they were often seen as interrelated, albeit sometimes opposed, perspectives as formulated in day-to-day discourse.

Using varimax rotation, two underlying dimensions were identified and extracted. These two dimensions of agricultural production norms and practices cut across the four localities, linguistic/cultural differences, and various roles in agricultural production. The first factor can be described as characterizing conventional modern farming using purchased inputs. It can be formulated in this way – "successful farming requires the use of modern chemical inputs and machinery."After accounting for the dimension of conventional chemical based farming, the second factor accounts for co-variation associated with traditional mixed farming food security systems. It can be summarized as indicating that "cash cropping should contribute to livestock and poultry production."

The analysis of the difference in mean values for the two factors for general agricultural production norms and practices indicates that size of farm and contact with extension agents have little impact on these technological perspectives of farmers. However, the analysis does demonstrate a significant difference between the perspectives of farmers and those of service sector/community agents. Service sector/community agents are more likely than farmers to agree that successful farming requires the use of modern chemical inputs and machinery (Table 50). Whereas these agents are less likely than farmers to believe that cash cropping should be integrated with livestock and poultry production (Table 51). Size of farm has a weak negative effect although significant correlation (at the .05 level) with the mixed farming factor, suggesting small farmers may be more comfortable with this traditional practice. Modern chemical-based farming is not correlated with farm size.

These findings indicate that there is a fundamental gap between the perspectives of farmers and those of the service sector/community leaders with respect to agricultural production norms and practices across the four sites. The general pattern remains when these data are analyzed within each community, although statistically significant differences are rare, and only in Kenya (modern chemical-based farming in Bungoma at P = 0.01, and mixed farming in Kitale at P = 0.05).

Table 50. Mean scores for Kenyan and Ugandan farmers and service sector/community agents level of agreement on basic farming approaches

	Small farmers	Large farmers	Service sector/ community agents
Conventional modern farming *	6.85 [a]	7.02 [a]	7.57 [b]
Mixed crop-livestock farming *	4.44 [a]	4.54 [a]	3.96 [b]
N	137	207	74

Notes: Values followed by different letters within the same row are statistically different.
Rows marked by * signify that T-test scores are significantly different at p =0.05.
Higher composite scores signify greater levels of agreement with the technological frame concept indicated by the factor.

Turning to CA, indicators we find that crop rotations are perceived by nearly all agricultural sector actors (farmers, service sector and community agents) as a best practice. There is a shared consensus on the importance of crop rotations in all four study communities. On the other hand, the perspectives on permanent vegetative soil cover are polarized. Respondents were asked whether they agreed or disagreed with the statement that "One should maintain a permanent crop cover". Seventy-three percent of the service sector/community actors agreed, while over a third of farmers (more often the larger ones) disagreed; and another third were uncertain. There is clearly a major disagreement between farmers and their advisors over the issue of maintaining crop cover. The third principle of CA appears to be the most controversial issue with respect to agricultural knowledge, norms and practices. There is much substantial disagreement over whether "Tillage causes land degradation" and much less uncertainty than for the soil cover indicator. These disagreements, however, appear to be within categories of actors, rather than between them. In this case, the agricultural service sector/community agents are less in agreement than with the other two CA propositions. In contrast, many more farmers are in agreement than was the case for maintaining soil cover (from nearly 40 to 50 percent). However, the distributions are such that there is no statistical difference in mean values, either across localities or within any particular one. The investigation of the distribution of these technological frame perspectives on conservation agriculture is more instructive at the local level where scientific and local knowledge meet the ecology and production systems. Each locality has its agro-ecological specificity. This specificity has an impact on the development of relevant local knowledge for farming and how each farming population integrates (often scientifically or commercially based) knowledge and practices coming from elsewhere. To introduce new concepts or practices to a specific locality requires taking these factors into account.

Let's look again at these indicators of agricultural production knowledge and practice from this perspective. Adherence to the perspective that successful farming requires the use of modern chemical inputs and machinery increases from Kapchorwa, Kitale, and Bungoma (in that order) to Tororo where it achieves its highest level. Interestingly, the greatest disparity is found between the frontier environment of Kapchorwa and the older industrial/rail center of Tororo and appears consistent with their histories. With respect to systems integrating cash cropping with livestock and poultry production, these two localities are likewise distinguished, as are Bungoma and Kitale. Tororo and Bungoma are less likely to advocate for the integration of cash cropping with livestock and poultry production than Kapchorwa and Kitale. This is also consistent with local cultures and histories, as the people of both Kapchorwa and Kitale have a stronger pastoral tradition. In Kapchorwa, integration of cattle and crop systems facilitates production as the slope and terrain in much of the area is ill suited to tillage by tractors.

Table 51. Mean scores for Kenyan and Ugandan farm and non-farm actors level of agreement on basic farming approaches by locality

	Uganda		Kenya	
	Tororo	Kapchorwa	Bungoma	Kitale
Conventional modern farming *	7.74 [a]	6.53 [b]	7.17 [c]	6.84 [bc]
Mixed crop-livestock farming **	5.07 [a]	6.00 [b]	5.09 [a]	6.07 [b]
N	108	116	94	100

Notes: Values followed by different letters within the same row are statistically different. In rows marked by * all T-Test scores are significantly different at P =0.05. In rows marked by **, all T-test scores are significantly different at P = 0.01. Higher composite scores signify greater levels of agreement with the technological frame concept indicated by the factor.

Table 52. Percentage of respondents by locality according to their level of agreement or disagreement with the statement that:

One should maintain a permanent crop cover	Agree	Uncertain/ neutral	Disagree	Mean values
Tororo (n=108)	33.3	40.7	25.9	3.08 [a]
Kapchorwa (n=116)	27.6	39.7	32.8	2.99 [a]
Bungoma (n=94)	24.5	25.5	50.0	2.82 [a]
Kitale (n=100)	51.0	21.0	28.0	3.50 [b]
N	142	135	141	

Notes: Chi-square = 32.385 significant at P = 0.0l.
T-test for differences in means significant at P = 0.05 for Tororo-Kitale comparison; at P = 0.01 for Kapchorwa-Kitale; and at P = 0.001 for Bungoma-Kitale.

Let's consider the similarities and differences between these localities for the two controversial CA items we have been analyzing above. With respect to whether "one should maintain a permanent crop cover," Kitale stands out with a majority in agreement with the statement and the highest mean value. In contrast, half of the Bungoma agricultural sector actors disagree with the statement. This is consistent with a concern expressed by several non-farm agricultural agents and farmers that the climate in Bungoma is too dry to produce cover crops in addition to food crops or to harvest enough biomass to provide adequate ground cover. People in Tororo and Kapchorwa are significantly more neutral on the issue, signifying that the use of cover crops may simply be an unfamiliar production method in these areas.

As for whether "tillage causes land degradation," Kapchorwa stands out as the strongest supporter of that perspective with a strong majority agreeing and the highest mean value. Likewise, reports during focus groups and qualitative interviews with service sector providers in Kapchorwa indicate that reducing soil erosion is a major concern for these farmers. A majority of respondents from Kitale and a plurality from Tororo also agree with the statement. However, both of these localities have significant minorities who disagree. Bungoma is most uncertain on the issue.

Table 53. Percentage of respondents by locality according to their level of agreement or disagreement with the statement that:

Tillage causes land degradation	Agree	Uncertain/ neutral	Disagree	Mean
Tororo (n=108)	41.7	26.9	31.5	3.13 [a]
Kapchorwa (n=116)	58.6	27.6	13.8	3.72 [b]
Bungoma (n=94)	31.9	38.3	29.8	3.06 [a]
Kitale (n=100)	52.0	12.0	36.0	3.35 [a]
n	195	109	114	

Notes: Chi-square = 33.676 significant at P = 0.01.
T-test for differences in means significant at P = 0.001 for Kapchorwa-Bungoma and Tororo-Kapchorwa comparisons; and at P = 0.05 for Kapchorwa-Kitale.

Development Impacts

We have learned about how agro-ecological zones shape the knowledge and perceptions of farmers. Non-farm agents are less likely to adapt scientific knowledge to local conditions. CA knowledge needs to be adapted to each zone to be more effectively communicated with farmers. Non-farm agents should carefully listen to the priorities and concerns of farmers in each agro-ecological zone to better promote appropriate CAPS.

We have also found that network research has important benefits to improving participatory research processes. Network research processes verify and expand the network of individuals included in local research and technology development activities. Hosting feedback sessions for research communities is an important opportunity to bring together local actors, discuss underlying drivers of local beliefs about agricultural production, and identify remaining challenges to the promotion of CAPS technologies.

Challenges and Responses

We are advancing our analysis of Lesotho data, although data validation has slowed this work. We still have to complete data collection in Haiti. Research on the Mali database has been delayed as no work can be conducted with our Malian partners. Nevertheless, we are preparing to analyze the existing database.

Objective 2: Quantify and describe structure and resource flows of agricultural sector networks.

Analyzing the composition and structure of agricultural production networks across the Kenya and Uganda communities is a multi-step process. First, we were interested in describing the general involvement of farmers in agricultural production networks across the sites and which members of the network were the most important to farmers as sources of agricultural information and resources. Second, to conduct the network analysis, the data collected regarding farmer contacts with agricultural service sector/community agents during the household survey was matched up to the data from service sector/community agents. While the network surveys collected data regarding resources and information/knowledge exchange, the

focus for analyzing network structure in the working paper is on knowledge and information exchange as the more inclusive network.

Farmers in Tororo report the fewest network contacts of any of the sites (2.8), and generally farmers in Kenya report significantly more contacts for agricultural resources than farmers in Uganda. In the higher potential areas of Kapchorwa (7.1) and Kitale (7.5), farmers report significantly more contacts for agricultural information than agricultural resources. This means that farmers in Tororo are exposed to far fewer sources of information than the farmers in the other three sites. Indeed, increasing activity in farmer networks through outreach programs will likely be a key initial step for stimulating innovation in agricultural networks in Tororo.

Table 54. Farmer information and resource contacts across sites

Location	Average Information Contacts	Average Resource Contacts	Range of Information Contacts	Range of Resource Contacts
Tororo (n= 93)	2.76[a]	2.84[a]	0-9	0-9
Kapchorwa (n= 97)	7.12[a]	3.65[b]	0-17	0-10
Bungoma (n= 75)	7.33[a]	7.39[a]	0-15	0-17
Kitale (n= 79)	7.51[a]	5.72[b]	0-18	0-11
All sites (n = 344)	6.07[a]	4.72[b]	0-18	0-17

Note: Values followed by different letters in the same row are significantly different from each other at the .01 level

The next step in the analysis was to identify the most important/influential individuals in the network. Measures of such power and influence in network analyses are typically described as measures of centrality. For our analysis, two measures of centrality were deemed especially important: degree centrality and betweenness centrality. Degree centrality is simply a measure of the number of connections between a given actor and other actors in the network and is measured as a count of the number of contacts for any given actor based upon their self-report and the report of others being in contact with that particular actor. Betweenness centrality reflects the extent to which an individual can facilitate or limit communication between other nodes in a network.

For the communities in Kenya, the findings demonstrate that extension takes a lead role as a central actor accompanied by the microfinance institutions in Kitale. Because of the higher potential of the region, it appears that extension agents have a more important role in the network. Overall, however, the agricultural production network of Kitale appears to have a wide range of different agents, but often organized in a variety of organizations. In contrast, in Bungoma, there appears to be a break between the two most central actors and a number of non-farm agents. Both the farm organization leader and the chief are highly connected and serve a key gatekeeper function in facilitating communication between other agents in the network. The local veterinarian and youth leader play a secondary role, followed by the pastor, market vendor, and extension agent.

Table 55. Most influential actors by site according to degree centrality

Rank	Tororo	Score	Kapchorwa	Score	Bungoma	Score	Kitale	Score
1	Farm Organization Leader	20	NAADS Coordinator (Extension)	20	Farm Organization Leader	20	Ministry of Agriculture (Extension)	20
2	Government Parastatal	19	Chief	20	Chief	19	Microfinance Institutions	20
3	Urban Agrovet	19	Counselors	19	Local Vet** Pastor** Market Vendor** Extension**	18	Stakeholder Forum	20
4	Local Agrovet	19	Local Agrovet* Women's Group Leader*	18			NGO	17

Note: * and ** indicate that the actors were tied for that rank.

In Uganda, actors in Tororo who have the most contacts also exercise the most control over the information flows between contacts. Clearly, the local farm organization leader, the governmental parastatal Tororo Datic, and agrovet suppliers are the most central actors in transmitting agricultural information and knowledge within the agricultural production network in Tororo. These actors represent key individuals to be engaged in efforts to promote knowledge of conservation agriculture production and practices. In Kapchorwa, the actors who have the most contacts do not necessarily exercise the most control over the information flows between contacts. The chief, NAADS coordinator, women's group leader, and local agrovets appear in the top four scores for both measures. These actors represent key individuals to be engaged in efforts to promote knowledge of conservation agriculture production and practices.

Table 56. Most influential actors by site according to betweenness centrality

Rank	Tororo	Score	Kapchorwa	Score	Bungoma	Score	Kitale	Score
1	Farm Organization Leader	20.42	Local Agrovet	28.25	Farm Organization Leader	26.87	Ministry of Agriculture (extension)	20.87
2	Government Parastatal	19.84	Women's Group Leader	16.93	Chief	24.44	Microfinance Institutions	20.05
3	Urban Agrovet	15.09	Chief	14.10	Local Vet	13.33	Stakeholder Forum	17.29
4	Local Agrovet	14.39	NAADS Coordinator	14.15	Youth Leader	11.76	NGO	11.23

Development impacts

These findings suggest two lessons for directing CA messages. The first is that not all communities have extensive agricultural production networks that can be relied upon to disseminate and digest new knowledge for the promotion of innovations. Sometimes those networks need to be expanded or substantially reinforced in order to ensure farmers and agents access to the resources and information they need to implement CAPS. In a specific case, it was recommended that the network be expanded to involve the Uganda National Agro-Dealers Association in order for farmers and service providers to access training on how to identify counterfeit agrochemicals and thus feel more secure about using herbicides as a component of CA. Second, the critically influential actors are not the same across all communities and influential actors are not all regarded with the same degrees of trust. While agrovets are highly trusted in Tororo and members of the agricultural network nearly universally believe that contact with agrovets should be increased, in Kitale they are less trusted because their motivation to make a profit may cause them to mislead farmers. Network analysis is therefore important to identify the most influential actors in each community and feedback sessions contribute to improved understanding of local qualitative perceptions of these actors.

Challenges and responses

We are advancing our analysis of Lesotho data, but are still in the process of validating the analyses. We still have to complete data collection in Haiti. Research on the Mali database has been slow as no work can be conducted with our Malian partners. Nevertheless, we can prepare an analysis of the existing database.

Objective 3: Determining critical network pathways and opinion leaders facilitating technological change.among farmers and their service sector partners

The feedback sessions in Kenya and Uganda provided valuable insights into how each community could move forward with facilitating technological change among farmers and their supporting service sectors. Research Associate Jennifer Lamb facilitated the Technology Network Discussions. The first section of the network presentation highlighted the importance of involving various members of the agricultural production network in the promotion of conservation agriculture. Then the most frequently farmer-cited contacts to obtain agricultural resources (seeds, fertilizer, agrochemicals, plowing services, veterinary services, loans/financing, etc.) and information were introduced. Following this, the presentation introduced the network map, and measures for identifying the centrality of particular agents. Next, graphs of the distribution of beliefs between small farmers, large farmers, and service providers were presented and impacts of extension contact on farmer knowledge and beliefs discussed. Finally, the network maps which bring together network structure and existing beliefs about agricultural production were presented and discussed for the ideas of "tillage causes land degradation" and "maintaining a permanent soil cover" (see Figure 39 for example). Throughout the workshop, participants were encouraged to provide feedback and ask questions about the results presented. In this section, reflections on the local workshops in each of the sites are provided interspersed with the network maps as presented in each workshop.

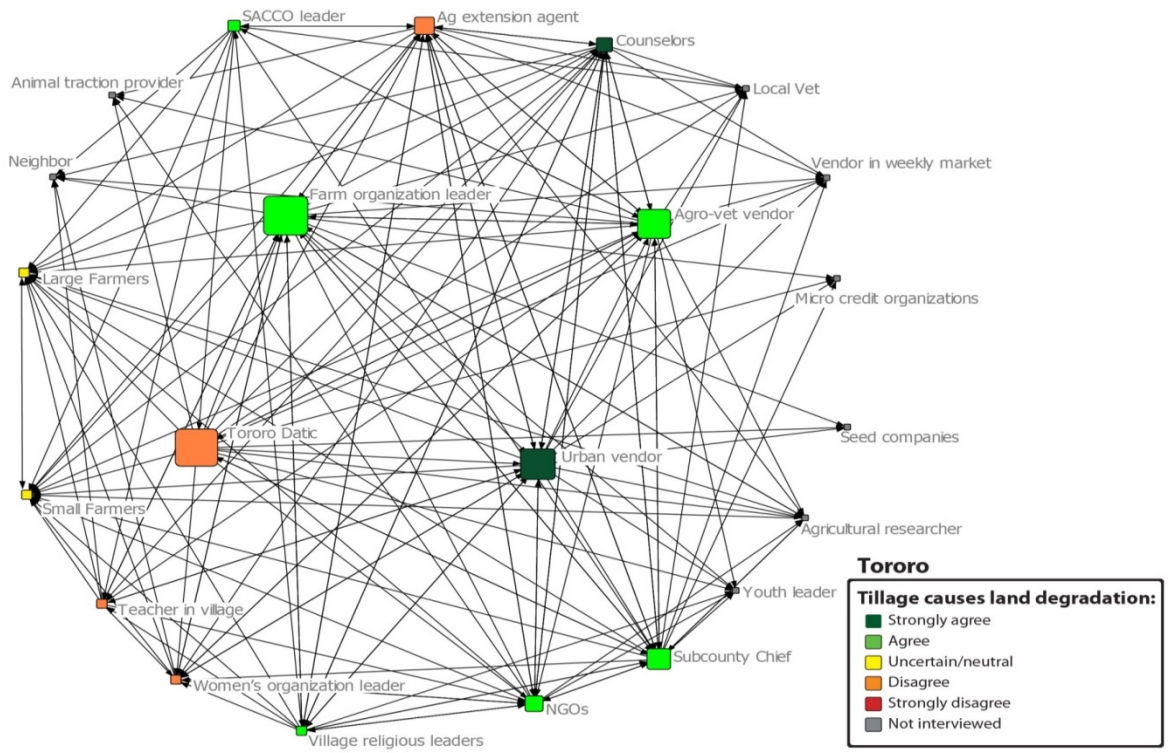


Figure 39. Network map highlighting betweenness centralities and position on whether tillage causes land degradation inTororo, Uganda

Development Impacts

Sharing findings and exploring network relationships with local farmers and their supporting agricultural and community agents improves problem solving and innovation capacities of local actors. In feedback workshops, understanding the structure and dynamics of resource flows in networks provided incentive to change local development activities. For example, in Kitale, Kenya, the primary role of agricultural vendors as information providers inspired farmer group leaders to increase their commitment to expanding outreach so as to ensure that farmers access high-quality information. In Tororo, the role of agrovets as information providers was seen in a more positive light as a venue in which posters should be located so that agrovets have an opportunity to educate local farmers about CA when they purchase agricultural products.

Challenges and Responses

We are advancing our analysis of Lesotho data, but are still in the process of validating the analyses. We still have to complete data collection in Haiti. Research on the Mali database has been slow as no work can be conducted with our Malian partners. Nevertheless, we can prepare an analysis of the existing database.

Degree and Nondegree training activities

The feedback sessions in Kenya and Uganda involved four workshops with local partners (service sector and community agents as well as farmer leaders). Fifty-four men and 30 women participated in these sessions during early February 2012.

Masters student, Jennifer Lamb completed her thesis and degree in Agricultural and Applied Economics. Three undergraduate students have been employed part-time to manage the SANREM Knowledge Base, assist in literature reviews, and conduct social network analyses.

Publications, presentations and other SANREM CRSP products

Two working papers have been drafted documenting the Technology Networks research findings for the LTRA-9 sites in Lesotho and one working paper for the LTRA-10 sites in Kenya and Uganda; four community-targeted presentations and corresponding extension brochures developed and distributed during the LTRA-10 workshops in February; and two papers were presented at meetings this summer (Rural Sociological Society and World Congress of Rural Sociology) and are being revised and submitted for journal publication.

Networking activities

Network feedback workshops were held in the four communities of Kenya and Uganda. These events were based on the working paper documenting the research findings and summarized in the four extension brochures for each community. These analyses and workshop provided the foundation for the papers presented at the Rural Sociological Society Annual Meeting and World Congress of Rural Sociology. Substantial interest was generated in our approach and our findings.

A new collaboration has been initiated with the Network Dynamics and Simulation Science Laboratory (NDSSL) of the Virginia Bioinformatics Institute (VBI). The Technology Networks CCRA and NDSSL are sharing an undergraduate research assistant who is adapting the Kenya and Uganda data set for social network simulation analyses.
Keith Moore participated in the Sustainable Intensification of Cereal-based Farming Systems in East and Southern Africa: Project Inception Workshop in Dar es Salaam, Tanzania on 6-9 February 2012. The project is being led by IITA and involved both national and international stakeholders from across east and southern Africa.
Jeni Lamb participated in a leadership development conference, the FrED Forum, in Boston, Mass., and explored how leadership studies may be incorporated to promote local network activity for the promotion of CA.

Highlights

- Completion of MS thesis on relationship between social networks and food security
- Four feedback workshops in Kenya and Uganda with LTRA-10
- Collaboration with the VBI to develop network simulation analyses
- Production of two working papers
- Two journal publications submitted

Soil Carbon and Soil Quality CCRA

Principal Investigator: Michael Mulvaney

Research progress by objective

The overarching goal of this CCRA is to determine if dryland smallholders in the developing world can increase soil organic carbon (SOC), and hence soil fertility, by adoption of conservation agriculture (CA). We know that CA increases SOC under mechanized agriculture in the developed world, but it is unclear if such increases are feasible in the developing world for smallholders growing staple crops. There is also an interest to determine the potential for carbon sequestration in these systems, which may potentially lead to payments under carbon trading schemes.

Coordination and standardization of soil and agronomic investigations among all 13 developing countries before and after CAPS are implemented is critical to measuring soil fertility and carbon sequestration changes due to CAPS.
Our specific objectives are to:

1. Quantify SOC in host country project sites before and after CAPS implementation.
2. Identify CAPS cropping systems or biophysical elements that improve soil fertility.
3. Relate increased soil fertility to site-specific socioeconomic environments.

We also facilitate LTRAs and host-country partners to build capacity regarding biophysical data collection from CA plots vs. current practice controls in order to determine effects on production and the ability to produce sufficient biomass to protect the soil and increase SOC.

The hypothesis of this CCRA is that CAPS in developing countries will increase SOC and soil fertility in <5 years after implementation, compared to conventional practices. We propose to use SOC as an indicator of soil quality and fertility. Although total SOC is expected to increase slowly after CAPS implementation, we will focus on parameters that are sensitive to short-term (< 5 years) changes in agricultural practices by quantifying SOC by density fractions and structural changes at Time 0 and after several years of CAPS. Basic soil fertility parameters (total carbon (C) and nitrogen (N), available phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), pH, cation exchange capacity (CEC), etc.) will also be measured in order to provide an overall picture of soil fertility changes due to CAPS.

One of the main functions of this CCRA is to facilitate coordination among the crop and soil scientists throughout all the LTRA project areas in order to quantify SOC and soil quality. This includes, but is not limited to:

1. determination of a common minimum dataset to determine SOC baseline data before the implementation of CAPS,
2. building a soils library from host country project areas in order to perform further soil analyses that will quantify several indicators of soil quality under one laboratory,
3. identify elements that improve soil fertility in project areas, and

4. relate increased soil fertility to site-specific socioeconomic and agro-climatological environments.

This work necessitates close collaboration with project principal investigators (PIs) and socioeconomic CCRA activities. We are identifying local gendered knowledge of soil fertility as well as determining the capacity of local CAPS to improve SOC. If the latter holds true, we will also determine the potential for payments under a carbon (C) trading system in coordination with LTRA and CCRA economists.

Objective 1: Quantify SOC fractions in host country project areas before CAPS implementation.

Critical research accomplishments

- We currently have Time 0 soil samples from sites in Haiti, Lesotho, Bolivia, Ecuador, Philippines, and Cambodia. Most of these samples have been analyzed for total SOC and N as well as plant available nutrients. Those from Haiti and Lesotho have arrived recently and will be analyzed this coming year.

- Sequential density fractionation (<1.8, 1.8-2.0, and >2.0 g cm^{-3}) has been accomplished on most Time 0 soil samples in our global library (Table 57). The fractionation procedure will be repeated on samples obtained after several years of CAPS, and used to determine changes in SOC due to CA.

- Two research proposals were submitted and accepted to obtain beamtime at the Near Edge X-ray Absorption Fine Structure (NEXAFS) synchrotron in Madison, WI. The two trips enabled us to quantify the chemical structure of the SOC at time 0 from fractionated SOC samples from Ecuador and Bolivia. These data will be used to determine the C speciation changes due to CA. The structure of C determines, in part, its chemical stability, and hence longevity, in soil. The other factor influencing C longevity is SOC association with clay minerals (physical protection), which may also be investigated using NEXAFS. If we are interested in the C sequestration potential of CAPS, we must understand the mechanisms of C sequestration and determine its ability to resist mineralization. We may also be able to estimate the mean residence time of SOC from fractionated Time 0 samples, if we can attract additional funding.

- Laboratory capacity was expanded in Corporant, Haiti by assisting in the construction of a deionized water system required for in-country determination of soil fertility.

Table 57. Samples received and analyses completed as of Sept. 2012

	Bolivia	Ecuador	Philippines	Cambodia	Kenya	Uganda	Lesotho	Bolivia Gender CCRA
Samples received	54	12	30	76	4	8	16	30
Analyses completed:								
Soil testing	54	12	30	76	4	8	16	30
CN	24	12	8	0	0	0	16	30
Density fractionation	24	12	7	0	0	0	0	N/A
NEXAFS	22	12	3	0	0	0	0	N/A
Bulk density	no	yes	no	yes	no	no	N/A	no

Development impact
A soils library from project research sites analyzed within a single laboratory will allow comparisons of soil quality at time zero before and after CAPS implementation. Time 0 samples will serve as a benchmark against which all future changes in soil fertility will be compared. This may also lay the foundation to allow those adopting CAPS in the developing world to earn C credits as part of a future C trading market.

Challenges and responses
Carbon sequestration rates. A global data analysis from 276 paired treatments indicated that an average of 0.57 ± 0.14 tons C/ ha yr was sequestered after changing from conventional tillage to no-till, except in wheat-fallow rotations where no change was found (West and Post, 2002). The study noted that an additional 0.20 ± 0.12 tons C/ ha yr can be sequestered by including rotations (except changing from continuous corn to a corn-soybean rotation, which resulted in non-significant treatment differences in SOC accumulation). In our CAPS systems, which employ both minimum tillage and crop rotations, we might therefore reasonably expect to sequester approximately 0.77 tons C/ ha yr, such that after three years we may accumulate approximately 2.3 tons C/ ha yr. However, the authors note that C sequestration rates reach a maximum in about 5-10 years after conversion from conventional agricultural practices, so after three years of our CAPS trials, we may reach C sequestration rates that are approaching their maxima, thereby increasing our chances of finding significant differences in SOC between treatments. After careful deliberation among the biophysical scientists, we are attempting to circumvent this potential problem by sampling soils at shallow depths. This will give us every chance to identify significant differences in C sequestration among experimental treatments, although the outcome is uncertain. Another potential criticism may be that we will not have benchmarks for SOC at deeper horizons, since there is some evidence that there are no SOC differences between no-till and plough-till when averaged at depth (Blanco-Canqui and Lal, 2008; Deen and Kataki, 2003). It should be noted that these studies were conducted in temperate climates. There is limited and conflicting evidence either way from tropical locations. Sisti et al. (2004) found that after 13 years in Southern Brazil, rotations that included hairy vetch (*Vicia villosa*) had significantly higher SOC concentrations to a depth of 100 cm. Diekow et al. (2005), working in Brazil at 30ºS, found similar results to 107.5 cm when legume rotations were included or when N fertilizer was applied, with an amazing C sequestration rate of 1.42 tons C ha yr in the whole 0-107.5 cm profile. Granted, these studies were conducted in an area with mild climate and year-round rainfall, which most of the SANREM locations do not enjoy. However, our locations are not in temperate regions, either. Therefore, the issue of C sequestration at depth at our project sites remains unknown. Ideally, we would like to have soil samples to 30 or 60 cm or even 100 cm. However, practical and financial constraints limit us to investigations of the surface horizons. We must leave it to the individual LTRA PIs to investigate at deeper depths if they are interested in such questions.

Incomplete dataset: While we anticipate receiving Time 0 soil samples from all the project sites, it is possible that LTRAs or their project partners will not be able to send us soil samples from their project sites and/or may collect the samples in an inappropriate manner. The CCRA-9 has

offered to pay for shipping costs associated with this objective. If needed, and if our budget allows, we will travel to the sites to collect these samples ourselves or assist the LTRAs in sample collection. In addition, we are dependent on the LTRA project partners to determine grain yield, above-ground biomass, and percent ground cover. It may be assumed that we will likely have an unbalanced dataset, in which case we intend to handle those data using appropriate non-parametric statistical methodology.

A GRA (Ph.D. student) was hired on May 16, 2011 but resigned effective Aug. 15, 2012. This presents a major setback in our ability to conduct research operations both on the ground (particularly in Haiti) and in the laboratory.

Objective 2: Identify cropping systems or biophysical elements of cropping systems that improve soil fertility and increase C sequestration.

Critical Research Accomplishments

Most projects have identified parameters that will be included in "best-bet" CAPS trials or already have full CAPS treatments in place. Data have been collected on cropping systems used in project areas for which we have Time 0 soil samples. These data will be geospatially cross-referenced to determine agro-ecological suitability of CAPS elements that may successfully be transferred to others parts of the world.

Development Impact

The identification of those cropping systems or elements of cropping systems that produce increases in productivity and soil fertility will allow researchers, extension agents, and producers to identify which of those elements apply to them, and correlate those elements to cultural practices that will improve fertility and productivity in their areas. This cross-site comparison will help participants using CAPS to select those elements that may apply to their agro-ecological zone, and thereby 'cross pollinate' successful CA technologies from one area of the world to another. This information is crucial to make practical recommendations to a wider audience.

Should host countries be compelled to participate in a carbon trading mechanism, the sequestration of soil carbon via CAPS may have economic ramifications for those countries. Currently, no trading mechanism exists where soil carbon is incorporated into economic models, but since soil carbon is the second greatest carbon sink on the planet, there is intense interest in developing such models.

Challenges and Responses

After CAPS on researcher-managed plots are tested and approved, the recommendations may be extended to farmer-managed fields. In some cases, on-farm trials have been implemented before researcher-managed trials. We will gather additional information from farmer-managed trials as they are implemented, as our budget allows, but we intend to concentrate our focus on researcher-managed trials. This objective requires the completion of Objective 1 in conjunction with a meta-analysis of the project locations, climate, and soil type.

Objective 3: Relate successful CAPS components to site-specific environmental conditions, including socioeconomic environments: What combinations of environmental conditions enable success of CAPS?

Critical research accomplishments

A complete dataset has been obtained for the determination of gendered knowledge of soil fertility in Bolivia, in collaboration with our in-country partners (Foundation for the Promotion and Research of Andean Products, PROINPA) and the Gender CCRA. Data analyses should be completed soon.

We currently have soil sampling teams collecting data in the Philippines to quantify gendered knowledge of soil fertility and relate that knowledge to gendered space in the Philippines, in collaboration with the Gender CCRA. We have assisted in building the capacity of the local partner there (International Center for Research on Agroforestry, ICRAF) to collect data on soil texture by providing the needed supplies and technical assistance. We also have geo-referenced data from the gendered survey. Soil samples from the survey are forthcoming.

Development impact

Knowledge of how gendered perceptions, beliefs, and knowledge as well as access to assets will improve understanding of soil management practices and how it may be effectively utilized for successful CAPS implementation at the field scale.

Challenges and responses
Knowledge of how gendered perceptions, beliefs, and knowledge as well as access to assets will improve understanding of soil management practices and how it may be effectively utilized for successful CAPS implementation at the field scale.

Degree and nondegree training activities

The Soil Quality CCRA PI served on the committee of one MS student, Ryan Stewart (male, U.S. citizen), who graduated in the past year from the Department of CSES at VT.

The Soil Quality CCRA PI serves on the graduate student committees of one PhD student, Nathan Kennedy (male, US citizen), at Virginia Tech within the Department of Forest Resources and Environmental Conservation under the direction of Gregory Amacher. Mr. Kennedy will investigate the potential for carbon payments for CAPS implementation in Haiti, among other projects.

A PhD student was hired on May 16, 2011, but resigned on Aug. 15, 2012. We are currently seeking another graduate student, probably a MS student.

Short-term training of in-country partners, students, and farmers includes 117 men and 90 women.

Publication, presentations, and other SANREM CRSP products

- Articles Published in Refereed Publications: 2 in review
- Theses and Dissertations: 1
- SANREM CRSP Annual Reports and Highlights: 1
- Conference Proceedings: 1 in press
- Papers/Seminars Presented: 1
- Magazine and Newspaper Articles: 2

Networking activities

1. The CCRA PI was invited to serve as the ASA Special Session Organizer for the session entitled "Conservation Agriculture for Improving Food Security and Livelihoods of Rural Smallholders in Rainfed Regions of Africa, Asia, Latin America and the Caribbean," to be held at the ASA-CSSA-SSSA International Annual Meetings on Oct. 22, 2012.
2. The CCRA PI continues to serve as the lead Editor of the Proceedings book to be published from the conference above, which necessitated many excellent networking opportunities with scientists and publishers from Southeast Asia.
3. Technical assistance was provided to the Haiti LTRA and their in-country partners at Zanmi Agrikol in Cange, Haiti for technical backstopping of the CA trials, conducting the CA workshops there, and outfitting the soils laboratory at the newly constructed school there.
4. Networking activities were also conducted at the ASA-CSSA-SSSA International Annual Meetings in San Antonio, TX.

5. Called a meeting of notable agronomists and soil scientists to discuss the need for common soil testing protocols in Haiti.

Highlights

- SOM fractionation of the Time 0 soil library from several LTRA project sites. These will be used to establish a common minimum dataset so that scientifically valid comparisons among project sites can be made.
- NEXAFS work has begun on the fractionated Time 0 soil samples to quantify C speciation of labile and recalcitrant SOM pools.
- Editing of a Proceedings book is complete and is now at the publisher.
- One graduate student (MS) graduated.
- Soil sampling is underway in the Philippines to determine gendered knowledge of soil fertility.
- A complete dataset is ready for analysis to determine gendered knowledge of soil fertility in Bolivia.

Associate Awards

Training of trainers for environmentally sound design and implementation of labor-based feeder road public works construction projects of the Productive Safety Net Program (PSNP)

At the request of USAID/ETHIOPIA, the Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program (SANREM CRSP) designed and implemented a training of trainers (ToT) program in labor-based road construction (LBRC) and related natural resources management to reduce environmental problems associated with the construction of Ethiopian Public Safety Net Program (PSNP) public works projects involving the construction and maintenance of rural feeder roads. The overall goal of the project was to improve the quality and sustainability of rural feeder roads constructed through the PSNP. Specific objectives of the project included: (1) develop a ToT curriculum on environmentally sound and sustainable rural feeder road construction and maintenance using a labor-based road construction (LBRC) approach; (2) implement the developed ToT curriculum on environmentally sound and sustainable rural feeder road construction and maintenance; and (3) assess and recommend improvements to the implemented ToT curriculum on environmentally sound and sustainable rural feeder road construction and maintenance.

The Training of Trainers for Environmentally Sound Design and Implementation of Labor-Based Feeder Road Public Works Construction Projects of the Productive Safety Net Program (PSNP) training program was held June 13-24, 2011 at the Ghion Ambassel Hotel in Dessie, Ethiopia. The training program consisted of 8 ½ days of classroom instruction and 2 ½ days of field demonstrations and exercises. Forty-one trainees participated in the two-week training program led by four civil engineering trainers with experience in LBRC and associated natural resource management and environmental issues. The training program was designed to train trainers who would then train woreda level trainers in the fundamentals of environmentally sound and sustainable LBRC and maintenance, who would in turn train woreda and kebele-level road construction supervisors to oversee the construction and maintenance of rural feeder roads constructed through the PSNP public works program. Trainees were trained in the technical aspects of LBRC and maintenance as well as learning and training theory and how to be effective trainers.

Learning modules on LBRC and maintenance learning were developed from the International Labour Organization's "Training modules on labour-based road construction and maintenance" (ILO, 1991). These training modules consist of videos as well as a written "Guide to the Training of Supervisors for Labour-Based Road Construction: Trainees Manual Parts 1 & 2" (ILO, 1981). Trainees were provided with an extensive "Labor-Based Road Construction (LBRC) eLibrary" containing the ILO LBRC videos, PowerPoint presentations used in this ToT program on all of the training module units, and public domain copies of 37 major publications (training manuals and handbooks) pertaining to rural road construction and maintenance.

An evaluation of the training program learning objectives at the conclusion of the training program found that all of the trainees made major gains in knowledge concerning LBRC and ToT techniques. Seventeen trainees rate the training program excellent, 14 rated it very good and one rated it good.

Appendixes

A. Training participants

Table 58. Long-term degree trainees

Student Name	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	LTRA	SANREM CRSP Advisor/PI	University(s) Degree Granting Institution First
Abigail Nguema	F	American	Agricultural Economics	Ecuador	N	Jun. 2010	Sep 2011	MS	Y	N	CCRA 6	Bertelsen	Virginia Tech
Albert Alwang	M	American	Economics	Ecuador	N	May 2011	July 2011	BS	N	N	7	Alwang, G. Norton, Bosch	Virginia Tech
Aliza Pradhan	F	Indian	Natural Resources /Environmental Management	US	N	Jan 2012	Sep 2014	PhD	Y	N	11	Idol	University of Hawaii-Manoa
Anna Testen	F	American	Plant Pathology	Bolivia Ecuador	N	Aug 2010	Dec 2012	MS	Y	Y	7	Backman	Penn State University
Annah Latane	F	American	Agricultural Economics & French	Ecuador	N	May 2011	July 2011	BS	N	Y	7	Alwang, G. Norton, Bosch	Virginia Tech
Arnulfo Portilla	M	Ecuadorian	Chemistry	Ecuador	N	Oct 2010	Dec 2011	Eng.	Y	N	7	Alvarado	INIAP (Ecuador)

Student Name	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	LTRA	SANREM CRSP Advisor/PI	University(s) Degree Granting Institution First
Bertrand Ricard	M	French	Agronomy	Cambodia	N	Apr 2010	Oct 2010	MS	N	Y	12	Chabierski, Boulakia, Penot	Institut Regions Chaudes (France)
Brinton Reed	M	American	Economics	USA	N	Sep 2011	Dec 2012	MS	Y	Y	11	Chan-Halbrendt	University of Hawaii-Manoa
Carl Yoder	M	American	Environmental Science	Lesotho & Mozambqe.	N	Aug 2011	Aug 2013	MS	Y	Y	9	Eash	University of Tennessee
Cecilia Turin Canchaya	F	Peruvian	Rural Sociology	USA	N	Aug 2007	Dec 2010	PhD	Y	Y	4	Gilles	Universidad Nacional Agraria La Molina (Peru) & Larenstein University (Holland)
Chhoeum Chankakada	M	Cambodian	Agronomy	Cambodia	N	Apr 2010	Oct 2010	MS	Y	N	12	Chabierski, Boulakia, Penot	Royal University of Agriculture (Cambodia)
Cynthia Lai	F	US Resident	Social Economics	India & Nepal	N	Sep 2009	Aug 2011	MS	Y	N	11	Chan-Halbrendt	University of Hawaii-Manoa

Student Name	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	LTRA	SANREM CRSP Advisor/PI	University(s) Degree Granting Institution First
David Moposita	M	Ecuadorian	Agronomy	Ecuador	N	Oct 2010	Dec 2011	Eng.	Y	N	7	Barrera	Instituto Nacional Autónomo de Investigaciones Agropecuarias
Don Immanuel Edralin	M	Filipino	Energy & Environmental Systems	Philippines	N	Aug 2011	May 2014	PhD	Y	Y	12	Reyes	North Carolina A&T State University
Emily Pfeufer	F	American	Plant Pathology	Bolivia & Ecuador	N	Aug 2010	Dec 2014	PhD	Y	Y	7	Gugino	Penn State University
Erine Thornburgh	F	American	Agronomy	USA	N	Summer 2011	Fall 2013	MS	Y	N	8	Prasad & Garrett	Kansas State University
Forrest Fleischmann	M	American	Public Policy	Global	N	Sep 2007	May 2012	PhD	Y	Y	1	Ostrom	Indiana University
George Mahama	M	Ghanaian	Agronomy	Ghana & USA	N	Spg. 2012	Spg. 2014	PhD	Y	N	8	Prasad & Staggenborg	Kansas State University
Hilary Kessler	F	American	Plant Pathology	Ecuador	N	Aug 2010	Dec 2014	PhD	Y	Y	7	Gugino & Backman	Penn State University

Student Name	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	LTRA	SANREM CRSP Advisor/PI	University(s) Degree Granting Institution First
Iddrisu Yahaya	M	Ghanaian	Agricultural Economics	Ghana & USA	N	Fall 2011	Spg. 2014	PhD	Y	N	8	Dalton & Prasad	Kansas State University
Isaac Chepkrui	M	Ugandan	Agricultural Economics	Uganda	N	Aug 2010	May 2012	MS	Y	N	10	Bashaasha	Makerere University (Uganda)
Jacqueline Marie Halbrendt	F	American	Horticulture	India & Nepal	N	Jan 2011	May 2014	PhD	Y	N	11	Idol & Evensen	University of Hawaii-Manoa
Jennifer Lamb	F	American	Agricultural Economics	Kenya & Uganda	N	May 2010	May 2012	MS	Y	N	CCRA 8	Moore	Virginia Tech
Jeremiah Okeyo	M	Kenyan	Soil Science	Kenya	N	Aug 2010	Jun 2014	PhD	Y	Y	10	J. Norton	University of Wyoming
Jess Martin	F	American	Crop & Soil Enviro. Sci - InternationaAgriculture	USA	N	Aug 2010	Aug 2011	BS	Y	N	CCRA 7	Christie	Virginia Tech
Jessica Boatwright	F	American	Agricultural Economics	Ecuador	N	May 2011	July 2011	BS	N	N	7	Alwang, G. Norton, Bosch	Virginia Tech
Jessica Schultz	F	American	Human Nutrition & Agricultural Sc.	Global	N	Apr 2011	Jul 2012	BS	N	N	ME	Moore	Virginia Tech

Student Name	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	LTRA	SANREM CRSP Advisor/PI	University(s) Degree Granting Institution First
Jocelyn Tabili	F	Filipina	Strategic Studies	Philippines	N	Jun 2011	Apr 2012	MS	Y	N	12	Dayo	University of Philippines Los Baños
Judith Odhiambo	F	Kenyan	Soil Science	Kenya & Uganda	N	Jan 2011	Dec 2014	PhD	Y	N	10	U. Norton	University of Wyoming
Jyotsna Krishnakumar	F	Indian	Socioeconomics	India & Nepal	N	Jan 2010	Oct 2010	MS	N	Y	11	Radovich	University of Hawaii-Manoa
Katherine DuBreuil	F	American	Agricultural Economics	Ecuador	N	May 2011	July 2011	BS	N	Y	7	Alwang, G. Norton, Bosch	Virginia Tech
Kathleen Weber	F	American	Soil Science	Ecuador	N	Aug 2010	Aug 2013	MS	Y	Y	7	Stehouwer	Penn State University
Keri Agriesti	F	American	Geography	USA & Bolivia	N	Aug 2010	May 2012	MS	Y	N	CCRA 7	Christie	Virginia Tech
Kim Bothi	F	Canadian	Sociology	Zambia	N	Aug 2005	Dec 2010	PhD	Y	Y	2	Buck & Travis	Cornell University
Lauren Moore	F	American	International Studies	Ecuador	N	May 2011	July 2011	BA	N	N	7, ME	Alwang, G. Norton, Bosch, Moore	Virginia Tech

Student Name	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	LTRA	SANREM CRSP Advisor/PI	University(s) Degree Granting Institution First
Linsey Shariq	F	American	Human Dimensions	India & Nepal	N	May 2011	May 2014	PhD	N	Y	11	Chan-Halbrendt & Gray	University of Hawaii-Manoa
Lyda Hok	M	Cambodian	Energy & Environmental Systems	Cambodia	N	Aug 2011	May 2014	PhD	Y	N	12	Reyes	North Carolina A&T State University
Mary Harman	F	American	Geography	USA & Philippines	N	Aug 2011	May 2013	MS	Y	N	CCRA 7	Christie	Virginia Tech
Matt Bruns	M	American	Soil Science	Lesotho	N	Jan 2010	Dec 2011	MS	Y	Y	9	Eash & Walker	University of Tennessee
Michael W. Graham	M	American	Soil science	Haiti	N	May 2011	Sep 2014	PhD	Y	N	CCRA 9	Mulvaney & Thomason	Virginia Tech
Moses Obbo Owori	M	Ugandan	Agricultural Economics	Uganda	N	Aug 2010	Jun 2012	MS	Y	N	10	Peck	University of Wyoming
Nadezda Amaya	F	Bolivian	Agricultural Economics	Bolivia	N	Aug 2010	Aug 2013	PhD	Y	Y	7	Alwang	Virginia Tech
Nathan Kennedy	M	American	Natural Resource Economics	Haiti	N	Mar 2010	May 2013	PhD	Y	N	6	Amacher	Virginia Tech

Student Name	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	LTRA	SANREM CRSP Advisor/PI	University(s) Degree Granting Institution First
Patrick Samba Oluka	M	Kenyan	Soil Science	Kenya & Uganda	N	Aug 2010	Jan 2013	MS	Y	N	10	Okalebo	Moi University (Kenya)
Patrick Ward	M	American	Agricultural Economics	Global	N	Jan 2009	Aug 2011	PhD	Y	Y	Policy	Shively	Purdue University
Paul Tarnate	M	Filipino	Land/Water Resource Engineering	Philippines	N	Nov 2006	Oct 2011	MS	Y	N	12	Ella	University of Philippines Los Baños
Pharnice Adikinye Ongonga	F	Kenyan	Soil Science	Kenya	N	Jan 2010	Jan 2013	MS	Y	N	10	Okalebo	Moi University (Kenya)
Rafael Padre	M	Filipino	Land/Water Resource Engineering	Philippines	N	Jun 2008	Apr 2012	PhD	Y	N	12	Ella	University of Philippines Los Baños
Robert Gaffney	M	American	Agricultural Economics	Ecuador	N	May 2011	July 2011	BS	N	N	7	Alwang, G. Norton, Bosch	Virginia Tech
Romina Manalo-Bondad	F	Filipina	Land/Water Resource Engineering	Philippines	N	Nov 2006	Oct 2011	MS	Y	N	12	Ella	University of Philippines Los Baños
Rosa Arévalo	F	Ecuadorian	Agronomy	Ecuador	N	Jan 2010	Sep 2011	Eng.	Y	N	7	Valverde	INIAP (Ecuador)

Student Name	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	LTRA	SANREM CRSP Advisor/PI	University(s) Degree Granting Institution First
Ryan Stewart	M	American	Crop & Soil Environmental Sciences	Haiti	N	Aug 2010	Sep 2012	MS	Y	N	6	Thomason	Virginia Tech
Tin Herawati	F	Indonesian	Family & Consumer Science	Indonesia	N	Aug 2008	May 2011	PhD	Y	Y	5	Trikoesoemaningtyas	Bogor Agricultural University (Indonesia)
Trevor Simmons	M	American	Crop and Soil Environmental Sciences	Ecuador	N	May 2011	July 2011	BS	N	N	7	Alwang, G. Norton, Bosch	Virginia Tech
Tyneth Ly	M	Cambodian	Agronomy	Cambodia	N	Mar 2011	Jul 2011	MS	Y	N	12	Chabierski & Boulakia	Hanoi University of Agriculture (Vietnam)
Wendy Jones	F	American	Soil Science	Lesotho	N	Jan 2010	Dec 2011	MS	Y	N	9	Eash & Walker	University of Tennessee

Table 59. Nondegree training activities

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Bolivia						
Field day	May 2012	Farmer group	6	3	PROINPA	Farmer participatory evaluation: minimum tillage planter prototypes
Short course	May 13 2012	Pablo Mamani Ana K Saavedra	1	1	International Potato Center	Evaluation of tolerance to abiotic factors
Short course	May 20 2012	Roberto Cayo	1		PROINPA	Quinua produccion and varieties
Short course	June 2012	Myra Claros		1	Penn State (Backman)	Endophytes and biological control of plant diseases
Field day	Feb 8 2012	Farmers in Waylla Pujru community	7	5	PROINPA	Evaluate farmer preferences for forage varieties
Field day	Feb 21 2012	Farmers in Waylla Pujru and Sancayani Alto communities	12	9	PROINPA	Evaluate farmer preferences for forage varieties
Ecuador						
Conference	Oct 20 2012	Professor and students of State University of Bolívar, and technicians	50	30	Penn State (Dr. Gallagher)	Learn conservation agriculture techniques and practices.
Workshop	Aug 11 2012	Farmers	4	2	INIAP	Learn irrigation and water management
Conference	Nov 28 2012	Professors and students of Cuenca Catholic University	88	40	INIAP (Víctor Barrera)	Analyze adaption of agriculture to climate change in the Andes.
Workshop	Dec 23 2012	Farmers of Culebrillas, and technicians.	8	4	INIAP (Moazir Célleri)	Analyze CA practices in potato-pasture systems

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	Jan 17-19 2012	Technicians	12	2	INIAP-CIP (Víctor Barrera)	Anlyze of agriculture to climate change in the Andes
Workshop	Jan 25 2012	Technicians and professors of State University of Bolívar	8	2	SANREM CRSP (Wills Flowers)	Learn about biological evaluation of soils.
Conference	Mar 6 2012	Professors and students of State University of Bolívar (Ecuador)	25	10	INIAP (Víctor Barrera)	Analyze adaption of agriculture to climate change in the Andes
Field visit	Jun 16 2012	Professor and students of Universidad Estatal de Bolívar.	14	8	INIAP (Moazir Célleri y Juan Arévalo)	Conservation agriculture
Field visit	Apr 7 2012	Students of Universidad Técnica de Ambato	13	7	INIAP (Aníbal Martínez)	Alternative crops
Field days	Nov 7 2012	Technicians, professors, students and farmers of Bolivar province.	240	80	INIAP (Luis Escudero, Rafael Parra, Franklin Valverde, Aníbal Martínez)	Conservation agriculture
Workshop	Aug 18 2012	Technicians, professors and farmers of Bolivar province.	8	4	INIAP (Moazir Célleri, Ruth Suárez y Maricruz Suárez)	Conservation agriculture
Ghana						
Workshop	25 - 26 Jul 2012	Farmers/extension agents/ NGOs	48	28	J.B. Naab, SARI, Wa, Ghana P.V.V. Prasad, KSU G. Mahama, KSU	Workshop to discuss and listen farmers experiences with CAPs
Field day	27 Sep 2012	Farmers/extension agents/ NGOs	53	22	J.B. Naab, SARI, Wa, Ghana	Field day to show farmers mother trials on minimum tillage and crop rotation effects

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Guatemala						
Workshop	12/22/2011	Farmers of Bola de Oro, technicians (Guatemala)	12	6	INIAP (Luis Escudero)	Learn about CA practices in maize-bean systems
Haiti						
Short course	10/12/2011	Farmers of Bois-Joly	50	50	Zanmi Agrikol agronomists	Obtain education on soil conservation methods
Short course	10/18/2011	Farmers of Bois-Joly	60	40	Zanmi Agrikol agronomists	Obtain education on soil conservation methods
Short course	10/30/2011	Farmers of Morne-Michel	55	45	Zanmi Agrikol agronomists	Obtain education on green manures in conservation agriculture
Short course	11/12/2011	Farmers of Bois-Joly	30	20	Zanmi Agrikol agronomists	Obtain education on green manures in conservation agriculture
Workshop	01/10/2012	Agronomists and technicians of Zanmi Agrikol at Corporant	4	1	Virginia Tech	Obtain training in establishment and planting of cover crop trials
Workshop	01/11/2012	Agronomists and technicians of Zanmi Agrikol at Lachateau	3	1	Virginia Tech	Obtain training in establishment and planting of cover crop trials
Workshop	01/12/2012	Agronomists of Caritas-Hinche at Maissade	2	0	Virginia Tech	Obtain training in establishment and planting of cover crop trials
Short course	01/12/2012	Smallholder farmers near Maissade experimental site	26	24	Virginia Tech Caritas-Hinche Agronomists	Learn key elements of conservation agriculture
Workshop	07/17/2012	Students at CFFL Agri-Technical School, farmers at Corporant	25	25	Virginia Tech, Zanmi Agrikol	Conservation Agriculture Methods: Demonstration and Application
Workshop	07/18/2012	Farmers and local community at Boucan Carre	34	33	Virginia Tech, Zanmi Agrikol	Conservation Agriculture Methods: Demonstration and application

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	20 Sep 2012	Farmers and local community at Boucan Carre	58	32	Virginia Tech, Zanmi Agrikol	Conservation Agriculture Methods: Demonstration and application
India						
Workshop	21 Dec 2011	Tentuli Village farmers	36	30	OUAT/University of Hawaii	Train on the management of harvest, post-harvest, and crop residues in CAPS; Focus group discussion on the first year of on-farm CAPS intervention
Workshop	24 Dec 2011	OUAT faculty and students, scientists, State govt. officials	220	80	OUAT/University of Hawaii	Present the findings of CAPS interventions for the first two years of the project; Collect feedback from local agricultural experts
Workshop	18 Jun 2011	OUAT professors and graduate students	13	14	University of Hawaii	Teach students and professors how to use the soil aggregate testing kit, so that they may be able to use it correctly for this project in the future.
Workshop	19 Jun 2011	Project partners and OUAT graduate students	10	2	University of Hawaii	To train graduate students about cognitive mapping and technology network survey.
Workshop	20-21 Jun12	Tentuli village farmers	32	30	University of Hawaii	To create a greater understanding of how farmers think about the elements most affecting farming decisions to improve planning and adoption of CAPS To explore social capitals among tribal farmers which can be used to promote sustainable farming system technologies i
Workshop	22 Jun12	Talachampei village farmers	10	4	OUAT/University of Hawaii	To introduce CAPS to new farmers

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Kenya						
Workshop	Nov 25 2011	Farmers/technical people	7	1	MHAC (NGO, Kenya)	Reflect on year one trial, elaborating CAPs, way forward
Workshop	14 Feb 2012	Agricultural service providers, community agents and farmers in Bungoma, Kenya	14	10	Virginia Tech	Report and discuss network research conducted in 2011
Workshop	16 Feb 2012	Agricultural service providers, community agents and farmers in Kitale, Kenya	11	5	Virginia Tech	Report and discuss network research conducted in 2011
Field day	Mar 14, 2012	MHAC students and staff	10	10	U. Wyoming; J. Norton, J. Norton Sr., U Norton	Operate and provide input on performance of MFI tillage implement; inform agricultural students about CA principles
Field day	Mar 15, 2012	Kitale Farmers	8	1	U. Wyoming; J. Norton, J. Norton Sr., U Norton	Operate and provide input on performance of MFI tillage implement; inform local farmers about CA principles
Lesotho						
Mentoring	Oct 1-9 2011	Farmers in Mpharane	18	13	Growing Nations Trust	Analyze conservation ag. systems in Lesotho. Explain the three principles of CA, management keys, field demonstrations
Mentoring	Oct 4-8 2011	Farmers in Liphiring	16	11	Growing Nations Trust	Analyze conservation ag. systems in Lesotho. Explain the three principles of CA, management keys, field demonstrations
Mentoring	Oct 4-8 2011	Farmers in Maphutseng	20	27	Growing Nations Trust	Analyze conservation ag. systems in Lesotho. Explain the three principles of CA management keys, field demonstrations

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Mentoring	Oct 4-8 2011	Farmers in Ha-Mootsinyane	20	24	Growing Nations Trust	Analyze conservation ag. systems in Lesotho. Explain the three principles of CA, management keys, field demonstrations
Workshop	Oct 11 2011	F.T.C, training of inmates	39	0	Growing Nations Trust	Analyze conservation ag. systems in Lesotho. Explain the three principles of CA, management keys, field demonstrations, field scale layout
Field day	Oct 31 2011	Farmers from Thabana-Morena	2	0	Growing Nations Trust	Analyze conservation ag. systems in Lesotho. Demo-farm visual display
Workshop	Oct 31 2011	Farmers	6	2	Growing Nations Trust	Learn CA principles, step by step procedures of applying CA, management keys
Workshop	Nov 9 2011	Extension officers from SA	8	5	Growing Nations Trust	Learn CA principles, step by step procedures of applying CA, management keys
Workshop	Nov 14-18 2011	Ministry of Forestry & Agriculture	6	13	Growing Nations Trust	Learn CAPS in Lesotho. Explain the three principles of CA, management keys, field demonstrations
Workshop	Nov16-18 2011	Mohale's Hoek Farmers	10	15	NUL	Learn CA in climate change adaptation
Workshop	Nov 17 2011	Extension officers (FORESTRY)	5	14	Growing Nations Trust	Learn CA principles, step by step procedures of applying CA, management keys
Workshop	Nov 17 2011	Extension officers (Ministry of Forestry)	5	14	Growing Nations Trust	Learn CA principles, step by step procedures of applying CA, management keys
Workshop	Nov 22,\ 2011	Farmers	10	0	Growing Nations Trust	CA principles, step by step procedures of applying CA, management keys

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	Nov 23-25 2011	Mafeteng farmers	10	10	NUL	Analyze CA in climate change adaptation
Workshop	Dec 6-9 2011	Thaba-Tseka farmers	15	9	NUL	Analyze CA in Climate Change Adaptation
Workshop	Jan 22, 2012	Mcc SwaLeSA service workers (Southern Africa)	20	3	Growing Nations Trust	Learn CA principles, step by step procedures of applying CA, management keys
Workshop	Feb 13 2012	Extension officers (F.A.O)	7	7	Growing Nations Trust	Learn CA principles, step by step procedures of applying CA, management keys
Workshop	Feb 24 2012	Farmers (THABA TSEKA) BFJ Group	6	4	Growing Nations Trust	Learn CA principles, step by step procedures of applying CA, management keys
Field day	Mar 2012	Khalo,Mootsinyane, Stanteng,Poqa (farmers)	5	6	Growing Nations Trust	Learn about weeding, cover crops, fertilizer trials, cover, stalk borer, problems of rabbits on beans
Seminar	Mar 2012	M/hoek Presibetry (Mohalinyane)	30	42	Growing Nations Trust	Learn about CA, weeding, cover crops
Field day	Mar 2012	Mpharane,Stanteng, Poqa and Mootsinyane farmers	11	13	Growing Nations Trust	Learn about cover crops, silage making
Workshop	Mar 13-14 2012	Members of the Conservation Agriculture Network,Lesotho	10	15	NUL	Prepare CA5-Year Strategic Plan
Workshop	Mar 15-16 2012	Lesotho College of Education Lecturers	5	7	NUL	Prepare for review of curricula on CA in the College of Agriculture
Field/ Farm visit	Apr 17 2012	Mohale's Hoek LEC	5	0	Growing Nations Trust	Field tour

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Field/Farm visit	Apr 17 2012	Serumula Dev. Assoc	3	0	Growing Nations Trust	Field tour
Workshop	Apr 2012	Mpharane Farmers	0	14	Growing Nations Trust	CA principles
Workshop	Apr 2012	SA Tour	13	17	Growing Nations Trust	Live-stock incorporation to crop production
Field/ Farm visit	May 5, 2012	WFP & Agric Extension	5	0	Growing Nations Trust	Field tour
Field/ Farm visit	May 14, 2012	DA Mohale's Hoek	2	3	Growing Nations Trust	Field tour
Workshop	May 2012	Mootsinyane, Stantenteng, Makilanyaneng, Maphutseng farmers	8	10	Growing Nations Trust	Cover crops, agric-business, mulching
Workshop	May 2012	Ministry of Forestry and Land reclamation	2	4	Growing Nations Trust	Inter-cropping
Workshop	Jun 2012	Poqa, Stanteng &Mpharane farmers	4	4	Growing Nations Trust	Importance of cover crops and legumes
Workshop	Jun 2012	Mootsinyane, Makilanyaneng, Ha Khalo & Ntabanyane farmers	4	9	Growing Nations Trust	Gross margins
Workshop	Jun 2012	Stanteng, Ha jobo & Ha Kantini farmers	5	6	Growing Nations Trust	Field scale lay-out, applying green cover crops

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	Jun 2012	Maphutsaneng and Morifi farmers	5	16	Growing Nations Trust	Cover crops
Field/Farm visit	Jul 17 2012	LEC members and volunteers	2	2	Growing Nations Trust	Field tour
Workshop	Jul 24-26 2012	Phamong farmers	5	4	Growing Nations Trust	CA principles, step by step procedures of applying CA, Management keys
Field/ Farm visit	Jul 27 2012	Makilanyaneng farmers	3	0	Growing Nations Trust	Field tour
Workshop	Aug 28-30 2012	Maphutsaneng farmers	4	11	Growing Nations Trust	CA principles, step by step procedures of applying CA, management keys
Workshop	Jul 2012	Masemouse, Mpharane, Maphutsaneng farmers	10	25	Growing Nations Trust	CA principles, timing in crop production
Workshop	Jul 2012	Mootsinyane and Ha kantini farmers	6	12	Growing Nations Trust	Gross margins, importance of mulch, plans for the next farming season
Farm visit	Aug 31 2012	Mapoteng farmers (Mount-Maloti Hospital)	7	6	Growing Nations Trust	CA farm tour
Mozambique						
Workshop	Oct 1 2011	Buzi Guara-Guara	44	53	CIMMYT	Planning meeting
Workshop	Oct 1 2011	Buzi Nhaufo	48	53	CIMMYT	Planning meeting
Workshop	Oct 2 2011	Nhamatanda Lamego	31	49	CIMMYT	CA principles
Short course	Oct 3 2011	Graduate student	1	0	University of Tennessee	Learn how to use SAS for survey analysis

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	Oct 3 2011	Angonia Gimo	38	25	CIMMYT	CA principles
Workshop	Oct 3 2012	Angonia Maguai	40	42	CIMMYT	CA principles
Workshop	Oct 12 2011	Angonia Ulongue	51	23	CIMMYT	Workshop
Workshop	Oct 15 2011	Farmers in Barue, Nhamazinga	17	24	CIMMYT	Demonstration design
Short Course	Oct 15 2012	Buzi Nhaufo	52	71	CIMMYT	CA principles
Workshop	Oct 20 2011	Buzi Guara-Guara	66	47	CIMMYT	CA principles
Workshop	Oct 20 2011	Nhamatanda Nharuchonga	47	30	CIMMYT	Planning meeting
Workshop	Oct 25 2011	Nhamatanda Nharuchonga	19	41	CIMMYT	Fertilization
Workshop	Oct 27 2011	Farmers in Barue, Malomwe	9	16	CIMMYT	Demonstration design
Workshop	Oct 30 2011	Gondola, Pumbuto	8	10	CIMMYT	Demonstration design
Workshop	Oct 31 2011	Angonia Nzewe	37	31	CIMMYT	Planning meeting
Workshop	Nov15 2011	Nhamatanda Lamego	15	23	CIMMYT	Pesticide handling
Workshop	Nov19 2011	Nhamatanda Lamego	18	21	CIMMYT	Seeding
Field day	Dec 9 2011	Nhamatanda Lamego	12	22	CIMMYT	CA principles
Workshop	Dec 15 2011	Nhamatanda Lamego	13	25	CIMMYT	Fertilization

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Field day	Dec 20 2011	Angonia Gimo	11	8	CIMMYT	CA principles
Field day	Dec 22 2011	Nhamatanda Lamego	15	30	CIMMYT	CA principles
Field day	Jan 5 2012	Buzi Nhaufo	43	56	CIMMYT	CA principles
Field day	Jan 8 2012	Angonia Nzewe	8	4	CIMMYT	CA principles
Field day	Jan 9 2012	Angonia Ulongue	8	4	CIMMYT	CA principles
Field day	Jan 11 2011	Buzi Guara-Guara	64	58	CIMMYT	CA principles
Field day	Jan 13 2012	Farmers in Barue, Nhamazinga	39	28	CIMMYT	CA principles
Field day	Jan 16 2012	Gondola, Pumbuto	12	4	CIMMYT	CA principles
Workshop	Jan 18 2012	Farmers in Barue, Malomwe	8	18	CIMMYT	CA principles
Field day	Jan 19 2012	Nhamatanda Nharuchonga	10	1	CIMMYT	CA principles
Short course	Jan 26 2012	Sussendenga Nhamatiquite	4	6	CIMMYT	Cover crops
Field day	Feb 2 2012	Buzi Nhaufo	82	69	CIMMYT	CA principles
Short course	Feb 4 2012	Farmers in Barue, Nhamazinga	30	59	CIMMYT	CA principles
Field day	Feb 4 2012	Buzi Guara-Guara	55	93	CIMMYT	CA principles
Field day	Feb 4 2012	Nhamatanda Nharuchonga	47	30	CIMMYT	CA principles
Workshop	Febr 5 2012	Buzi Nhaufo	42	57	CIMMYT	CA principles
Field day	Feb 9 2012	Angonia Gimo	36	26	CIMMYT	CA principles

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Field day	Feb 9 2012	Angonia Maguai	36	26	CIMMYT	CA principles
Field day	Feb 11 2012	Nhamatanda Lamego	4	12	CIMMYT	CA principles
Field day	Feb 13 2012	Angonia Nzewe	8	6	CIMMYT	CA principles
Field day	Feb13 2012	Angonia Ulongue	8	6	CIMMYT	CA principles
Field day	Feb 14 2012	Farmers in Barue, Malomwe	10	21	CIMMYT	CA principles
Field day	Feb16 2012	Nhamatanda Lamego	11	27	CIMMYT	CA principles
Field day	Feb 16 2012	Angonia Gimo	19	5	CIMMYT	CA principles
Field day	Feb 16 2012	Angonia Maguai	19	5	CIMMYT	CA principles
Field day	Feb 16 2012	Angonia Nzewe	19	5	CIMMYT	CA principles
Field day	Feb 16 2012	Angonia Ulongue	5	19	CIMMYT	CA principles
Field day	Febr 21 2012	Farmers in Barue, Nhamazinga	16	20	CIMMYT	CA principles
Field day	Feb 24 2012	Angonia Nzewe	3	0	CIMMYT	CA principles
Field day	Feb 25 2012	Buzi Guara-Guara	62	56	CIMMYT	CA principles
Field day	Feb 27 2012	Buzi Nhaufo	42	78	CIMMYT	CA principles
Field day	Mar 5 2012	Sussendenga Nhamatiquite	3	5	CIMMYT	CA principles
Field day	Mar 6 2012	Farmers in Barue, Nhamazinga	32	39	CIMMYT	CA principles

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Field day	Mar 7 2012	Angonia Gimo	11	23	CIMMYT	CA principles
Field day	Mar7 2012	Angonia Maguai	11	22	CIMMYT	CA principles
Short course	Mar 8 2012	Farmers in Barue, Malomwe	26	42	CIMMYT	CA principles
Workshop	Mar 9 2012	Farmers in Barue, Nhamazinga	25	28	CIMMYT	Demonstration design
Workshop	Mar 10 2012	Buzi Guara-Guara	35	67	CIMMYT	CA principles
Workshop	Mar 12 2012	Enumerator candidates	12	3	UT, CIMMYT and IIAM	Familiarize candidates with survey instrument, and finalize survey for field testing.
Workshop	Mar13 2012	Enumerator candidates	12	3	UT, CIMMYT and IIAM	Play roles in exercises conducted for and between trainees to enhance survey efficiency and hone local language vocabulary.
Field day	Mar14 2012	Enumerators	6	2	UT, CIMMYT and IIAM	Field testing of survey instrument
Field day	Mar 21 2012	Gondola, Pumbuto	7	6	CIMMYT	CA principles
Field day	Mar 23 2012	Nhamatanda Lamego	8	8	CIMMYT	CA principles
Field day	Mar 24 2012	Farmers in Barue, Malomwe	6	12	CIMMYT	CA principles
Field day	Mar 29 2012	Nhamatanda Lamego	13	27	CIMMYT	CA principles
Field day	Marc30 2012	Nhamatanda Nharuchonga	27	13	CIMMYT	CA principles
Field day	Apr 1 2012	Nhamatanda Nharuchonga	7	3	CIMMYT	CA principles
Field day	Apr 4 2012	Gondola, Pumbuto	45	30	CIMMYT	CA principles

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Field day	Apr 4 2012	Angonia Gimo	21	9	CIMMYT	CA principles
Field day	Apr 4 2012	Angonia Maguai	21	9	CIMMYT	CA principles
Field day	Apr 4 2012	Angonia Nzewe	21	9	CIMMYT	CA principles
Field day	Apr 4 2012	Angonia Ulongue	21	9	CIMMYT	CA principles
Field day	Apr 11 2012	Angonia Gimo	42	60	CIMMYT	CA principles
Field day	Apr 11 2012	Angonia Maguai	42	60	CIMMYT	CA principles
Field day	Apl 12 2012	Farmers in Barue, Malomwe	19	28	CIMMYT	CA principles
Short course	Apr 16 2012	Gondola. Pumbuto	5	2	CIMMYT	Cover crops
Field day	Apr 16 2012	Sussendenga Nhamatiquite	15	29	CIMMYT	CA principles
Workshop	Apr 20 2012	Nhamatanda Nharuchonga	8	3	CIMMYT	Workshop
Field day	Apr 24 2012	Angonia Ulongue	3	0	CIMMYT	CA principles
Field day	Apr 27 2012	Nhamatanda Lamego	14	29	CIMMYT	CA principles
Field day	May 23 2012	Sussendenga Nhamatiquite	4	8	CIMMYT	CA principles
Field day	May 24 2012	Angonia Gimo	27	33	CIMMYT	CA principles
Workshop	May 24 2012	Angonia Nzewe	8	10	CIMMYT	CA principles
Workshop	May 24 2012	Angonia Maguai	27	33	CIMMYT	CA principles

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	May 24 2012	Angonia Ulongue	8	10	CIMMYT	CA principles
Nepal						
Workshop	19 Dec 2011	*(Nepal)* Thumka Village farmers	9	0	Li-Bird	Orient farmers on the action research of the SMARTS project
Workshop	20 Dec 2011	*(Nepal)* Thumka Village farmers	8	5	Li-Bird	Orient farmers on CAPS and the importance of improving soil and crop yield
Workshop	21 Dec 2011	Hyakrang Village farmers	7	2	Li-Bird	Orient farmers on the action research of the SMARTS project
Workshop	22 Dec 2011	Hyakrang Village farmers	10	6	Li-Bird	Orient farmers on CAPS and the importance of improving soil and crop yield
Workshop	24 Dec 2011	Khola Gaun Village farmers	7	4	Li-Bird	Orient farmers on CAPS and the importance of improving soil and crop yield
Workshop	25 Dec 2011	Khola Gaun Village farmers	8	1	Li-Bird	Orient farmers on the action research of the SMARTS project
Workshop	2 Jan 2012	TU/IAAS Project associates and M.S. students	20	6	University of Hawaii /AAS	Present an introduction to CAPS and conduct AHP and cognitive modeling surveys /Presentation of project field activities and observations
Workshop	3 Jan 2012	LI-BIRD Research Associates, IOF M.S. students	16	11	University of Hawaii	Present an introduction to CAPS and conduct AHP and cognitive modeling surveys
Workshop	5 Jan 2012	Thumka Village farmers	11	8	University of Hawaii	Conduct AHP and cognitive modeling surveys
Workshop	7 Jan 2012	Hyakrang Village farmers	9	10	University of Hawaii	Conduct AHP and cognitive modeling surveys

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Demonstration	8 Jan 2012	IOF Master's Students, LI-BIRD research associate	4	1	University of Hawaii	Explain and demonstrate the weather station functioning, maintenance and data off-loading methods
Workshop	9 Jan 2012	Khola Gaun Village Farmers	7	10	University of Hawaii	Conduct AHP and cognitive modeling surveys
Workshop	19 Jun 2012	IAAS Project associates and M.S. students	12	12	University of Hawaii	Train IAAS graduate students on the methodology for collecting information on technology networks, gender, and cognitive mapping surveys
Workshop	20 Jun 2012	Thumka Village farmers	5	5	University of Hawaii	Discuss seasonal calendar of agricultural, community, and off-farm activities
Workshop	23 Jun 2012	Hyakrang Village farmers	4	3	University of Hawaii	Discuss seasonal calendar of agricultural, community, and off-farm activities
Workshop	25 Jun 2012	Khola Gaun Village farmers	4	3	University of Hawaii	Discuss seasonal calendar of agricultural, community, and off-farm activities
Short course	27 Jun 2012	LI-BIRD Soils Specialist	1	0	University of Hawaii	Train the LI-BIRD soils specialist on a new methodology for sampling and measuring water stable aggregates in soils a
Workshop	25 Aug 2012	Village farmers from Thumka, Hyakrang, and Khola Gaun	19	9	Li-Bird	To train village farmers on the principles of Integrated Pest Management
Philippines						
Workshop	Oct 8 2011	Farmers and Academe	12	7	ICRAF- Claveria	Enhance knowledge on rubber agroforestry systems

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	Oct 25- 27 2011	Farmers, LGU, Academe	22	14	ICRAF, USAID	Participatory bio-diversity conservation and agroforestry development for environment services projects for Mt. Apo Natural Park
Field day	Nov 15 2011	Farmers	34	19	PADAC/SANREM	Crop diversification through the adoption of soybean based cropping systems (under DMC management)
Workshop	Nov 19 2011	Rubber planters in Northern Mindanao	27	10	CRDFI, URRPA and ICRAF	United Rubber Planter and Processor Association (URRPA) training to expand rubber plantation in Mindanao
Workshop	Feb 6-8 2012	Farmers, LGU technicians, PO and NGO officers	18	9	CRDFI, ICRAF, SEARCA, USAID	Gain knowledge on various Conservation Agriculture with Trees Agroforestry Practices and Technologies to control soil erosion, sedimentation and pollutants
Focus group	Febr 14 2012	Farmer cooperators (SANREM-CAPS)	12	18	ICRAF-Claveria, Dr. Christie, Ms. Dayo	Facilitate gender perspective for Conservation Agriculture
Field day	Feb 24 2012	Professors and students from Agusan Sur State College of Agricultural Technology	49	37	CRDFI ICRAF	Gain knowledge on various conservation agriculture with trees agroforestry practices and technologies implemented in Claveria
Field day	Feb 24 2012	Farmers form Sumilao, Bukidnon with LFPI project coordinator	9	7	CRDFI ICRAF	Gain knowledge on various conservation agriculture with trees agroforestry practices and technologies implemented in Claveria
Field day	Feb 24 2012	Professors and students from Mindanao State University of Marawe	18	32	CRDFI ICRAF	Gain knowledge on various conservation agriculture with trees agroforestry practices and technologies implemented in Claveria
Field day	Mar 8 2012	Professors and students from Mindanao State University of Marawi	4	8	CRDFI ICRAF	Gain knowledge on various conservation agriculture with trees agroforestry practices and technologies implemented in Claveria

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Field day	Apr 10 2012	LGU officials, farmers from Linamon Lanao del Norte	25	18	ICRAF-Claveria/ Claveria Research and Development Foundation, Inc (CRDFI)	Enhance knowledge on CAwT technology, concepts, principles and practices implemented in Claveria
Field day	Apr11 2012	Academe, farmers, researchers, LGU officials	16	32	ICRAF-Claveria/ Claveria Research and Development Foundation, Inc (CRDFI)	Enhance knowledge on CAwT technology, concepts, principles and practices implemented in Claveria
Workshop	Apr 24-27 2012	Researchers, farmers	4	0	ICRAF-Claveria/ Claveria Research and Development Foundation, Inc.	Enhance knowledge on CAwT technology, concepts, principles and practices implemented in Claveria
Workshop	May 10 2012	Instructors and students from Digos City	15	8	ICRAF-Claveria/ Claveria Research and Development Foundation, Inc.	Enhance knowledge on CAwT technology, concepts, principles and practices implemented in Claveria
Workshop	Jun 16, 2012	Farmers from different Barangays in Claveria	11	6	ICRAF-Claveria/ Claveria Research and Development Foundation, Inc.	Enhance knowledge on CAwT technology, concepts, principles and practices and acquire knowledge on rubber technology
Field day	Jul 9, 2012	Academe, farmers, researcher, LGU officials	28	61	ICRAF-Claveria/ Claveria Research and Development Foundation, Inc.	Enhance knowledge on CAwT technology, concepts, principles and practices implemented in Claveria

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Focus Group	Jul 10 2012	Farmers from Barangay Rizal, Claveria, Mis, Or.	9	18	ICRAF-Claveria / Mary Harman / Claveria Research and Development Foundation, Inc (CRDFI)	Gender perspectives on soil for conservation agriculture
Focus Group	Jul 13 2012	Farmers form Barangay Patrocinio, Claveria, Miscantis, Orientalis	6	15	ICRAF-Claveria/ Claveria Research and Development Foundation, Inc (CRDFI) /MaryHarman	Gender perspective on soil for conservation agriculture
Field day	Jul 19 2012	SANREM CAPS farmer cooperators, researchers	10	7	ICRAF-Claveria/ Claveria Research and Development Foundation, Inc (CRDFI)	Updates on SANREM CAPS farmer-managed experimental sites
Field day	Jul 21 2012	Religious ministries from different municipalities in Mindanao	30	9	ICRAF-Claveria/ Claveria Research and Development Foundation, Inc (CRDFI)	Enhance knowledge on CAwT technology, concepts, principles and practices implemented in Claveria
Field day	Aug 8 2012	Provincial Agriculture Council	13	0	ICRAF-Claveria/ Claveria Research and Development Foundation, Inc (CRDFI)	Enhance knowledge on CAwT technology, concepts, principles and practices implemented in Claveria

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	Aug 14 2012	ICRAF Claveria Staff	3	1	Virginia Tech – Mary Harman	To acquire knowledge on GIS program
Field day	Aug 15 2012	Provincial Agriculture Council members of Misamis Oriental (First batch)	13	15	ICRAF-Claveria/ Claveria Research and Development Foundation, Inc (CRDFI)	Enhance knowledge on CAwT technology, concepts, principles and practices implemented in Claveria and learn more about organic agriculture
Field day	Sep 15 2012	Farmers members of Basic Ecclesiastical Community (BEC) of Catholic Church	34	16	ICRAF-Claveria/ Claveria Research and Development Foundation, Inc (CRDFI)	Enhance knowledge on CAwT technology, concepts, principles and practices implemented in Claveria and learn more about organic agriculture
Field day	Sep 4 2012	Provincial Agriculture Council members of Misamis Oriental (2nd Batch)	24	24	ICRAF-Claveria/ Claveria Research and Development Foundation, Inc (CRDFI). Agricultural Training Institute (ATI)-DA Region10	Enhance knowledge on CAwT technology, concepts, principles and practices implemented in Claveria and learn more about organic agriculture
Field day	Sep7 2012	Provincial Agriculture Council members of Misamis Oriental (3rd batch)	26	10	ICRAF-Claveria/ Claveria Research and Development Foundation, Inc (CRDFI). Agricultural Training Institute (ATI)-DA Region10	Enhance knowledge on CAwT technology, concepts, principles and practices implemented in Claveria and learn more about organic agriculture

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Field day	Sep 12-13 2012	Claveria farmers	21	9	ICRAF-Claveria/ Claveria Research and Development Foundation, Inc (CRDFI)	Enhance knowledge on CAwT technology, concepts, principles and practices, as well as rubber nursery and budwood garden establishment
Field day	Sep 14 2012	Municipal environment and natural resources officers (MENROs), PAMB members, Municipal and Provincial council members, mayors	17	5	ICRAF-Claveria/ Claveria Research and Development Foundation, Inc. (CRDFI)	Enhance knowledge on CAwT technology, concepts, principles and practices and watershed management
Field day	Sep 26 2012	Municipal Agriculture officers and Municipal and Provincial Council members chairing agriculture and environment for five provinces of Northern Mindanao (Region 10)	32	14	ICRAF-Claveria/ Claveria Research and Development Foundation, Inc (CRDFI). Agricultural Training Institute (ATI)-DA Region10	Enhance knowledge on CAwT technology, concepts, principles and practices implemented in Claveria and learn more about organic agriculture
Uganda						
Workshop	Oct 12-13 2011	Farmers, local government and NGO representatives in Tororo and Kapchorwa	22	6	AT Uganda	Assess implementation constraints and progress evaluation
Field days	Oct 18-20 2012	Farmers in Tororo (S), Kisoko (F), Molo (F)	10	11	AT Uganda FEC	Learn about fertilizer application at top dressing and knowledge sharing on fertilizer types, application methods in relation to plant stages, CA, and yield

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Field days	4, 8 Nov 2011	Kapchorwa farmers	7	14	AT Uganda FEC and FRA	Enhance farmers' understanding of best agronomic practices and CA
Field days	5 , 9 Nov 2011	Kwosir and Kaplak farmers	9	16	AT Uganda FEC and FRA	Safe use/ application of agrochemicals and CA
Field days	10, 11 Nov	Kapchorwa farmers	13	13	AT Uganda FEC and FRA	Properly harvest and thresh of maize. Maintaining ground cover for CA
Field days	5 Dec 2011	Kapchorwa farmers	3	7	AT Uganda FRA	Properly harvest and thresh maize. Maintaining ground cover for CA
Field days	6 Dec 2011	Kapchorwa farmers	3	7	AT Uganda FRA	Properly harvest and thresh maize. Maintaining ground cover for CA
Field days	12 Dec 2011	Kapchorwa farmers	5	2	AT Uganda FRA	Properly harvest and thresh maize. Maintain ground cover for CA
Workshop	11 Nov 2011	Tororo farmers	14	6	AT Uganda FEC and FRA	Increase awareness about SANREM CRSPS and share knowledge on CA
Workshop	14 Nov 2011	Kisoko farmers	5	15	AT Uganda FEC and FRA	Increase awareness about SANREM CRSPS and share knowledge on CA
Workshop	16 Nov 2011	Tororo farmers	10	8	AT Uganda FEC and FRA	Enhance data collection and record keeping
Workshop	17 Nov 2011	Kisoko farmers	4	12	AT Uganda FEC and FRA	Enhance data collection and record keeping
Workshop	18, 19 Nov 2011	Tororo farmers	8	15	AT Uganda FEC and FRA	Plan for 2012 activities
Workshop	22 Nov 2011	Kapchorwa farmers	5	11	Manor House and AT Uganda Ltd	Review and reflect on 2011 year's performance
Workshop	28 Nov 2011	Tororo farmers	6	10	Manor house and AT Uganda Ltd	Review and reflect on 2011 year's performance
Field day	24 Nov 2011	Kwosir farmers	5	13	AT Uganda FEC and FRA	Share CA lessons learnt from the trials

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Field day	25 Nov 2011	Kaplak farmers	4	9	AT Uganda FEC and FRA	Share CA lessons learnt from the trials
Field day	29 Nov 2011	Tororo farmers	2	0	AT Uganda FEC and FRA	Bean harvesting processes
Field day	30 Nov 2011	Molo farmers	6	0	AT Uganda FEC and FRA	Bean harvesting processes
Mentoring	21 Nov 2011	Tororo farmers	2	0	AT Uganda FEC and FRA	Maintaining mucuna by preventing it from climbing and choking the maize crop in the trial sites.
Mentoring	24 Nov 2011	Tororo farmers	2	1	AT Uganda FEC and FRA	Maintaining mucuna by preventing it from climbing and choking the maize crop in the trial sites.
Mentoring	25 Nov 2011	Tororo farmer	0	1	AT Uganda FEC and FRA	Maintaining mucuna by preventing it from climbing and choking the maize crop in the trial sites.
Mentoring	26 Nov 2011	Tororo farmers	3	0	AT Uganda FEC and FRA	Maintaining mucuna by preventing it from climbing and choking the maize crop in the trial sites.
Mentoring	26 Nov 2011	Tororo farmers	2	1	AT Uganda FEC and FRA	Maintaining mucuna by preventing it from climbing and choking the maize crop in the trial sites.
Workshop	9 Feb 2012	Agricultural service providers, community agents and farmers in Tororo	16	8	Virginia Tech	Report and discuss network research conducted in 2011
Workshop	10 Feb 2012	Agricultural service providers, community agents and farmers in Kapchorwa	13	7	Virginia Tech	Report and discuss network research conducted in 2011

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Mentoring	11-13 Feb 2012	Kapchorwa farmers	8	0	AT Uganda FRA	Establish 1st season experiments, share knowledge with farmers on importance of CA, herbicide application and handling
Mentoring	16 Feb 2012	Kwosir farmers	4	0	AT Uganda FRA	Establish 1st season experiments, share knowledge with farmers on importance of CA, herbicide application and handling
Mentoring	14, 15 Feb 2012	Kaplak farmers	4	0	AT Uganda FRA	Establish 1st season experiments, share knowledge with farmers on importance of CA, herbicide application and handling
Mentoring	26 Feb 2012	Tororo farmers	4	0	AT Uganda FRA	Establish 1st season experiments, share knowledge with farmers on importance of CA, herbicide application and handling
Mentoring	27 Feb 2012	Molo farmers	3	5	AT Uganda FRA	Establish 1st season experiments, share knowledge with farmers on importance of CA, herbicide application and handling
Mentoring	28 Feb 2012	Kisoko farmers	4	3	AT Uganda FRA	Establish 1st season experiments, share knowledge with farmers on importance of CA, herbicide application and handling
Mentoring	25 Feb 2012	Kapchorwa farmers	2	1	AT Uganda FRA	Establish of 1st season experiments, share knowledge with farmers on importance of CA, herbicide application and handling
Mentoring	27 Feb 2012	Kwosir farmers	2	2	AT Uganda FRA	Establish 1st season experiments, share knowledge with farmers on importance of CA, herbicide application and handling
Mentoring	28 Feb 2012	Kaplak farmers	2	2	AT Uganda FRA	Prepare plots in the current practice strip (ploughing) of all the experimental/trial sites

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Mentoring	8 Mar 2012	Tororo farmers	4	0	AT Uganda FEC/FRA	Prepare plots in the current practice strip (ploughing) of all the experimental/trial sites
Mentoring	9 Mar 2012	Kisoko farmers	1	2	AT Uganda FRA	Prepare plots in the current practice strip (ploughing) of all the experimental/trial sites
Mentoring	12 Mar 2012	Molo farmers	3	2	AT Uganda FRA	Prepare plots in the current practice strip (ploughing) of all the experimental/trial sites
Mentoring	13 Mar 2012	Kisoko farmers	3	2	AT Uganda FRA	Prepare plots in the current practice strip (ploughing) of all the experimental/trial sites
Mentoring	14 Mar 2012	Molo farmers	0	3	AT Uganda FRA	Prepare plots in the current practice strip (ploughing) of all the experimental/trial sites
Field day	14 Mar 2012	Molo farmers	1	0	AT Uganda FEC/FRA	Prepare the plots in the no- tilland minimum-till strips for 1st season's planting including herbicide application
Field day	19 Mar 2012	Kaplak farmers	14	13	Wyoming University, Manor House & AT Uganda Ltd	Introduce the MFI to the farmers, test how it works and it's effectiveness compared to the common ox plough
Field day	20 Mar 2012	Keere farmers	23	11	Wyoming University, Manor House & AT Uganda Ltd	Introduce the MFI to the farmers, test how it works and it's effectiveness compared to the common ox plough
Field day	20 Mar 2012	Kwosir farmers	30	14	Wyoming university, Manor House & AT Uganda Ltd	Introduce the MFI to the farmers, test how it works and it's effectiveness compared to the common ox plough

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Field day	22 Feb 2012	Tororo farmers	2	11	AT Uganda FRA. Moi University	Getting soil samples from on-stations for study
Field day	23 Feb 2012	Kapchorwa farmers	17	0	AT Uganda FRA. Moi University	Getting soil samples from on-stations for study
Field day	25 Jan 2012	Tororo farmers	2	2	AT Uganda FRA & ME	Harvest , thresh, weigh and collect data of the maize in the different trial sites in Tororo.
Field day	26 Jan 2012	Kisoko farmers	4	21	AT Uganda FRA & ME	Harvest , thresh, weigh and collect data of the maize in the different trial sites in Tororo.
Field day	27 Jan 2012	Molo farmers	7	14	AT Uganda FRA & ME	Harvest , thresh, weigh and collect data of the maize in the different trial sites in Tororo.
Workshop	13 Mar 2012	Kisoko farmers	1	8	AT Uganda FEC/FRA	Farmers to understand the relationship between costs, income levels and profit across the tillage systems in CA in comparison with current practices
Workshop	29 Mar 2012	Kisoko farmers	3	15	AT Uganda FEC/FRA	Farmers to understand the relationship between costs, income levels and profit across the tillage systems in CA in comparison with current practices
United States						
Short course	Dec 2011	CIP, CIAT, and IFPRI staff; US graduate students	8	6	Virginia Tech (Alwang, Norton and Larochelle)	Impact assessment for agricultural technologies
Short course	Jul-Sep 2012	Matt Capelli	1		Virginia Tech (Alwang)	Data analysis

SANREM CRSP publications, presentations and other products

Article Published in Refereed Journal (18)

Alwang, J. and A. Gandarillas. 2012. Introducción. Investigaciones en el manejo sostenible de cuencas y recursos en la agricultura tradicional: El caso de Tiraque Revista de Agricultura, Ciencias Agrícolas, Pecuarias, Forestales, y Veterinarias, 51: 3-6. (Spanish).

Amaya, N. and J. Alwang. 2012. Acceso a información, relaciones de género y acceso a los mercados de papa en la sub Cuenca del Rio Toralapa en Tiraque-Bolivia. Revista de Agricultura (Bolivia), v. 51: 63-72. (Spanish).

Barrera, V. and J. Alwang. 2012. Agricultural innovation for enhanced natural resources in the Ecuador Highlands. New Agriculturalist: Research and Innovation, May 2012

Barrera, V., J. Alwang, and E. Cruz Collaguazo. 2010. Análisis de la viabilidad socio-económica y ambiental del sistema de producción papa-leche en la microcuenca del rio Illangama-Ecuador. Archivos Latinoamericanos de Producción Animal 19 (1-2) 57-67. (Spanish).

Barrera, V.H., L.O. Escudero, J. Alwang and R. Andrade. 2012. Integrated management of natural resources in the Ecuador Highlands. Agriculture Sciences 3(5): 768-779.

Castelhano, M. J. Alwang, N. Kuminoff, and R. Botello. 2012. Eligen los agricultores las variedades de papa a producir como una forma de manejar mejor el riesgo. Revista de Agricultura (Bolivia), v. 51: 39-46. (Spanish).

Henry, A., L. Mabit, R.E. Jaramillo, Y. Cartagena, and J.P. Lynch. 2012. Land use effects on erosion and carbon storage of the Río Chimbo watershed, Ecuador. Journal of Plant and Soil. (In Press)

Lai, C., C. Chan, J. Halbrendt, L. Shariq, P. Roul, T. Idol, C. Ray, and C. Evensen. 2012. Comparative economic and gender, labor analysis of conservation agriculture practices in tribal villages in India. International Food and Agribusiness Management Review 15(1): 73 - 86.

Larochelle, C. and J. Alwang. 2012. The role of risk mitigation in production efficiency: A case study of potato cultivation in the Bolivian Andes. Journal of Agricultural Economics. (In Press)

Larochelle, C., J. Alwang and R. Botello. 2012. Análisis de la eficiencia en la producción de papa. Revista de Agricultura (Bolivia), v. 51: 27-35. (Spanish).

Mamani, P., Saavedra, A. K., Edino G. and J. Alwang.2012. La agricultura de conservacion: un posible camino hacia una major gestion de los recursos, mayor productividad y mejores condiciones socioeconomicas en la region andina. Revista de Agricultura (Bolivia), v. 51: 35-38. (Spanish).

Melnick, R.L., A.L. Testen, A.M. Poleatewich, P.A. Backman and B.A. Bailey. 2012. Detection and expression of enterotoxin genes in endophytic strains of *Bacillus cereus*. Letters in Applied Microbiology 54(5): 468–474.

Plata, G., P. Backman, and A. Poleatewich. 2012. Evaluación de bacterias endófitas para el control de enfermedades de importancia económica en papa. Revista de Agricultura (Bolivia), v. 51: 55-58. (Spanish).

Plata, G., P. Backman, and A. Poleatewich. 2012. Evaluación de bacterias endófitas para el control de enfermedades foliares en haba. Revista de Agricultura (Bolivia), v. 51: 59-62. (Spanish).

Ruiz, O., J. Cahill, S. Arrazola, M. Mercado, F. Navarro, M. Fernandez. 2012. Biodiversidad de la sub cuenca del Rio Toralapa. Revista de Agricultura (Bolivia), v. 51: 7-16. (Spanish).

Saavedra, A. K. 2012. Diagnostico de la erosión y degradación actual de los suelos del la región alto andina de la provincia Tiraque, Cochabamba. Revista de Agricultura (Bolivia), v. 51: 17-26. (Spanish).

Testen, A.L., J.M. McKemy, and P.A. Backman. 2012. First report of quinoa downy mildew caused by *Peronospora variabilis* in the United States. Plant Disease Notes 96(1): 146.

Walker, S., C. Heatwole, J. Cossio. 2012. Evaluación de un modelo de simulación de dinámicas de nutrientes, mineralización y materia seca en la zona andina de Bolivia. Revista de Agricultura (Bolivia), v. 51: 47-54. (Spanish).

Books/Book Chapters

Catacutan, D.C., A.R. Mercado, Jr., M.E. Chiong-Javier, V.B. Ella, M.V.O. Espaldon, A.C. Rola, M.C. Palada, C. Duque-Pinon, J.A. Saludadez, A.M. Penaso, M.R. Nguyen, C.T. Pailagao, I.B. Bagares, N.R. Alibuyog, D. Midmore, M.R. Reyes, R. Cajilig, W. Suthumchai, K. Kunta and S. Sombatpanit (eds.) 2012, Vegetable-agroforestry systems in the Philipines, Special Publication No. 6b, World Association of Soil and Water Conservation (WASWAC), Beijing, China and the World Agroforestry Center (ICRAF), Nairobi, Kenya, 457 pp.

Chiong-Javier, M.E., C. Duque-Pinon, A.R. Mercado and M.R. Reyes. 2012. Holding their own: Smallholder production, marketing and women issues in Philippine agroforestry. De La Salle University, Manila, Philippines.

Theses and Dissertations

Bruns, M. 2012. Optimizing maize planting date, plant population, and fertilizer application rates for Lesotho Subsistence Farmers. M.S. Thesis. University of Tennessee-Knoxville.

Bruns, W. 2012. Energy balance and carbon dioxide flux in conventional and no-till maize fields in Lesotho, Southern Africa. M.S. Thesis. University of Tennessee-Knoxville.

Lai, C. 2011. Comparative Economic Analysis of Conservation Agricultural Practices in Tentuli Village, India. Master's Thesis. University of Hawaii at Manoa: Honolulu, Hawaii, USA.

Lamb, J. 2011. Food security and social networks: Impacts for smallholder farmers in the Mount Elgon region of Kenya and Uganda. Master's Thesis. Virginia Polytechnic and State University: Blacksburg, VA.

Larochelle, C. 2011. Three essays on productivity and risk, marketing decisions, and changes in well-being over time. PhD Dissertation. Virginia Polytechnic and State University: Blacksburg, VA.

Manalo-Bondad, R. and S. De Gloria. 2012. Simulation of yield response of corn (Zea mays) to changes in selected climatic and soil parameters using DSSAT CERES-Maize model under conventional plow-based and conservation agriculture production systems in Claveria. Master's Thesis. Misamis Oriental State College of Architecture and Technology: Clavaria, Misamis Oriental, Philippines.

Melnick, R.L. 2011. Endophytic Bacillus spp. of *Theobroma* cacao : Ecology and potential for biological control of cacao diseases. PhD. Dissertation. Pennsylvania State University. The Graduate School Department of Plant Pathology.

Moposita, D. 2011. Evaluación de sistemas de labranza, uso de suelo y fertilización en el cultivo de papa (*Solanum tuberosum L.*) el la microcuenca del Río Illangamo, Provincia Bolívar. Undergraduate Thesis. Guaranda, Ecuador: Universidad Estatal de Bolivar. (Spanish).

Nguema, A. 2011. Two papers evaluating the economic impact of agricultural innovation. Master's Thesis. Virginia Polytechnic and State University: Blacksburg, VA.

Portilla, A. 2012. Evaluación de la biodisponibilidad del nitrógeno en cultivo de fréjol arbustivo (*Phaseolus vulgaris L.*) con cobertura y bajo sistemas de labranza de conservación, en la microcuenca del Río Alumbre - Bolívar. Undergraduate thesis. Quito, Ecuador: Universidad Central del Ecuador. (Spanish).

Stewart, R.E. 2012. Physical and chemical parameters of common soils in the Central Plateau region of Haiti. Master's Thesis.Virginia Polytechnic and State University: Blacksburg, VA.

Tarnate, P. and M. Osena. Modeling solute transport in soil under conventional plow-based and conservation agriculture production systems in Claveria. Master's Thesis. University of the Philippines, Los Baños: Oriental, Philippines

Abstracts

Halbrendt, J., C. Lai, C. Chan-Halbrendt, T. Idol, C. Ray, C. Evensen, and P.K. Roul. 2011. An integrative approach for introducing conservation agricultural practices to tribal societies in India. Paper presented at the Second International Conservation Agriculture Workshop and Conference in Phnom Penh, Cambodia, 4-7 July 2011.

Harman, M., M.E. Christie, K. Agriesti, R. Botello, and H. Dayo. 2011. Soils knowledge and gendered landscapes in Bolivia and the Philippines: Can GIS tell their story? Abstract submitted to the Annual Meeting of the Association of American Geographers, New York, New York, 2012.

Extension Publications/Learning Tools

Local Initiatives for Biodiversity, Research and Development. 2011. LI-BIRD 2012 Calendar, LI-BIRD Chautari. Distributed to partner organizations, farmers, businesses, and other stakeholders in January 2012.

SANREM CRSP. 2012. Network opportunities for promoting conservation agriculture: Bungoma, Kenya.

SANREM CRSP. 2012. Network opportunities for promoting conservation agriculture: Kitale, Kenya.

SANREM CRSP. 2012. Network opportunities for promoting conservation agriculture: Kapchorwa, Uganda.

SANREM CRSP. 2012. Network opportunities for promoting conservation agriculture: Tororo, Uganda.

OUAT. 2012. Sustainable Management of Agroecological Resources for Tribal Societies (SMARTS): Conservation agriculture-based participatory research in Kendujhar, Orissa. Bhubaneswar, India: Orissa University of Agriculture and Technology (OUAT)

Local Initiatives for Biodiversity, Research and Development. 2011. LI-BIRD 2012 calendar, LI-BIRD Chautari. Distributed to partner organizations, farmers, businesses, and other stakeholders in January 2012.

SANREM CRSP. 2012. Network opportunities for promoting conservation agriculture: Bungoma, Kenya.

SANREM CRSP. 2012. Network opportunities for promoting conservation agriculture: Kitale, Kenya.

SANREM CRSP. 2012. Network opportunities for promoting conservation agriculture: Kapchorwa, Uganda.

SANREM CRSP. 2012. Network opportunities for promoting conservation agriculture: Tororo, Uganda.

OUAT. 2012. Sustainable Management of Agroecological Resources for Tribal Societies (SMARTS): Conservation agriculture-based participatory research in Kendujhar, Orissa. Bhubaneswar, India: Orissa University of Agriculture and Technology (OUAT)

Papers/Seminars Presented

Agriesti, K., M.E. Christie, and R. Botello. 2012. Gender, local soil knowledge, and access to resources in the Andean Region, Bolivia. Presented at the Annual Meeting of the Association of American Geographers New York, NY, 28 February 2012.

Boulakia, S., A. Mercado, S. Chabierski, V.B. Ella, L. Hok, N. Edralin and M. Reyes. 2012. Conservation agriculture for food security in Cambodia and the Philippines. Presented at the 2012 National Council for Science and the Environment Conference: Environment and Security. January 18-20, 2012, Washington, DC.

Eash, N., D.M. Lambert, M. Marake, C. Thierfelder, F.R. Waker and M.D. Wilcox. 2012. Small-holder adoption of conservation agriculture in Lesotho and Mozambique. Presented at the International Conference on Climate Change, Recycling of Agricultural Resources, Technology Improvement and Agriculture Management, Huazhong Agricultural University, Wuhan, China, January 7 - 12, 201.

Ella, V.B., M.R. Reyes and A. Mercado, Jr. 2012. Soil quality monitoring and evaluation under conventional plow-based and conservation agriculture production systems in southern Philippines. CIGR Meeting Paper No C-1160. Paper presented at the 2012 International Conference of Agricultural Engineering, Valencia, Spain, July 8-12, 2012.

Ella, V.B., J. Keller, M.R. Reyes, and R. Yoder. 2012. Water distribution uniformity improvement of microtube-type and button-type drip irrigation system using adjustable pressure-loss lateral takeoff valves. CIGR Meeting Paper No. C-1144. Paper presented at the 2012 International Conference of Agricultural Engineering, Valencia, Spain, July 8-12, 2012.

Halbrendt, J., C. Chan-Halbrendt, L. Shariq, S. Gray and C. Lai. 2012. Constructing community fuzzy cognitive maps to promote adoption of conservation agricultural production practices. Presented at the proceedings of the 22nd Annual International Food and Agribusiness Management Association World Forum and Symposium, Shanghai, China, 11-14 June 2012.

Halbrendt, J., L. Shariq, C. Chan-Halbrendt, C. Lai, T. Idol, C. Ray, P.K. Roul, and K.N. Mishra. 2011. Development of an integrated approach for introducing conservation agricultural practices to the tribal communities of Odisha, India. Presented at the Second International Conservation Agriculture Workshop and Conference in Phnom Penh, Cambodia, 4-7 July 2011.

Kennedy, N. and G. Amacher. 2012. The utilization of soil conservation practices in Central Haiti. Presented at the ASA, CSSA, and SSSA Annual Meetings, Cincinnati, OH, 21-24 October 2012.

Lai, C. 2011. Comparative economic analysis of conservation agricultural practices in Tentuli Village, India. Presented at the International Food and Agribusiness Management Association 2011 Annual World Symposium, Frankfurt, Germany, 20-21 Jun 2011.

Lai, C., C. Chan-Halbrendt, J. Halbrendt, D. Naik and C. Ray. 2012. Comparative analysis of farmer and professional preferences towards conservation agriculture practices in Kendujhar, Odisha: An analytical hierarchy process study. Published at the proceedings of the 22nd Annual International Food and Agribusiness Management Association World Forum and Symposium, Shanghai, China, 11-14 June 2012.

Prasad, P.V.V., J.B. Naab, M.D. Doumbia, and T.D. Dalton. 2011. Conservation agricultural practices in West Africa: Challenges and opportunities. Presented at the International Conference on Sustainable Agriculture and Food Security: Challenges and Opportunities, Bandung, Indonesia, 27-28 September 2011.

Prasad, P.V.V., J.B. Naab, M.D. Doumbia, and T.D. Dalton. 2011. Opportunities for sustainable intensification of agricultural practices to improve crop productivity of small holding farmers in West Africa. Presented at the International Conference on Sustainable Agriculture and Food Security: Challenges and Opportunities, Bandung, Indonesia, 27-28 September 2011.
Reed, B., C. Chan-Halbrendt, J. Halbrendt, C. Lai, T.J.K. Radovich and P. Limbu. 2012.

Economic analysis of farm labor and profitability of three tribal villages in Nepal. Presented at the proceedings of the 22nd Annual International Food and Agribusiness Management Association World Forum and Symposium, Shanghai, China, 11-14 June 2012.

Roul, P.K., K.N. Mesha and S.N. Dashi. 2011. Sustainable tribal farming through conservation agriculture: SMARTS experience in Kendujhar. Paper presented at Golden Jubilee Workshop on Conservation Agriculture held at OUAT on 24 December 2011. Bhubaneswar, India: Orissa University of Agriculture and Technology (OUAT)

Wilcox, M.D., E. Bisangwa, D.M. Lambert, N. Eash, F.R. Walker, and M. Marake . 2012. Smallholders, sustainability and food security: Conservation agriculture in a developing country context. Presented at the International Conference on Climate Change, Recycling of Agricultural Resources, Technology Improvement and Agriculture Management, Wuhan, China, January 7-10 2012.

Electronic Presentations

Barrera, V.H. Adaptación de la agricultura y la ganadería al cambio climático en los Andes: Experiencias desde el ámbito de la I+D+i. Presented at Universidad Estatal de Bolivar, Guaranda, Ecuador, 6 March 2012. 2012. (Spanish).

Christie, M.E. Integrating gender and increasing women's participation: Experiences from Peanut, SANREM, and IPM CRSPs. Presented at the Horticulture CRSP Annual Meeting, Bangkok, Thailand, 10 February 2012.

Christie, M.E., K. Agriesti, and R. Botello. Gendered perspectives on sheep, livelihoods, and sense of place in Sank'ayani Alto, Bolivia. Presented at the Conference of Latin American Geographers (CLAG), Merida, Mexico, 11-13 January 2012.

Ella, V.B. Initial results on soil quality; SANREM-CRSP conservation agriculture for food security in the Philippines. Presented at Claveria, Misamis Oriental, Philippines. 18 January 2011.

Ella, V.B. SANREM CRSP Project activities in the Philippines. Presented at the IPM CRSP Annual Meeting, Los Baños, Laguna, 2 August 2011.

Ella, V.B. Water use efficiency for increased agricultural productivity, sustainability and competitiveness in the Philippines: Technologies and practices, issues and problems, and recommendations. Presented at the NAST Roundtable Discussion on Intensification of Agriculture, Manila, Philippines, 21 February 2011.

Halbrendt, J. An introduction to conservation agricultural production systems. Presented at Local Initiatives for Biodiversity, Research and Development (LI-BIRD), in Thumka village, Hyrakrang village, and Khola Gaun village, Pokhara, Nepal and at the Institute of Agriculture and Animal Science (IAAS), Rampur, Nepal, 1-10 January 2012.

Halbrendt, J. Introduction to SANREM / SMARTS Project. Presented at LI-BIRD Headquarters, Pokhara, Nepal, March 2011.

Halbrendt J. Using cognitive mapping to assess farmer decision-making. Presented at Local Initiatives for Biodiversity, Research and Development (LI-BIRD), Thumka village, Hyrakrang village, and Khola Gaun village, Pokhara, Nepal and the Institute of Agriculture and Animal Science (IAAS), Rampur, Nepal, 1-10 January 2012.

Harman, M., M.E. Christie and I. Bagares. A mixed methods approach to studying gender and conservation agriculture in the Philippines. Presented at the Office of International Research, Education, and Development (OIRED), 5 September 2012.

Idol, T. Conservation agriculture & soil health: The US perspective. Presented at Orissa University of Agriculture and Technology (OUAT), Bhubaneswar, India on 24 December 2011.
Lai, C. and C. Chan-Halbrendt. Farmers' preference: AHP workshop and analysis. 2011.

Laker-Ojok, R., D. Sikuku, and J. Lamb. Technology networks for conservation agriculture: Kapchorwa, Uganda. SANREM CRSP Technology Networks Workshop. Bungoma, Kenya. February 10, 2012.

Lamb, J. Technology networks for conservation agriculture: Bungoma, Kenya. 2012. SANREM CRSP Technology Networks Workshop. Bungoma, Kenya. February 14, 2012.

Lamb, J. Technology networks for conservation agriculture: Kitale, Kenya. 2012. SANREM CRSP Technology Networks Workshop. Bungoma, Kenya. February 16, 2012.

Lamb, J. Technology networks for conservation agriculture: Tororo, Uganda. 2012. SANREM CRSP Technology Networks Workshop. Bungoma, Kenya. February 9, 2012.

Lamb, J. N., K.M. Moore, R. Laker-Ojok, D.N. Sikuku, D.S. Ashilenge, and J. Norton. 2012. "Using a Social Network Approach to Improve Participatory Research for Conservation Agriculture: Initial Findings from the Mt. Elgon Region Initial Findings from the Mt. Elgon Region". Paper presented at the Rural Sociological Society Annual Meeting. Chicago, Illinois, July 2012.

Local Initiatives for Biodiversity, Research, and Development (LIBIRD). Sustainable Management of Agroecological Resources in Tribal Soceties (SMARTS): Field observation in Nepal. Presented at LIBIRD on 22 March 2011.

Mercado, A.R. Conservation Agriculture with Trees (CAwT): Enhancing agroforestry economic benefits and environmental services. Presented at the IGRAF-SLE GIZ Consultation Meeting, IRRI, Los Banos, Laguna, Philippines, 4 August 2011.

Mercado, A.R., M.R. Reyes, and V.B. Ella. Developing conservation agriculture in the Philippines. Presented at the Conservation Agriculture Research in the Philippines and Cambodia Workshop, 6 July 2011.

Moore, K.M., J.N. Lamb, R. Laker-Ojok, D.N. Sikuku, D.S. Ashilenge, and J. Norton. 2012. "Social networks and agricultural production knowledge: Findings from the Mt. Elgon Region (Kenya and Uganda)". Paper presented at the World Congress of Rural Sociology. Lisbon, Portugal. August 2012.

Orissa University of Agriculture and Technology (OUAT). Sustainable Management of Agro-ecological Resources for Tribal Societies (SMARTS): Conservation agriculture-based participatory research in Kendujhar, Orissa. Presented at Orissa University of Agriculture and Technology (OUAT), Bhubaneswar, India March 2012.

Reed, B.F. Farmer preference for CAPS: Workshop and analysis. Presented at Khola Gaun, Hyrakrang, and Thumka villages, Pokhara, Nepal, 5-10 January 2012.

Reed, B.F. Staff preference for CAPS: Workshop and analysis. Presented at Local Initiatives for Biodiversity, Research and Development (LI-BIRD), Pokhara, Nepal and The Institute of Agriculture and Animal Science (IAAS), Rampur, Nepal, 1-4 January 2012.

Reed B.F., C. Chan-Halbrendt, J. Halbrendt, C. Lai, T.J.K. Radovich, and P. Limbu. Analysis of farmer and extension agent preference in Nepal using Analytic Hierarchy Process. Presented at 24th Annual University of Hawaii at Manoa's College of Tropical Agriculture and Human Resources and College of Engineering Student Research Symposium, 13--14 April 2012.

Saavedra, A. K. Proyecto "SANREM - BOLIVIA" avance de actividades: 2011 – 2012. (Spanish).

Barrera, V.H. Adaptación de la agricultura y la ganadería al cambio climático en los Andes: Experiencias desde el ámbito de la I+D+i. Presented at Universidad Estatal de Bolivar, Guaranda, Ecuador, 6 March 2012. 2012. (Spanish).

Christie, M.E. Integrating gender and increasing women's participation: Experiences from Peanut, SANREM, and IPM CRSPs. Presented at the Horticulture CRSP Annual Meeting, Bangkok, Thailand, 10 February 2012.

Christie, M.E., K. Agriesti, and R. Botello. Gendered perspectives on sheep, livelihoods, and sense of place in Sank'ayani Alto, Bolivia. Presented at the Conference of Latin American Geographers (CLAG), Merida, Mexico, 11-13 January 2012.

Ella, V.B. Initial results on soil quality; SANREM-CRSP conservation agriculture for food security in the Philippines. Presented at Claveria, Misamis Oriental, Philippines. 18 January 2011.

Ella, V.B. SANREM CRSP Project activities in the Philippines. Presented at the IPM CRSP Annual Meeting, Los Baños, Laguna, 2 August 2011.

Ella, V.B. Water use efficiency for increased agricultural productivity, sustainability and competitiveness in the Philippines: Technologies and practices, issues and problems, and recommendations. Presented at the NAST Roundtable Discussion on Intensification of Agriculture, Manila, Philippines, 21 February 2011.

Halbrendt, J. An introduction to conservation agricultural production systems. Presented at Local Initiatives for Biodiversity, Research and Development (LI-BIRD), in Thumka village, Hyrakrang village, and Khola Gaun village, Pokhara, Nepal and at the Institute of Agriculture and Animal Science (IAAS), Rampur, Nepal, 1-10 January 2012.

Halbrendt, J. Introduction to SANREM / SMARTS Project. Presented at LI-BIRD Headquarters, Pokhara, Nepal, March 2011.

Halbrendt J. Using cognitive mapping to assess farmer decision-making. Presented at Local Initiatives for Biodiversity, Research and Development (LI-BIRD), Thumka village, Hyrakrang village, and Khola Gaun village, Pokhara, Nepal and the Institute of Agriculture and Animal Science (IAAS), Rampur, Nepal, 1-10 January 2012.

Harman, M., M.E. Christie and I. Bagares. A mixed methods approach to studying gender and conservation agriculture in the Philippines. Presented at the Office of International Research, Education, and Development (OIRED), 5 September 2012.

Idol, T. Conservation agriculture & soil health: The US perspective. Presented at Orissa University of Agriculture and Technology (OUAT), Bhubaneswar, India on 24 December 2011.
Lai, C. and C. Chan-Halbrendt. Farmers' preference: AHP workshop and analysis. 2011.

Laker-Ojok, R., D. Sikuku, and J. Lamb. Technology networks for conservation agriculture: Kapchorwa, Uganda. SANREM CRSP Technology Networks Workshop. Bungoma, Kenya. February 10, 2012.

Lamb, J. Technology networks for conservation agriculture: Bungoma, Kenya. 2012. SANREM CRSP Technology Networks Workshop. Bungoma, Kenya. February 14, 2012.

Lamb, J. Technology networks for conservation agriculture: Kitale, Kenya. 2012. SANREM CRSP Technology Networks Workshop. Bungoma, Kenya. February 16, 2012.

Lamb, J. Technology networks for conservation agriculture: Tororo, Uganda. 2012. SANREM CRSP Technology Networks Workshop. Bungoma, Kenya. February 9, 2012.

Lamb, J. N., K.M. Moore, R. Laker-Ojok, D.N. Sikuku, D.S. Ashilenge, and J. Norton. 2012. "Using a Social Network Approach to Improve Participatory Research for Conservation Agriculture: Initial Findings from the Mt. Elgon Region Initial Findings from the Mt. Elgon Region". Paper presented at the Rural Sociological Society Annual Meeting. Chicago, Illinois, July 2012.

Local Initiatives for Biodiversity, Research, and Development (LIBIRD). Sustainable Management of Agroecological Resources in Tribal Soceties (SMARTS): Field observation in Nepal. Presented at LIBIRD on 22 March 2011.

Mercado, A.R. Conservation Agriculture with Trees (CAwT): Enhancing agroforestry economic benefits and environmental services. Presented at the IGRAF-SLE GIZ Consultation Meeting, IRRI, Los Banos, Laguna, Philippines, 4 August 2011.

Mercado, A.R., M.R. Reyes, and V.B. Ella. Developing conservation agriculture in the Philippines. Presented at the Conservation Agriculture Research in the Philippines and Cambodia Workshop, 6 July 2011.

Moore, K.M., J.N. Lamb, R. Laker-Ojok, D.N. Sikuku, D.S. Ashilenge, and J. Norton. 2012. "Social networks and agricultural production knowledge: Findings from the Mt. Elgon Region (Kenya and Uganda)". Paper presented at the World Congress of Rural Sociology. Lisbon, Portugal. August 2012.

Orissa University of Agriculture and Technology (OUAT). Sustainable Management of Agro-ecological Resources for Tribal Societies (SMARTS): Conservation agriculture-based participatory research in Kendujhar, Orissa. Presented at Orissa University of Agriculture and Technology (OUAT), Bhubaneswar, India March 2012.

Reed, B.F. Farmer preference for CAPS: Workshop and analysis. Presented at Khola Gaun, Hyrakrang, and Thumka villages, Pokhara, Nepal, 5-10 January 2012.

Reed, B.F. Staff preference for CAPS: Workshop and analysis. Presented at Local Initiatives for Biodiversity, Research and Development (LI-BIRD), Pokhara, Nepal and The Institute of Agriculture and Animal Science (IAAS), Rampur, Nepal, 1-4 January 2012.

Reed B.F., C. Chan-Halbrendt, J. Halbrendt, C. Lai, T.J.K. Radovich, and P. Limbu. Analysis of farmer and extension agent preference in Nepal using Analytic Hierarchy Process. Presented at 24th Annual University of Hawaii at Manoa's College of Tropical Agriculture and Human Resources and College of Engineering Student Research Symposium, 13--14 April 2012.

Saavedra, A. K. Proyecto "SANREM - BOLIVIA" avance de actividades: 2011 – 2012. (Spanish).

Poster /Conference Proceedings

Moore, K.M., J. Lamb, and I. Yahaya. 2011. Predisposition for conservation agriculture in North West Ghana. Proceedings of the 5th World Congress of Conservation Agriculture incorporating 3rd Farming Systems Design Conference held in Brisbane, Australia, 26-29 September 2011

Mulvaney, M.J., C.W. Wood, and A.J. Price. Biomass shifts and suppresses weed populations under conservation agriculture. Proceedings of the 5th World Congress of Conservation Agriculture incorporating 3rd Farming Systems Design Conference held in Brisbane, Australia, 26-29 September 2011

SANREM CRSP Working Papers

Ares, A., K. M. Moore, M.J. Mulvaney, M.E. Christie, M.K. Bertelsen, and G. Norton. 2012. The Sustainable Agriculture and Natural Resources Management Collaborative Research Support Program (SANREM CRSP): Improving food security and rural livelihoods through conservation agriculture. Poster presented at the National Council on Science and the Environment Annual Conference. Washington, D.C. January 2012.

Barrera, V. 2012. Gestión integrada de cuencas y manejo de recursos naturales en la adaptación de la agricultura al Cambio Climático: Experiencia en la subcuenca del río Chimbo-Ecuador. Poster presented at a Conference at the Universidad Técnica Estatal Luis Vargas Torres, 23-24 August, 2012.

Bisangwa, E., M.D Wilcox, D.M Lambert, M.Marake, F.R. Walker, N. Eash and W.M. Park. 2012. Conservation agriculture in Lesotho: The drivers of adoption and the role of extension. Poster presented at 8th Annual Conference of the National Association of Community Development Professionals, Park City, Utah, 20-23 May 2012.

Christie, M.E. 2012. Participatory mapping and gendered space: Kitchenspace, value chains, peanuts, and pesticides. Poster presented at the Annual Meeting of the Association of American Geographers in New York City, NY 26 February 2012.

Christie, M.E., C. Luebbering, K. Agriesti, M. Byrne, K. Montgomery, E. Van Houweling, L. Zseleczky and M. Harman. 2011. Gender and participatory mapping: Local knowledge and empowerment in development research. Poster presented at the Southeastern Division Association of American Geographers, Savanna, GA, 20-22 November 2011.

Delgado, J.A., J. Alwang, C. Monar, L. Escudero, A.K. Saavedra, V. Barrera and R. Botello. 2012. A new nitrogen index to assess sustainability of cropping systems of Andean Regions of South America. Poster presented at the 67th Annual SWCS International Conference, Fort Worth, Texas, 22-25 July 2012.

Halbrendt, J., S. Gray, S. Crow, L. Shariq and B.B. Tamang. 2012. Using fuzzy cognitive mapping to understand farmers' perception of sustainable agricultural practices for enhanced food security in Nepal. Poster presented at the 24th Annual University of Hawaii at Manoa's College of Tropical Agriculture and Human Resources and College of Engineering Student Research Symposium, Honolulu, HI 13-14 April 2012.

Harman, M. 2012. Local soil knowledge and gendered landscapes in Bolivia and the Philippines: Can GIS tell their story?. Poster presented at the Annual Meeting of the Association of American Geographers in New York City, NY 26 February 2012.

Larochelle, C. and J. Alwang. 2012. Access to information, gender relations and access to potato markets in the Jatun Mayu watershed located in Tiraque, Bolivia. Poster presented at the International Associated of Agricultural Economists Triennial Conference, Foz de Iguacu, Brazil, 18-24 August.

Larochelle, C. and J. Alwang. 2012. Market participation decisions and market choices: A case study of Bolivian potato farmers. Poster presented at the International Association of Agricultural Economists Triennial Conference, Foz de Iguacu, Brazil, 18-24 August.

Naab, J.B., and P.V.V. Prasad. 2011. Influence of conservation agricultural practices on maize and soybean yield in Upper West region of Ghana. Poster presented at the Second International Conservation Agriculture Workshop and Conference in Southeast Asia, Phnom Penh, Cambodia, 4-7 July 2011.

Paudel, B., T.J.K. Radovich, J. Halbrendt and K. Thapa. 2012. Potential of Conservation Agriculture Practices (CAPs) in enhancing food security of tribal people in central mid-hills of Nepal. Poster presented at the 24th Annual University of Hawaii at Manoa's College of Tropical Agriculture and Human Resources and College of Engineering Student Research Symposium, Honolulu, HI. 13-14 April 2012.

Pradhan, A., J. Halbrendt, C. Lai, T. Idol, C. Chan-Halbrendt, C. Evenson, C. Ray, P.K. Roul and K.N. Mishra. 2012. A comparative study of conservation agriculture production systems (CAPS) for tribal people of Odisha, India . Poster presented at the 24th Annual University of Hawaii at Manoa's College of Tropical Agriculture and Human Resources and College of Engineering Student Research Symposium, Honolulu, HI. 13-14 April 2012.

Reed, B.F. 2012. Tribal farmer preferences for conservation agriculture production systems: An application of Analytic Hierarchy Process. Poster presented at the 22nd Annual Hawaii International Tropical Fruit Conference, Honolulu, HI, September 13-16, 2012.

Reed B.F., C. Chan-Halbrendt, J. Halbrendt, T.J.K Radovich, S. Crow and P. Limbu. 2012. Improving food security in Nepal: An economic analysis of conservation agriculture adoption in three subsistence farming villages. Poster presented at the 24th Annual University of Hawaii at Manoa's College of Tropical Agriculture and Human Resources and College of Engineering Student Research Symposium, Honolulu, HI 13-14 April 2012.

Testen, A.L and Backman, PA. 2011. Atahualpa's revenge: the spread of quinoa downy mildew. Poster presented at the Northeastern Division The American Phytopathological Society.

Testen, A.M. and P. A. Backman. 2012. Detection and incidence of *Pernospora variabilis* in quinoa seeds. Poster presented at the 2012 Penn State University Graduate Research Exhibition in University Park, Pennsylvania, 25 March 2012.

Testen, A.M. and P. A. Backman. 2011. First report of quinoa downy mildew in the United States: implications for global quinoa production. Poster presented at Northeast Division of the American Phytopathological Society in New Brunswick, New Jersey, 12 - 14 October 2011.

Ares, A., K. M. Moore, M. Kelly and M. Mulvaney. 2011. Research strategy report. SANREM CRSP Working Paper No. 01-12

Moore, K.M., J. N. Lamb, R. Laker-Ojok, J. Nyachwo, D. N. Sikuku, D.S. Ashilenje, E. J. Mukhwana, B. Bashaasha, and J. Norton. 2012. Agricultural actors, networks and mind-sets: Discovering the predisposition for CAPS in the Mt Elgon region of Uganda and Kenya. SANREM CRSP Working Paper No. 01-12.

Moore, K.M., M. V. Marake, M. Hawkins, and D. Lambert. 2012. Agri-'culture' and farmer identity in Botha-Bothe District: The context for conservation agriculture. SANREM CRSP Working Paper No. 02-12.

WWW Sites and Documents

Christie, M.E. CCRA-7: Gendered perspectives for conservation agriculture. http://www.oired.vt.edu/sanremcrsp/professionals/research-activities/phase4/ccras/ccra7/.

Pradhan, A., C. Chan-Halbrendt and P.K. Roul. 2012. Sustainable management of Agroecological Resources for Tribal Societies (SMARTS): University of Hawaii and Orissa University of Agriculture and Technology.

Fact Sheets (Small Ext. Pubs)

LIBIRD. 2012. Sustainable Management of Agriculture Economic Resources for Tribal Societies. Pokhara, Nepal: Local Initiatives for Biodiversity, Research and Development (LIBIRD). Fact Sheet distributed to businesses, farmers and extension agents around Pokhara, Nepal, January 2012.

Tamang, B.B. and K. Thapa. 2012. Sustainable management of agriculture economic resources for tribal societies. Pokhara, Nepal: Local Initiatives for Biodiversity, Research and Development (LIBIRD)

Newsletters

Water Resources Research Center, University of Hawaii at Manoa. UH conservation agriculture project working to help tribal communities in India and Nepal. Water Resources Research Center, University of Hawaii at Manoa. 2011.

Videotapes/DVDs

Crow, S. and M. Panzella. 2012. Water Stable Aggregate Field Toolkit. Dept. of Natural Resources and Environmental Management. University of Hawaii at Manoa. Available at: http://www.youtube.com/watch?v=S1GogaMk8l8.

Magazine and Newspaper Articles

Barrera, V.H. and J. Alwang. 2012. Enhancing natural resources in Ecuador's highlands. New Agriculturalist.

Other

Agriesti, K. 2012. Ethnopedology Annotated Bibliography: CCRA-7.

Agriesti, K. 2012. Political ecology and feminist political ecology annotated bibliography: CCRA-7.

Christie, M.E. 2011. CCRA 7: Gendered perspectives for conservation agriculture. SANREM CRSP household soil survey.

SANREM CRSP leveraged funding, FY2011

Table 60. SANREM CRSP leveraged funding

Brief description or title of activity being funded or supported[1]	Leader name	Leader institution	Funding period (start year end date)[2]	Source of funds or support[3]	Non-tracked funding or support contributing to SANREM activities[4], $	Funding or support for non-SANREM activities resulting from SANREM activities[5], $
Conservation agriculture and natural resource management in Saraguro, Provincia de Loja, Ecuador	Barrera	INIAP	2010-2012	SENACYT, Govt. of Ecuador	$500,000	
Graduate studies in plant pathology at Penn State University	Backman	Penn State	2010-2011	Penn State scholarships and stipends (4 students)	$93,000	
Graduate studies in agricultural economics at Virginia Tech	Alwang	Virginia Tech	2010-2011	Department of AAEC	$40,000	
Nursery construction for reforestation, erosion reduction, and agroforestry	Barrera	INIAP	2010-2011	USAID/Ecuador small project fund	$5,000	
Establishment of a small-scale facility to produce bio-inputs for agricultural production	Barrera	INIAP	2010-2011	USAID/Ecuador small project fund	$5,000	
Support for project activities to enhance NRM in Chimbo area	Barrera	INIAP	2010-2011	INIAP-SENESCYT	$12,000	
Application of SANREM-generated NRM and CA practices to Saraguro, Loja Province	Barrera	INIAP	2010-2011	INIAP-MAE		$16,000
INTSORMIL - CRSP	Prasad	Kansas State Univ.	Oct 2010 - Sep 2011	USAID	80,000	
USAID - Mali Mission - Research	Prasad	Univ. of Nebraska	Oct 2010 - Sep 2011	USAID	92,000	

Borlaug LEAP Fellowship	Jay Norton/ Jeremiah Okeyo	University of Wyoming	Oct 1, 2011- Set 30, 2012	UC Davis	$20,000	$20,000
Thesis support for student	Stephane Boulakia	PADAC	Jun 2010 to May 2011	PADAC	$10,000	
Support for Dr. Agustin Mercado and Dr. Victor Ella to attend second international conservation agriculture workshop and conference, Phnom Penh, Cambodia, July 4-7, 2011	Stephane Boulakia	CANSEA	Jul 4-7, 2011	CIRAD	$4,000	

USAID common indicators for SANREM CRSP

Table 61. USAID Common Indicators

Indicator	Documentation (list each relevant item by indicator category)
Beneficiaries	
Increases in smallholder income	$424/hectare (India); $329/hectare (Nepal); $405/hectare (Lesotho); 20% increase (Ghana)
Improved nutrition of smallholder families (increase in caloric and protein intake)	Potential increases of 182-213% protein and 5% increase in carbohydrate availability in Nepal and India
Health benefits (reduction in malnourishment)	
Number of male-headed rural households benefiting directly from interventions	272 (plus 1763 without gender)
Number of female-headed rural households benefiting directly from interventions	64
Number of partner organizations and active institutional members of those partner organizations	2099
Number of agriculture related firms benefiting directly from interventions	24
Number of producer organizations assisted/benefiting	29
Number of water user associations assisted/benefiting	
Number of trade and business associations assisted/benefiting	
Number of community based organizations assisted/benefiting	12
Number of women's organizations/associations assisted/benefiting	14
Number of new public-private partnerships assisted/benefiting	3

Indicator	Documentation (list each relevant item by indicator category)
Training	
Male participants in short-term training	3939
Female participants in short-term training	3435
Male participants in long-term training	42
Female participants in long-term training	36
Technologies	
Increase in crop yields	Yes, 20-30 percent; in one case over 200%
Decrease in production costs	Some, 40%; $26/hectare/year; $40/hectare/year
New technologies/management practices under research	69
Technologies or management practices being field tested	78
Technologies made available for transfer	22
Hectares under new technologies	3366
Number of farmers adopting new technologies	6371
Number of processors adopting new technologies	
New surveillance systems	9