



Conservation Agriculture as a Potential Pathway to Better Resource Management, Higher Productivity, and Improved Socio-Economic Conditions in the Andean Region



Host-Country Partners: Ecuador

- Instituto Nacional de Investigaciones Agropecuarias (INIAP), lead partner
- International Plant Nutrition Institute (IPNI)
- 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 (GPB); Alcaldía de Guaranda y Chillanes
- Sistema de Información Geográfica Agropecuaria (SIGAGRO-MAG)
- IPM Innovation Lab



Host-Country Partners: Bolivia

- Foundation for the Promotion and Research of Andean Products (PROINPA), lead partner
- Universidad Mayor de San Simón: Crops and Soils Department, Environment Department, CIFEMA (agricultural engineering center)
- Centro Regional Avaroa
- Sindicato Agraria Tiraque, Alcaldía de Tiraque
- USAID Food Security Program, Fundación Valles
- Forage Research Center (CIF)

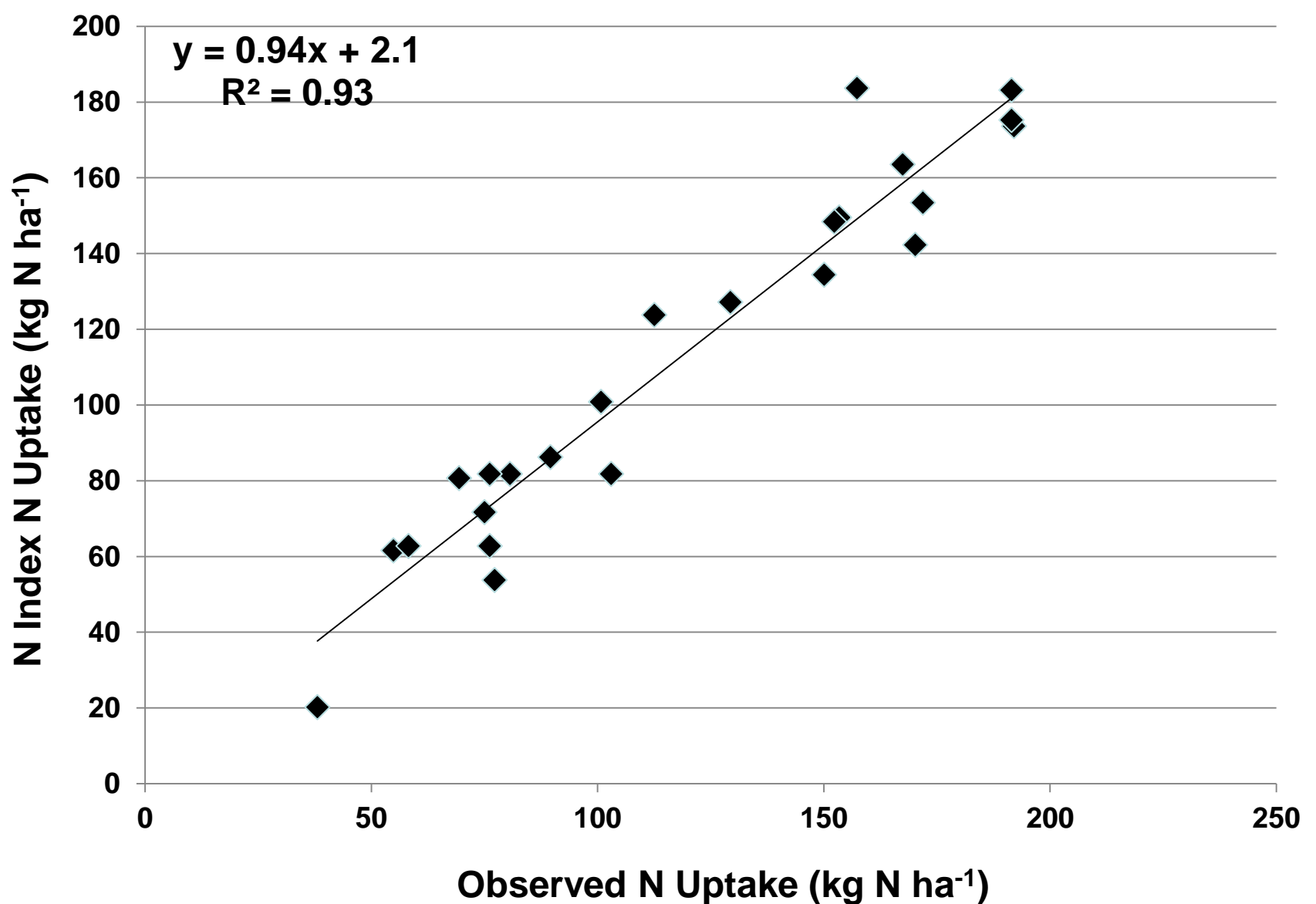


US Partners

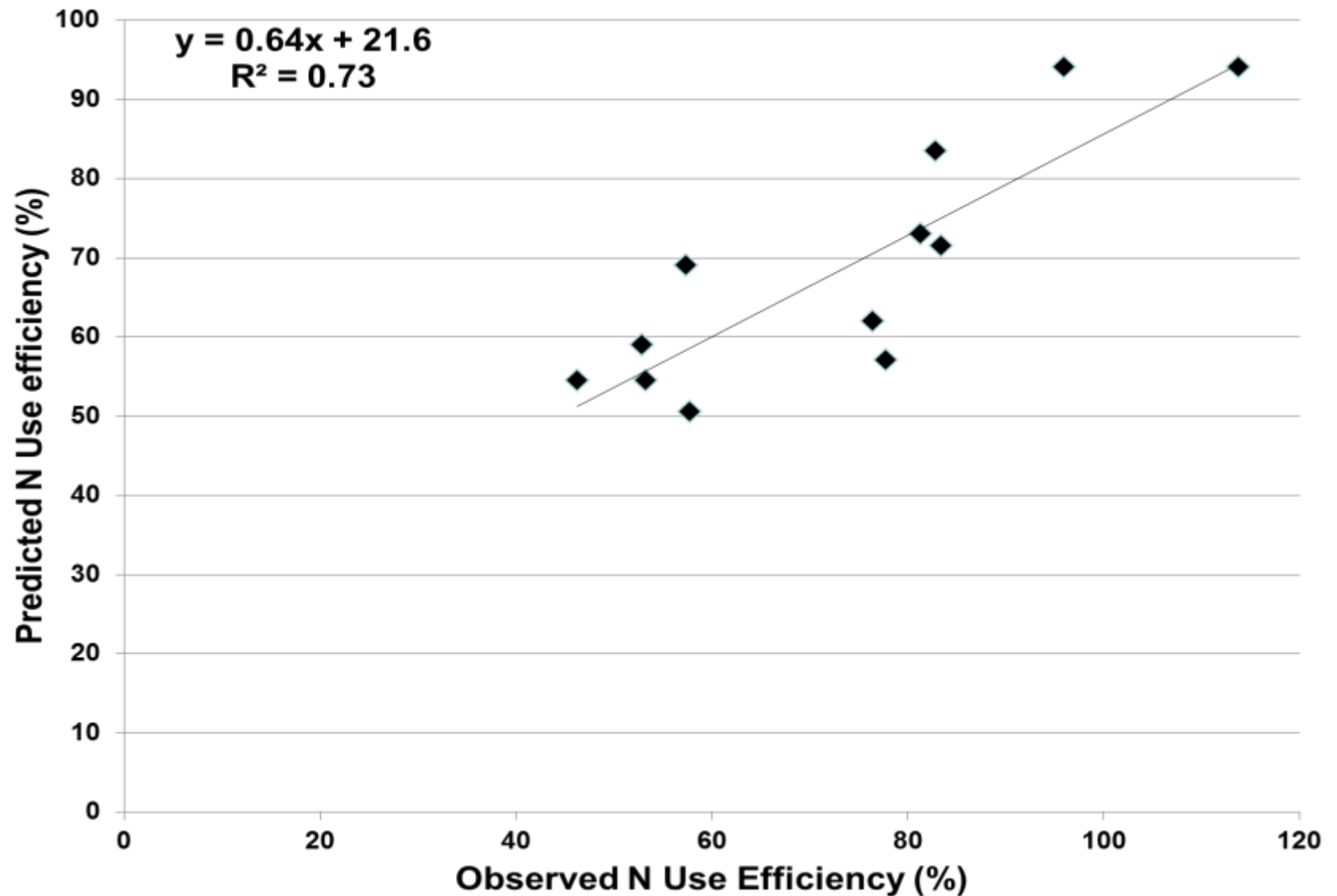
- Jeffrey Alwang Ag. and Applied Economics, Virginia Tech
- Darrell Bosch, Ag. and Applied Economics, Virginia Tech
- George W. Norton, Ag. and Applied Economics, Virginia Tech
- Sarah Hamilton, International Development, Univ. of Denver
- Richard Stehouwer, Crop and Soil Sciences, Penn State
- Rob Gallagher, Crop and Soil Sciences, Presbyterian College
- Jorge A. Delgado, Soil Plant Nutrient Research Unit, USDA/ARS, Fort Collins, CO
- Paul Backman, Plant Pathology, Penn State

Main Achievements to Date

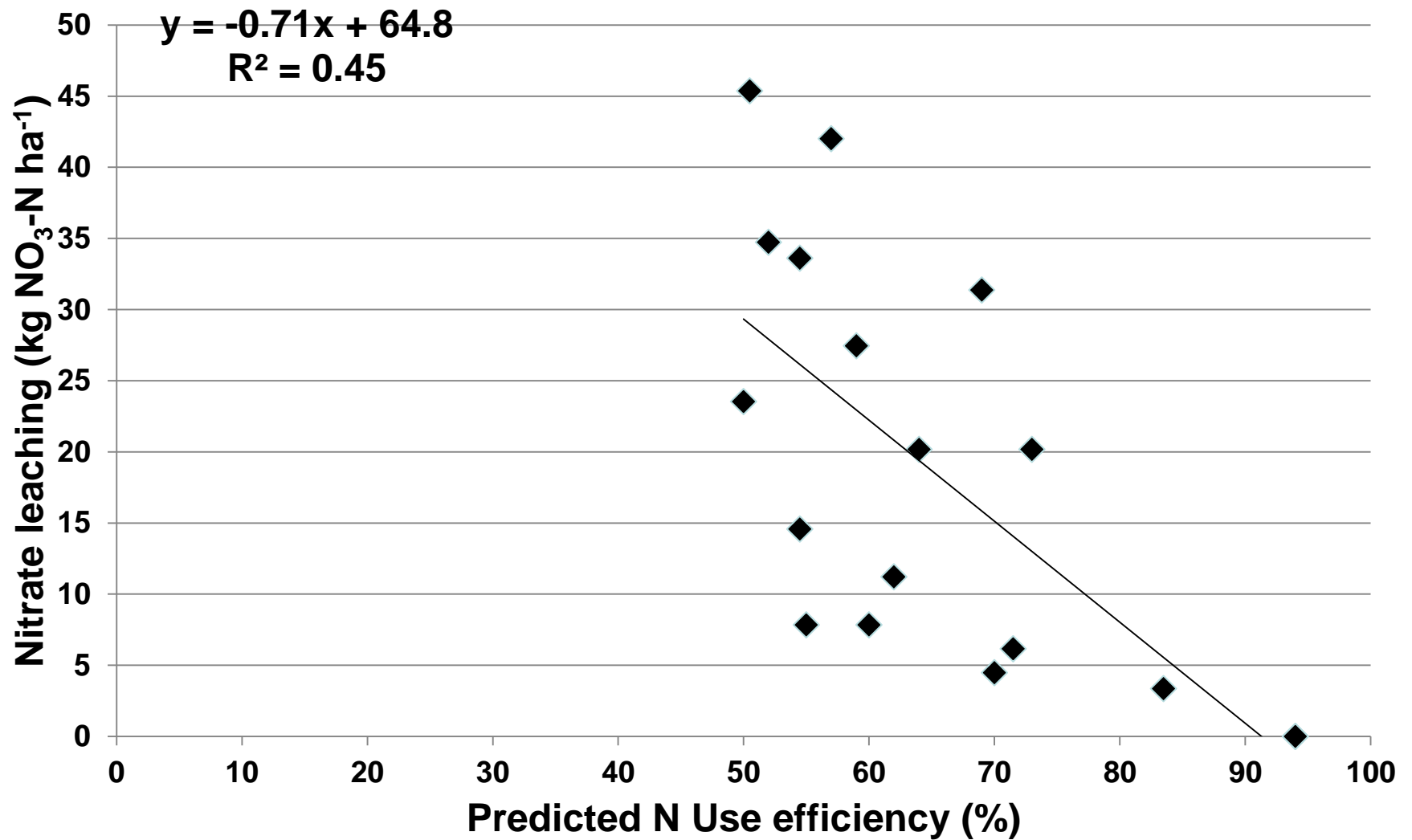
- Laboratory for soils analysis built in Bolivia; comprehensive training in soils analysis (both countries); accessible soils data base
- Field experiments conducted in both countries-in 4th year in cycle (in Ecuador)
- Satellite experiments to examine: plant growth (bacillus and others), phosphorus availability, water management
- Major involvement of local universities: student labor (tesistas), guide and manage research, and equipment development
- Created no-till seeder for quinoa (Bolivia)
- Analysis of CA impacts on: soil health (physical and chemical analysis); productivity and profitability; erosion, runoff and water quality
- Joint research with IPM Innovation Laboratory
- Nitrogen index (computer tool to assist technicians and some growers) calibrated and validated for both countries



The **Ecuador** Nitrogen Index's predictions of the above-ground N uptake for corn were compared to the measured (observed) total N crop uptake at six farmer fields, and found to be accurate ($r^2 = 0.93$; $P < 0.001$)



The N use efficiency estimated by the **Ecuador** Nitrogen Index was significantly correlated with the measured (observed) N fertilizer use efficiency ($r^2 = 0.73$; $P < 0.001$).



The nitrogen use efficiency (NUE) calculated by the **Ecuador** Nitrogen Index was correlated with nitrate leaching, and nitrate leaching potential decreases as NUE increases ($r^2 = 0.45$; $P < 0.01$).

TRABAJOS CON CIFEMA

Segundo prototipo



Other Achievements

- Formal student training: 5 MS (all female); 5 PhD (4 female); 13 UG (3 female); 13 students from host-country. Several SANREM graduate students have received prestigious awards
- SANREM internship program: 23 US undergraduate students have participated
- Informal training: last three years we have trained 987 males and 417 females in field days, short courses, workshops and others
- Substantial publicity for project: in Ecuador, SANREM has appeared at least 3 times on national TV
- SANREM-led symposium at the 2013 AAEA annual meetings
- SANREM special issue in Journal of Soil and Water Conservation

Research Results

- CA trials from Ecuador (2 watersheds) and Bolivia showing promise: saving labor, slightly higher yields, more soil retention
- Statistically significant increases in productivity and profits, but magnitudes are small
- Evidence of need for enhanced nutrient management: nitrogen and phosphorus
- No evidence to-date of CA impact on soil parameters
- CA for quinoa showing substantial potential
 - Water availability huge issue (particularly in Bolivia)
 - No till equipment now available to quinoa farmers
 - Yield trials showing yield increases with no-till quinoa (Bolivia)

Tillage and crop residue management effects on yields and nutrient cycling in AR CAPS



Evidence of accelerated erosion in the Alumbre sub-watershed due to tillage and lack of vegetative cover.

- Production intensification on steeply sloping Andisols in the AR has accelerated erosion.
- CAPS with decreased tillage and increased cover and return of crop residues can decrease erosion, but impact on yields and loss of animal fodder could discourage CAPS adoption.
- Investigated CAPS in two production systems:
 - pasture-potato-oats/vetch-barley
 - oats/vetch-bean-oats/vetch-maize

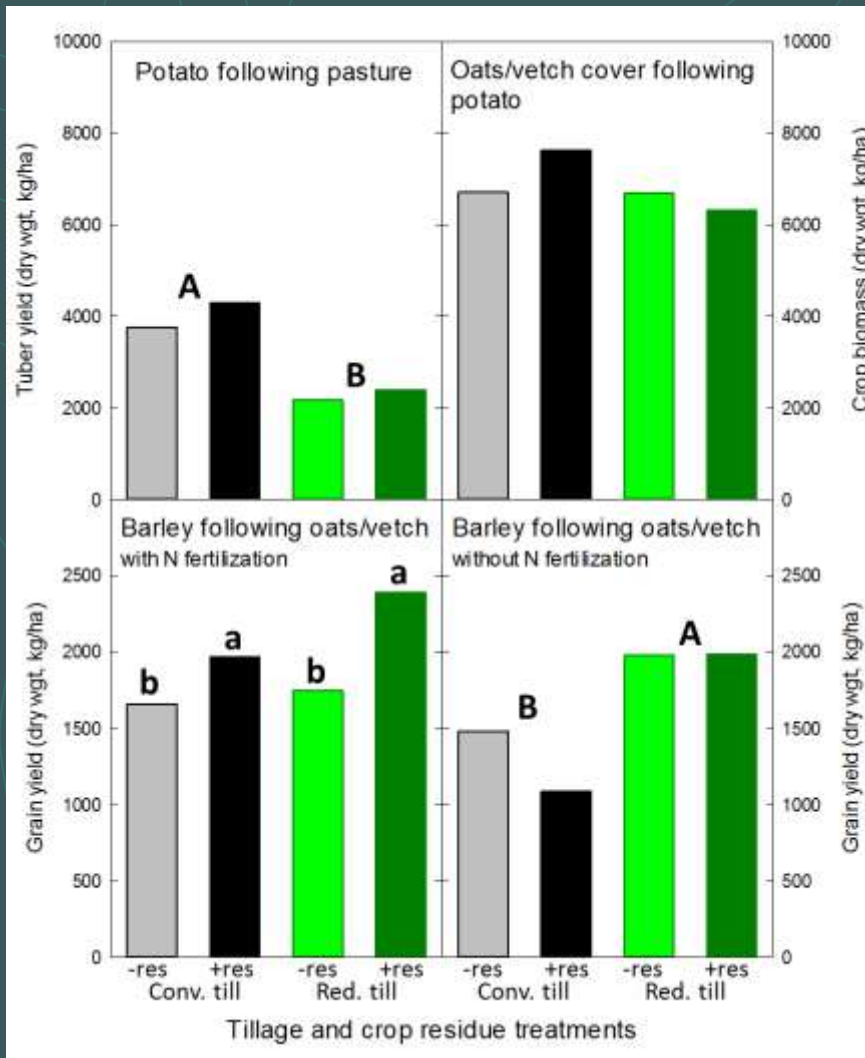
- Is there a yield penalty from reducing tillage?
- How much does returning crop residues decrease nutrient removal?
- Can decreased nutrient removal offset the need for fertilizer?

Illangama crop yields: Experiment One

Pasture-potato-oats/vetch-barley

Conventional and reduced tillage

Crop residues removed or left in field



Crop Yields

- Reduced tillage decreased potato yield in the first crop cycle, had no effect on oats/vetch, and increased barley yield when no N fertilizer was applied.
- Leaving residue in the field only increased barley yield when N fertilizer was applied.

Illangama crop yields: Experiment One

Pasture-potato-oats/vetch-barley

Conventional and reduced tillage

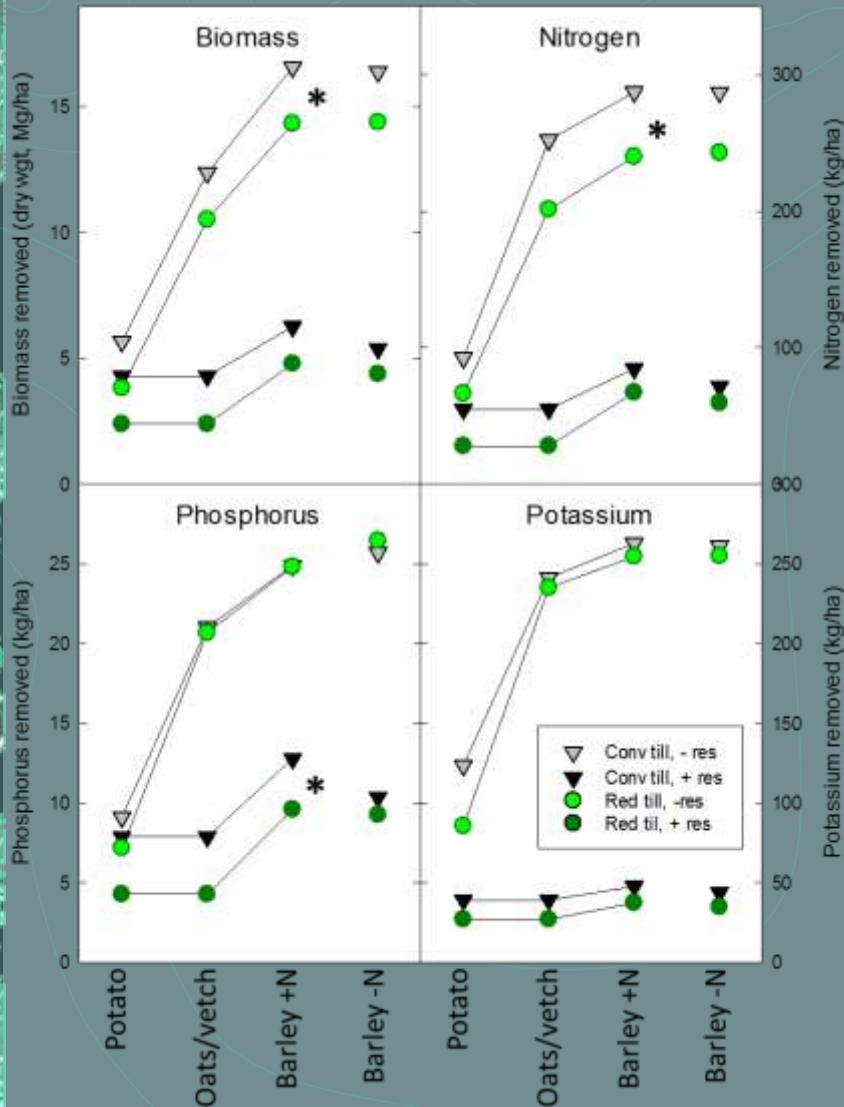
Crop residues removed or left in field

Cumulative biomass and nutrient removal

- Removing crop residues resulted in a 3 – 5 fold increase in the amount of biomass and nutrients removed from the system

- The oats vetch cover crop accounted for most of the difference.

- Difference in nutrient removal is comparable to nutrient uptake by barley and potato crops.



Illangama crop yields: Experiment One

Pasture-potato-oats/vetch-barley

Conventional and reduced tillage

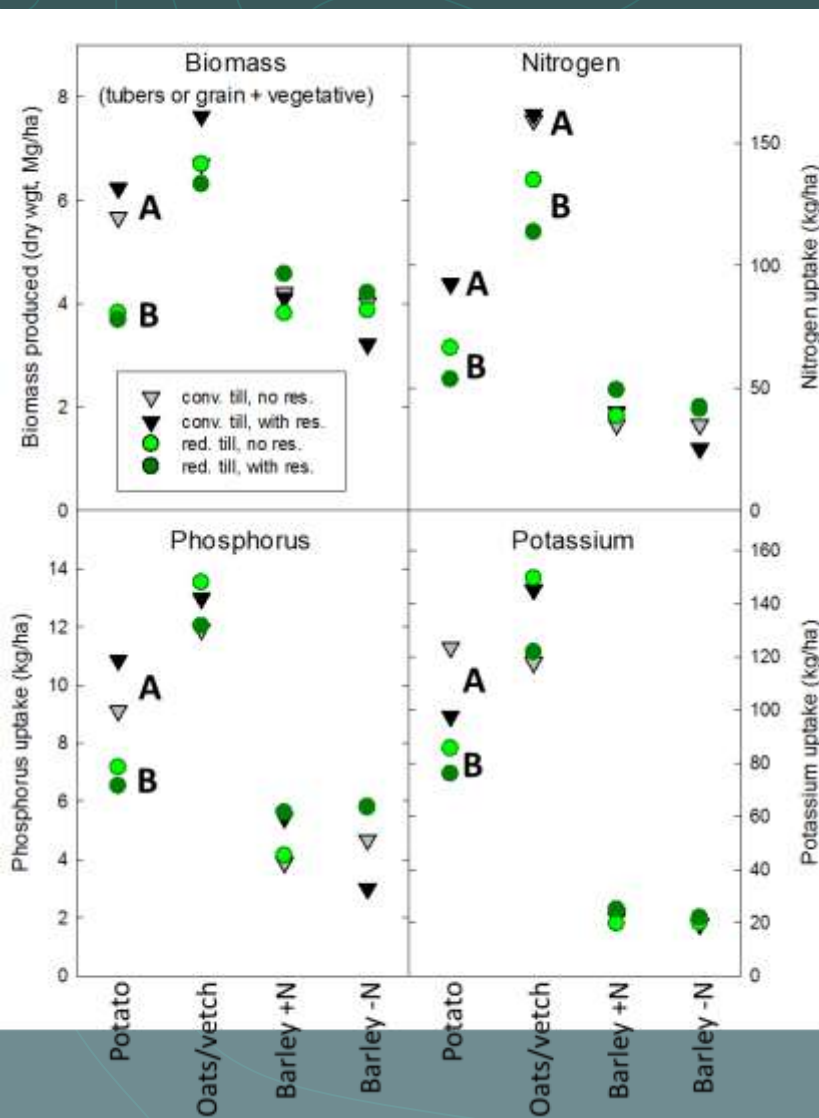
Crop residues removed or left in field

Biomass production and nutrient uptake

Reduced tillage reduction of potato yield was reflected in decreased biomass production and N, P and K uptake.

Tillage did not affect biomass and nutrient uptake by barley

However the large increase in system nutrients from oats/vetch residue did not increase barley biomass production or nutrient uptake.



Illangama crop yields: Experiment Two

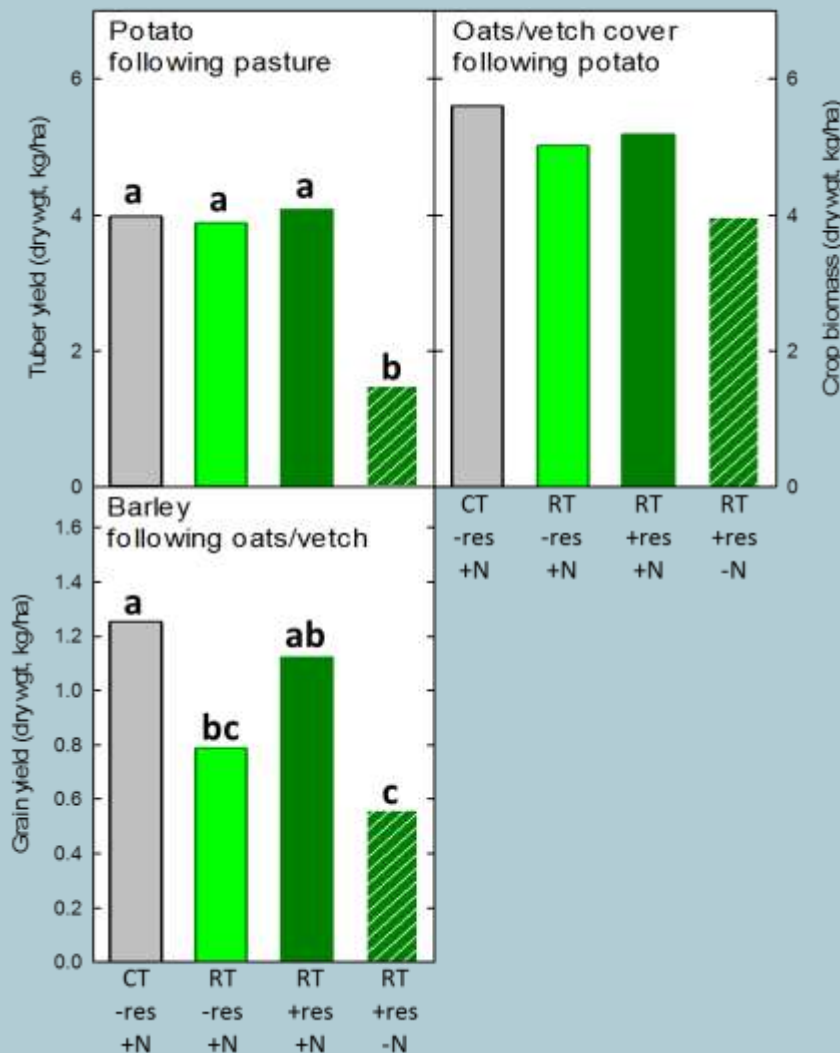
Pasture-potato-oats/vetch-barley

Conventional and reduced tillage

Crop residues removed or left in field

Crop Yields

- Tillage and residue management did not affect potato yield in the first crop cycle.
- No N fertilizer applied to potato decreased potato yield, as well as that of subsequent crops.
- An apparent barley yield reduction from reduced tillage was compensated for by leaving crop residue in the field.

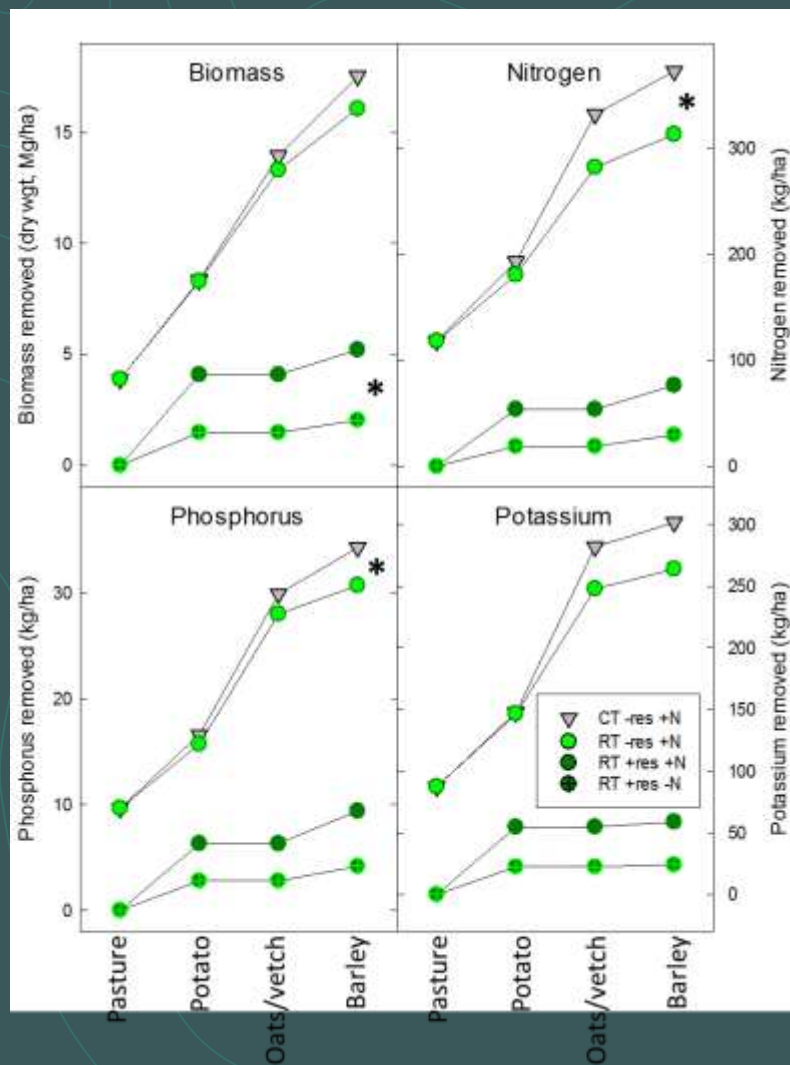


Illangama crop yields: Experiment Two

Pasture-potato-oats/vetch-barley

Conventional and reduced tillage

Crop residues removed or left in field



Biomass and nutrient removal

- Removing crop residues resulted in a 3 – 5 fold increase in the amount of biomass and nutrients removed from the system,
- The oats vetch cover crop accounted for most of the difference.
- Reduced tillage decreased some nutrient removal due mainly to decreased biomass production.

Illangama crop yields: Experiment Two

Pasture-potato-oats/vetch-barley

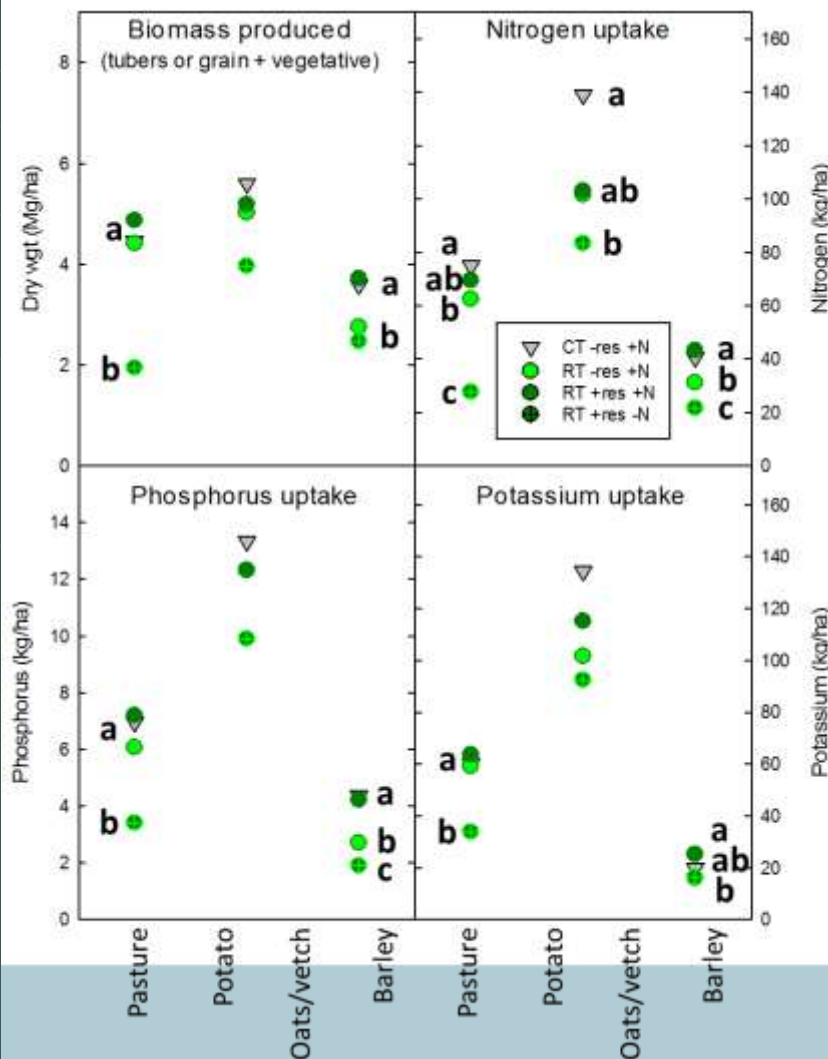
Conventional and reduced tillage

Crop residues removed or left in field

Biomass production and nutrient uptake

Not applying N fertilizer to potato decreased N uptake of all crops, and biomass production and P and K uptake of potato and barley.

The decrease in barley biomass production and nutrient uptake from reduced tillage was offset by not removing oats/vetch residues.



Conclusions

- Reductions in tillage intensity initially decreased crop yields
- The yield penalty from decreased tillage appears to diminish or even reverse with subsequent crops in the cycle.
- Substantial decreases in removal of biomass and nutrients can be achieved by leaving crop residues and cover crops in the field.
- Leaving oats/vetch cover in the field increased barley yield and nutrient uptake, however residues did not compensate for decreased fertilizer inputs.
- Leaving crop residues in the field compensated for the yield penalty associated with reduced tillage in barley.
- Yield and nutrient uptake benefits of not removing crop residues did not appear until the third crop in the cycle. This benefit may increase with subsequent crop cycles. Longer term research is needed to test this possibility.
- Short-term results do not indicate residues could offset fertilizer inputs.

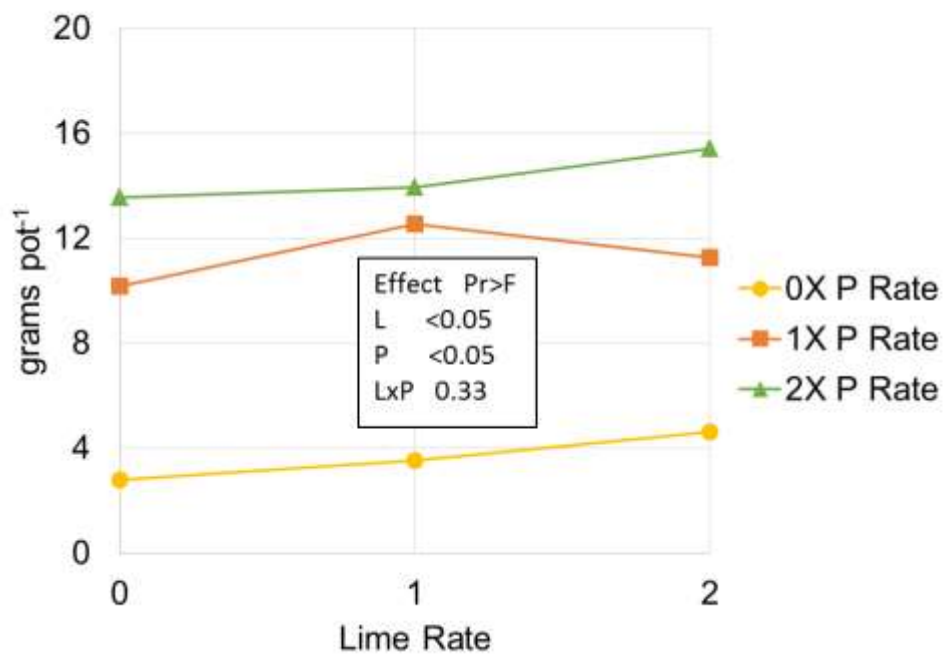
Andisols are unique soils developed from volcanic ash parent material. Andisols irreversibly sorb large amounts of phosphorus, thus P nutrition is limiting and large annual additions of P fertilizer are needed to improve production.



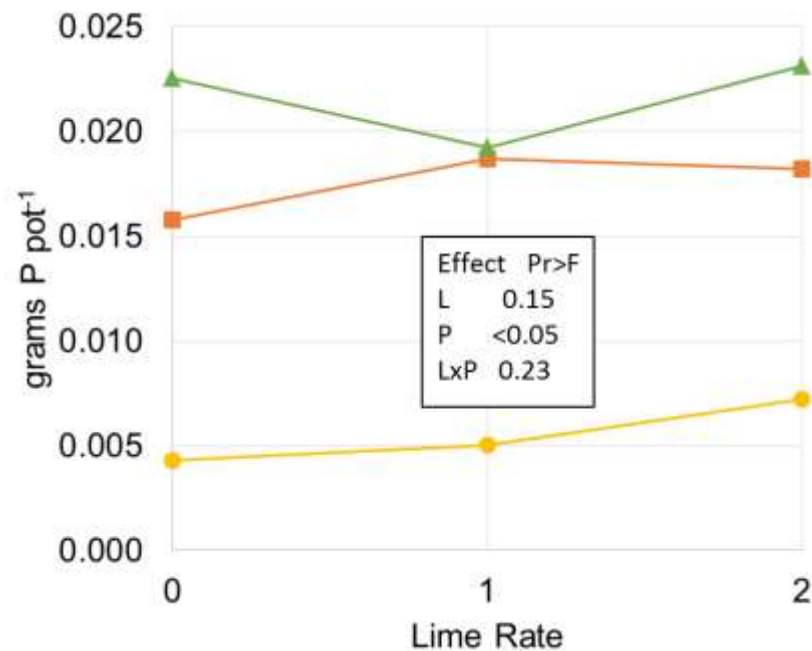
- Some evidence in the literature that liming acid Andisols could decrease their P sorption capacity.
- Investigated if application of lime and P fertilizer will improve P fertilizer response and P uptake.

Plant biomass was increased by lime and by P fertilizer amendments, however there was no interactive effect. P uptake was not changed by liming.

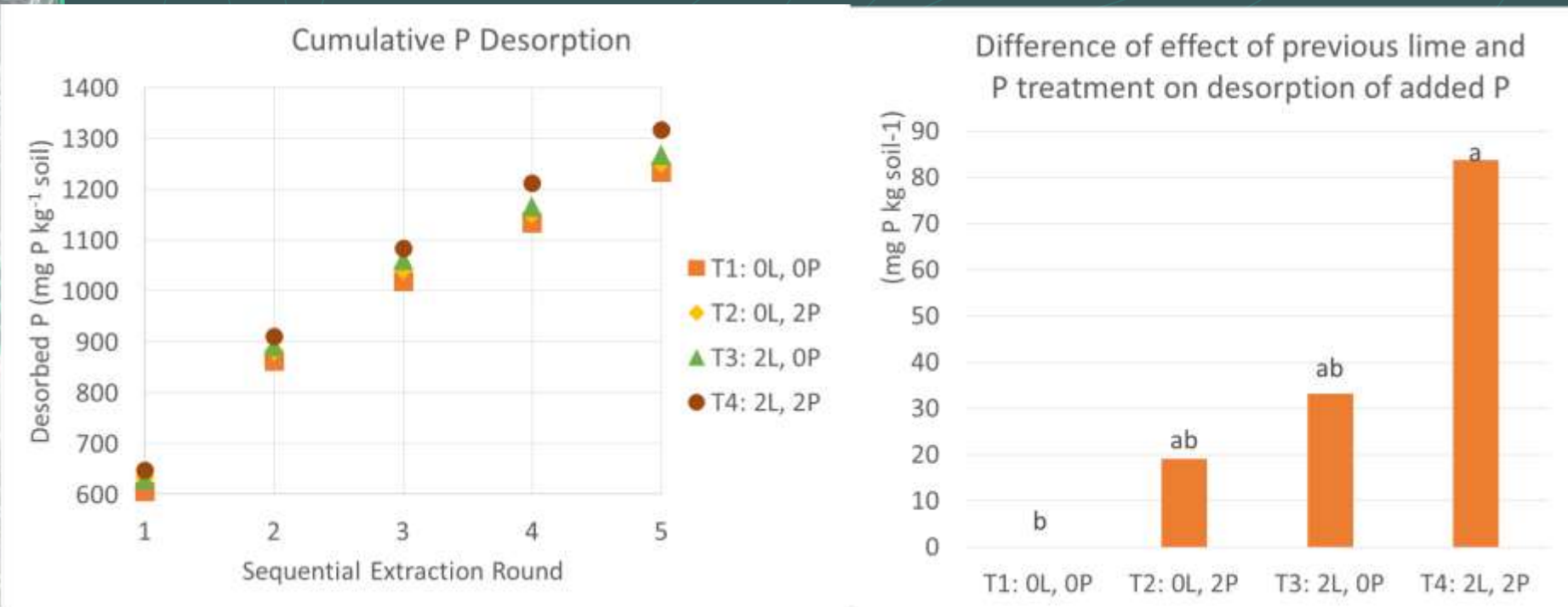
Dry Plant Biomass



P Uptake



In laboratory studies when P was added to previously limed soils P desorption was increased by lime.

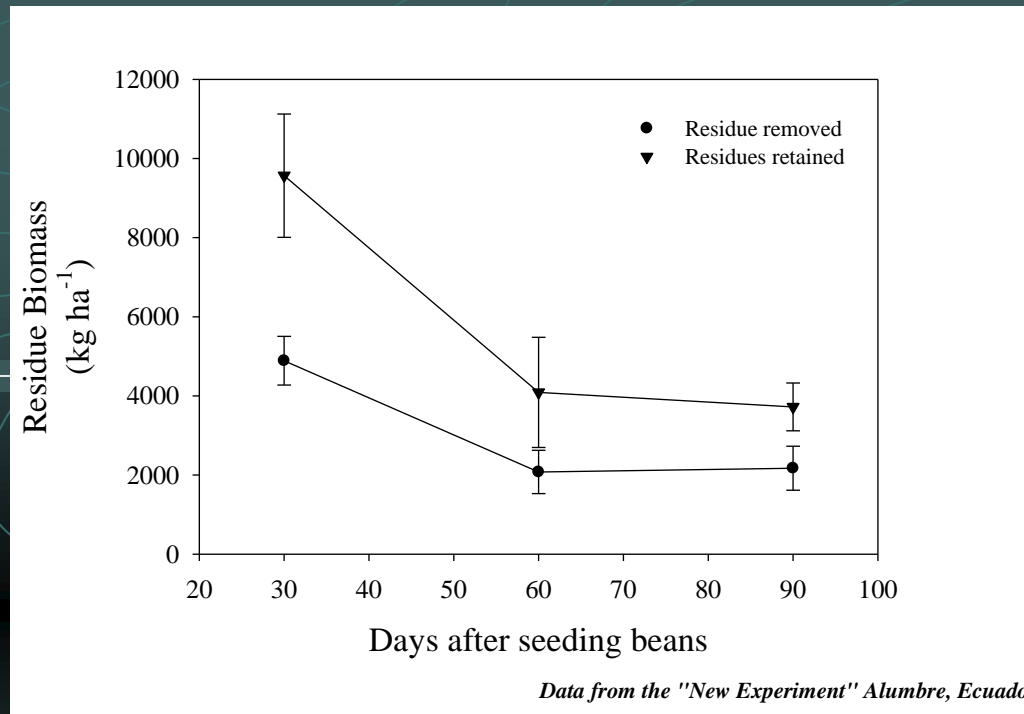


Liming may increase P availability in soils for subsequent crops. Future research should focus on effects of liming on plant response over multiple cropping cycles.

Summary of results from Alumbre (maize-beans) trials

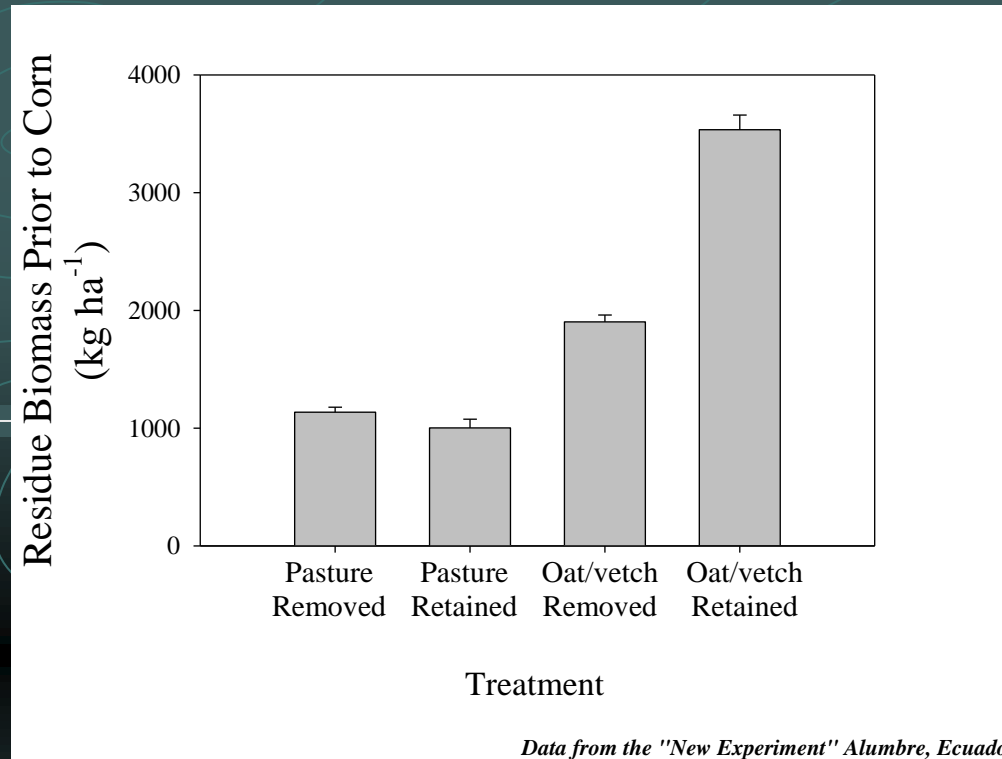


Although retaining surface residues resulted in higher soils surface cover throughout the (bean) cropping season, residue amount did not influence labile soil N & C levels or yield parameters.



Conservation benefits of CAPS may (at times) come at an economic expense to farmers, making adoption a challenge.

In the corn phase of this experiment, the oat/vetch cover crop produced considerably more biomass than the natural pasture, but did not necessarily affect labile N & C and yield parameters.



CAPS effects may be difficult to detect in the short term in field sites with a high degree of spatial variability.



Summary points: Alumbre

- CAPS technologies (cover crops, residue retention, reduced tillage, etc.) are agronomically feasible for High Andes cropping systems.
- Impact on biophysical soil/crop properties may not be apparent in the short-term.
- Moving from “look – see” type experiments to more rigorous mechanistic data collection has huge logistical (i.e. remote field sites) and institutional (i.e. equipment & supplies, familiarity with protocols) hurdles to be overcome.



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Thank you!