The LTRAS Century

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http://agronomy.ucdavis.edu/LTRAS/homepage.htm University of California, Davis

LTRAS as a Research Facility

Because LTRAS is a 100-year experiment, the effects of current research activities on the long-term value of the site is a constant concern. In some ways, there are fewer restrictions on research at LTRAS than at other long-term sites. For example, the Long-Term Ecological Research in Row Crop Agriculture project in Michigan has designated sampling areas in each plot which are accessible only by a designated path. (Like LTRAS, they also have areas set aside in each plot for higher-impact activities.) This issue of *The LTRAS Century* discusses research opportunities at LTRAS (mainly from a student perspective) and the mechanisms we have developed to minimize conflict between long- and short-term goals.

Our primary long-term goal is to determine which of the ten cropping systems at LTRAS are sustainable, i.e., able to maintain yields indefinitely, without requiring ever-increasing inputs, and without unacceptable impacts on the environment. Any objective measure of sustainability will require decades of data showing long-term trends in system performance, including yield, resource use efficiency, and losses of nitrate and pesticides to the environment. Short-term comparisons of cropping systems are also worthwhile, but only long-term experiments like LTRAS can uncover problems that may take decades to develop (see "Surprises", p. 3.)

Long-term experiments are expensive, so another goal is to develop and test scientific hypotheses that will let us generalize our results to other locations and other cropping systems. To do this, we try to encourage wide-ranging research at LTRAS by UCD faculty and their students and postdocs, to identify key system components and to analyze their interactions. Our research approval procedures (see p. 2), are intended to minimize conflicts among current and future researchers at LTRAS.

Akbar Abshahi Yazdi Retires

The first member of the LTRAS staff is retiring. Akbar Abshai Yazdi earned an undergraduate degree from the University of Tehran and MS and PhD degrees from UC Davis. He was the first LTRAS staff member, hired by former director, Montague Demment. His long-term legacy will include databases used to record details of farm operations, as well as data from the on-site weather station, which he also maintained. We will miss his cheerful attitude, whatever the weather. Best wishes from all of us!

A Grad Student's Experience at LTRAS

by Martin Burger (advised by Louise Jackson)

I am interested in the short-term nitrogen (N) dynamics of soils that regularly go through wet/dry cycles. Since microbial activity, which mediates N transformations, can be expected to differ with carbon availability, a comparison of responses to wetting in a high *vs.* a low organic matter input system is meaningful. Thus, the sufficient (conventional) and organic tomato system at LTRAS were chosen.

The LTRAS site has been ideal for my research in many respects because the different cropping systems maintained there are in close proximity of each other, and sampling sites can be chosen to be on the same soil type. Management of these systems is consistent, *e.g.*, there will be no sudden changes in farming practices that could jeopardize comparisons or interpretation of results.

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Undergraduate Research at LTRAS

by Cynthia "Simon" Hsu (advised by Kate Scow)

The intimate association between soil microorganisms and plant nutrient cycles raises questions about the feasibility of manipulating soil microbial populations to optimize nutrient availability and/or prevent nutrient losses from the soil system. A first step in exploring this potential is understanding what factors affect soil microbial activity or the microbial biomass, and how soil microbial populations respond to these factors.

In the spring of 1995, soil samples were taken from 12 of the LTRAS winter wheat field plots to test whether microbial activity or biomass were affected by the form of nitrogen applied (fertilizer or winter legume cover crop), or by the amount of water applied (supplemental irrigation or rainfed only). The plots were sampled on three dates (4/15/95, 5/16/95 and 6/18/95) and samples (3 per treatment) were analyzed using standard procedures to estimate microbial activity rates and biomass levels.

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This experiment was conducted in the second year of the LTRAS project. The results showed that after only one 2-year rotation, significant differences were detectable in both microbial activity rates and biomass levels, supporting the theory that microbial biomass assays may be a valuable indicator of changes in the soil system that result from changes in agricultural management practices. The major findings in the project were:

1) the use of a cover crop had a more pronounced affect on microbial activity and biomass than irrigation practices, specifically cover crop treatments showed significantly higher activity rates and biomass levels than fertilized treatments on 4/15 and 6/18 ($P < 0.05$);

2) the irrigated treatments had significantly higher microbial biomass nitrogen levels than the rainfed treatments on 6/18 ($P < 0.05$); and,

3) microbial biomass carbon levels were not significantly different for any of the treatments but had a highly significant negative correlation with final wheat yields ($r = -0.839$, $P < 0.001$).

The opportunity to design and implement a field-based research project as an undergraduate student was of immense value to me, especially in my decision to go on for an advanced degree. I think that access to the LTRAS fields to conduct undergraduate research, and the technical and field support I received from the LTRAS staff, were unexpected benefits that made my undergraduate education at UC Davis one of the best preparations for graduate study [at Cornell]. I hope other undergraduate students are able to take advantage of this unique resource while they are at Davis.

This project was funded by the President's Undergraduate Fellowship program and by the SDA/EPA Agriculture in Concert with the Environment program.

Martin Burger (continued from p. 1)

Setting up the field experiments required considerable planning and cooperation between the LTRAS field management and our lab group. For instance, scheduling and timing of irrigation had to be coordinated. In order to compare results, such as gaseous N emissions, measurements had to be taken simultaneously in both systems. This planning paid off and we were able to collect useful data at four key points during the cropping season. Removal and disturbance of soil was more problematic. To be able to use an ^{15}N-tracer under controlled conditions, we had to excavate intact soil cores in cylinders, and permission was only given if the cores were taken from a single bed. Permits have to be obtained for almost any type of sampling at LTRAS, and it is important to plan as far ahead as possible and allow for extra time for processing requests and subsequent communication with the field management.

Measurements of N_2O emissions, microbial biomass and inorganic N showed that responses to irrigation take place within hours. Activity declines after 2-3 d, especially in the surface because this layer dries out quickly. Yet, it is the surface layer where most microbial growth and inorganic N production occurs and where inorganic N is most concentrated. The next step of my research is to find out if tomato plants are able to exploit irrigation events by taking up a large amount of inorganic N during the short time-span between rewetting and drying out of the surface soil.

Another Grad Student's Experience

by Peter Brostrom (advised by Ted Hsiao)

I worked for two seasons in the LTRAS fields as a graduate student in Dr. Hsiao's Plant Water Laboratory. The objective was to develop baseline corn root length measurements for the organic and conventional treatments. Soil cores were taken at 30 cm depths to a depth below the root zone (close to 3m at full maturity) three times during the corn growing season. In the laboratory, the roots were washed out of the soil and then root length was measured using a grid root intersection method. Since the treatments are relatively new, no significant differences in root length densities were observed. It is expected that the greater amount of plant residue being added to the organic treatments will improve the soil structure over time. The improved organic soil structure should lead to differences in corn root length densities creating research possibilities for a future graduate student 20, 50 or 100 years from now.

Peter is currently Farm Manager at the Sustainable Agriculture Farming Systems (SAFS) project.

Current Procedures for Approval of Research Activities at LTRAS

Research activities at LTRAS are governed by the LTRAS Charter, which was unanimously approved in 1993 at a meeting to which all UCD faculty involved in LTRAS were invited. The entire Charter is available at **http://agronomy.ucdavis.edu/LTRAS/charter.html.**

The research activities approval process has two main objectives:

1) to minimize adverse impacts of one research project on others (current or future), and

2) when adverse impacts are unavoidable (and justified by the importance of the research) to provide a permanent record of the impacted locations so that they can be avoided by future researchers whose results might be adversely affected.

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Researchers wanting to collect samples or conduct other research at the LTRAS site are asked to complete a Research Authorization Request Form, which can be downloaded from the LTRAS web site. Use this form to explain what you want to do, where (which plots and locations within plots), when, and why. The completed forms are distributed to the LTRAS Executive Committee, which usually either approves the request or suggests modifications (intended to reduce the adverse impacts without compromising the goals of the research). The Committee has delegated to the LTRAS Director (currently R. Ford Denison) the authority to approve some activities (e.g., "soil sampling involving the removal of < 1 kg soil $plot^{-1}$ $year^{-1}$") without review.

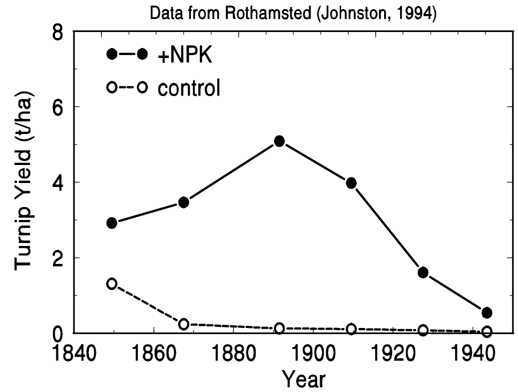
In some cases, the Executive Committee seeks guidance from the larger LTRAS General Committee, which has ultimate authority to set research policy under the LTRAS Charter. A recent example involved a proposal for the use of ^{15}N-enriched isotopic tracers at the site. The value of the proposed research was not disputed, but the addition of even small amounts of ^{15}N could invalidate another useful technique based on the natural abundance of N isotopes. After much discussion (see **http://agronomy.ucdavis.edu/LTRAS/mtg98b.html**), it was decided to restrict the use of ^{15}N to one phase of each cropping system. Although the approval process requires some advance planning, virtually 100% of all requests have been approved in some form.

Once approved, the research approval forms provide a permanent record of research activities which may be consulted by future generations of researchers working at the site.

The LTRAS Charter also obligates anyone doing research at the site to share data collected, mainly so that future researchers will have access to data needed to identify long-term trends. First-publication rights are retained by the group collecting the data. (See the Charter for details of this policy.)

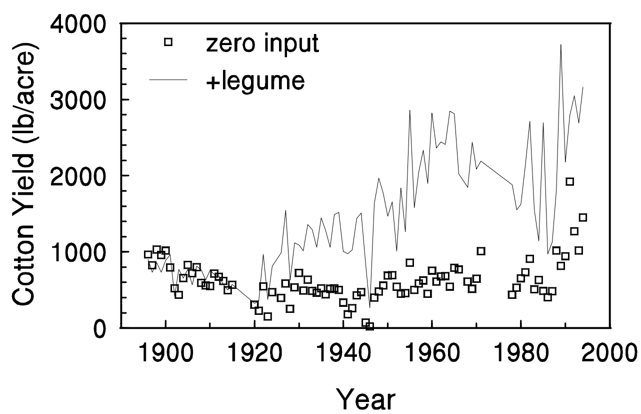
Surprise! Unexpected results from other long-term experiments

The combination of cropping systems at LTRAS makes it a valuable resource for various research projects, not all of which have a long-term focus. But it is important to recognize that a practice that appears to work well in the short-term may have serious negative long-term consequences. For example, turnip yields in the Agdell experiment at Rothamsted, England, declined to zero in a few years without fertilizer ('control' data in graph). Yields in the fertilized (+NPK) plots increased steadily for 40 years. An agronomist at the turn of the last century might have concluded that this four-year rotation was sustainable. But then yields began to decline, and in 1940



the system was abandoned. We now know that the N fertilizer was gradually acidifying the soil, but it took decades for the resulting change in soil microbial populations to cause severe root disease. (In another experiment at Rothamsted, continous wheat receiving NPK fertilizer is going strong after 150 years.)

Long-term experiments also sometimes show that practices that appear to be of limited value in the short-term have important long-term benefits. In Alabama's "Old Rotation," for example, winter legume cover crops (like those at LTRAS) did little to benefit cotton yields at first. During the first twenty years of this 100-year experiment, cotton yields in the cover crop treatment were similar to those in the unfertilized plots (see below). Yields in the cover crop system gradually improved, however, so that today they often exceed fertilized yields.



Short-term yield trends at Rothamsted or Alabama would have been very misleading as predictors of long-term sustainability. Trends in soil properties (e.g., soil acidification) may provide an early warning. Researchers working at LTRAS are monitoring various "soil quality indicators." Which of these will prove to be the best long-term predictors remains to be seen.

LTRAS in a Nutshell

LTRAS is now in the sixth cropping year of what is planned as a 100-year experiment. Long-term experiments are important, as results from other sites around the world show that short-term trends can be misleading. Some important soil parameters (such as organic matter) change over periods of decades rather than years, so up to 100 years may be needed to be certain which of our ten cropping systems are sustainable.

Researchers at LTRAS want to understand the relationship between sustainability and external inputs, especially irrigation water and nitrogen fertilizer. The ten cropping systems in the main LTRAS experiment differ in crops, N source, and use of irrigation (see below). Sustainability will be determined from long-term trends in yield, efficiency in use of limited resources (such as water), profitability, and environmental impact (such as leaching of nitrate or pesticides). We are monitoring trends in key soil properties, such as organic matter, weed seeds, pH, and salinity to see if any of these are good predictors for long-term sustainability.

Research at LTRAS supports efforts to design more sustainable cropping systems, including both environmental and economic considerations. We also expect to make important short-term contributions to agricultural science. Methods developed at LTRAS have already been applied in on-farm research. Although LTRAS is primarily a research and extension facility, we also contribute to UCD's teaching mission by hosting field trips, undergraduate interns and graduate student research.

LTRAS Staff Directory

- R. Ford Denison, Director; (530)752-9688; fax 2-4361; rfdenison@ucdavis.edu.
- Dennis Bryant; Assoc. Director; 2-5368; fax 2-4361; dcbryant@ucdavis.edu
- SRA (recruitment planned for 4/99)
- Sean Eldridge; Farm Equip. Mgr.; sjeldridge...
- Israel Herrera; Agric. Tech.; igherrera...
- Elizabeth Martini, Grad. Student; eemartini...
- LTRAS field facility phone: (530)757-3162**.**
- LTRAS field facility fax: (530)757-3158

Executive Committee

- Ted Hsiao; Land, Air & Water Resources.
- Robert Norris; Weed Science.
- Richard Plant; Agronomy & Range Science.
- Louise Jackson; Vegetable Crops.

The LTRAS Century is published approximately once a year. For a free subscription, send your name and address to:

R. Ford Denison/LTRAS
Agronomy & Range Science, UCD
Davis, CA 95616
email: rfdenison@ucdavis.edu

Cropping System	First Year	Alternate Year
rainfed wheat control (RWC)	Unfertilized rainfed wheat	fallow
rainfed wheat/legume (RWL)	Unfertilized rainfed wheat	rainfed legume cover crop
rainfed wheat/fallow (RWF)	fertilized rainfed wheat	fallow
irrigated wheat control (IWC)	Unfertilized irrigated wheat	fallow
irrigated wheat/legume (IWL)	Unfertilized irrigated wheat	rainfed legume cover crop
irrigated wheat/fallow (IWF)	fertilized irrigated wheat	fallow
conventional wheat/tomato (CWT)	fertilized irrigated wheat	fertilized irrigated tomato
conventional corn/tomato (CCT)	fertilized irrigated corn	fertilized irrigated tomato
legume/corn/tomato (LCT)	Legume cover crop followed by irrigated corn	fertilized irrigated tomato
organic corn/tomato (OCT)	Legume cover crop followed by corn w/ irrigation and compost	legume cover crop followed by tomato w/ irrigation and compost

The ten cropping systems (2-yr rotations) in the main LTRAS experiment differ in crops, N source, and use of irrigation and pesticides.