The LTRAS Century

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

Caught in the Web

You can now download *The LTRAS Century* from the World Wide Web address above. All five issues, including this one, are available to download. The LTRAS homepage also includes a list of publications from research at LTRAS, a staff directory (with email addresses), and a list of major supporters. We will try to keep these lists current.

The newsletters are stored in PDF format, so you will also need to download the Acrobat viewer (free from Adobe) if you haven't already done so. Permission is granted to print and copy the newsletter for non-commercial (e.g., classroom) use.

Our web page includes some photos of research at LTRAS as well as links to related sites.

Field Trip Tips

LTRAS has always been popular for field trips by classes at UC Davis. ASE110 (Agronomic Crops), PLB142 (Crop Ecology), PLB158 (Mineral Nutrition), and PBI225 (Field Methods) were among this year's visitors from UCD. More recently, we have been visited by classes from UC Berkeley and from Stanford. Here are some tips for faculty members considering a visit to LTRAS.

Contact us at least two weeks in advance. Someone from the LTRAS team should be present during your visit to answer questions and to recommend parts of the field where you can see the most interesting side-by-side comparisons that week. We will make sure that pesticide safety regulations regarding field entry are followed and we sometimes restrict vehicle entry under very wet or very dry conditions, to reduce road damage and dust problems.

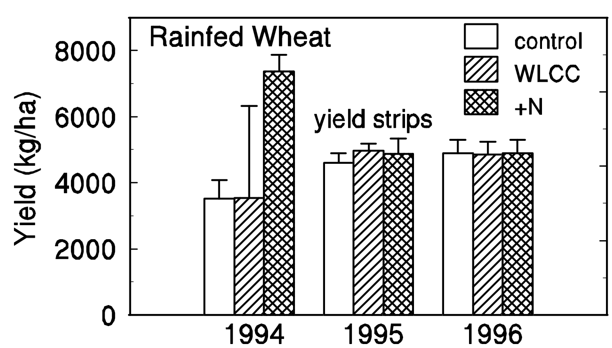
Fall is the least interesting time to visit. Corn (maize) is usually harvested in October, whereas wheat and winter legume cover crops haven't usually grown much until January or February. Otherwise, there is usually something growing and interesting comparisons among treatments to see most of the year.

LTRAS Symposium

The largest meeting to date of people doing research at the UCD's Long Term Research on Agricultural Systems (LTRAS) site took place January 23rd on the Davis campus. The 16 speakers included undergraduate and graduate students, UCD faculty and staff, a Yolo County farm advisor, and a visiting scientist from Japan. This issue of *The LTRAS Century* mainly contains summaries of some of the talks.

Are We Sustainable Yet?

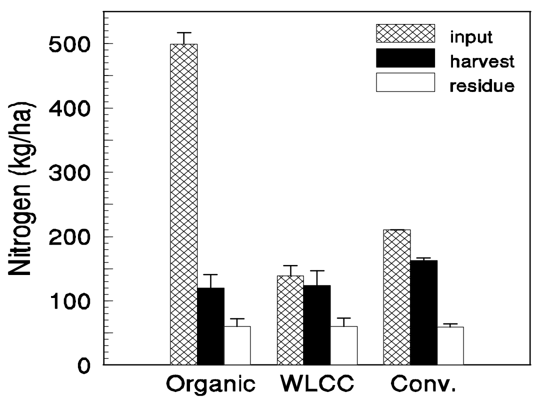
LTRAS Director **Ford Denison** opened the program by presenting yield data for the first three years. There have been some interesting interactions between cropping systems and years. For example, nonirrigated wheat which received nitrogen fertilizer had much higher yields than unfertilized wheat in 1994, but not after the unusually wet winters of 1995 and 1996. (None of the wheat plots harvested in 1994 had yet grown a winter legume cover crop, so it is not surprising that wheat yields of the WLCC system were almost identical to those of the unfertilized control in 1994.) A related interaction with wet winters was reported in the last issue.



It is too early to draw conclusions about the sustainability of our cropping systems, but Denison commented on the sustainability of LTRAS itself, mentioning various infrastructure improvements that increase research opportunities at LTRAS. Flooding was a serious problem in some plots in 1995 (overall yields were even lower than those in the nonflooded yield strips) and in 1996, mainly due to inadequate capacity of a drainage ditch shared by LTRAS and our neighbors. During the fall of 1996, this ditch was enlarged substantially. There has been no significant flooding since then, despite some heavy rains this past winter.

Nitrogen Budgets

Daryl Lee, a postgraduate researcher supported by a grant from the USDA/NRI Agricultural Systems program, presented data on overall nitrogen budgets of cropping systems at LTRAS. Comparisons among N budgets for corn in 1996 are graphed below.



There was a reasonable balance between N inputs and N removal in the grain, both for the conventional system and for WLCC system, in which N released by a WLCC (plowed under in the spring) provided the only N input during the growing season. The organic system, in contrast, had N inputs from compost as well as a WLCC. Total N inputs to the organic corn greatly exceeded N harvested in the grain. Some of the "extra nitrogen" presumably accumulated as soil organic matter, while some may have been lost to leaching or denitrification. We are currently analysing soil samples to see whether any increase in soil organic N can be detected yet in the organic system. Research related to leaching and denitrification is discussed below.

N Losses during Irrigation

Louise Jackson, a faculty member in Vegetable Crops, introduced a series of presentations by grad students **Erica Lundquist, Dianne Louie, Robin Miller, and Martin Burger**, all supervised by Jackson and her colleagues **Kate Scow** and **Dennis Rolston**, both of UCD's Department of Land Air & Water Resources (LAWR). They explained that nitrogen availability in agricultural soils is affected by seasonal changes in microbial activity as well as very short term pulses caused, for example, by rewetting of dry soil. The purpose of their project is to examine how irrigation and rainfall affect microbial activity and N cycling in organic and conventional management systems for tomatoes. The organic system uses a WLCC and composed poultry manure for fertility, and they found that it has higher soil microbial biomass and dissolved organic C than the conventional system, which uses inorganic fertilizer.

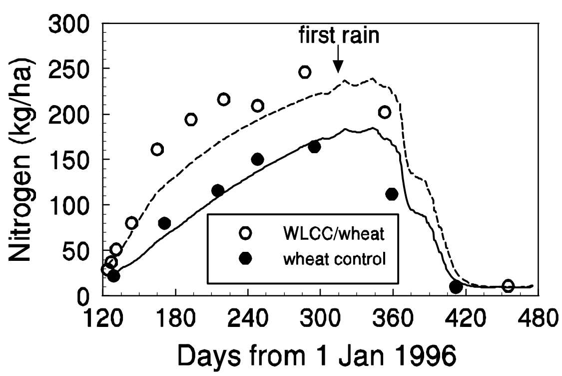
In late summer of 1995, they found that soil respiration and denitrification (conversion of nitrate to gaseous loss of N_2 and N_2O under anaerobic conditions) were higher and responded more quickly to rewetting in the organic system. On the surface, which experiences severe drying, there was a large immediate increase in microbial biomass and nitrate, followed by a decrease. These measurements indicate that soil activity is much more dynamic that generally thought, and that the resulting fluctuations in available N could be important for plant nutrition and losses of N to the environment.

At four key periods during the 1996 growing season, measurements of respiration, denitrification and soil N concentrations were made after rewetting soil by irrigation or simulated rainfall. In soil under the organic tomatoes, denitrification measurements were highest in April, after organic amendments had recently been incorporated into the soil. Microbial biomass C and N were significantly lower in October, in drier soil after the fall harvest, than at other sampling times. Soil nitrate typically declined during the 3-day period after rewetting the soil. In the conventional tomato/wheat rotation, denitrification was greatest in October, just after 100 lbs N/acre were added to fertilize the wheat. In general, denitrification was lower in the conventional soil, and peak denitrification occurred several hours later than in the organic soil, suggesting a less active denitrifying microbial population. Nitrate rarely declined during the 3-day sampling period in the conventional soil. These seasonal measurements suggest that N and C cycling are quite different in the two management systems through the growing season, and that a better understanding of the seasonality of microbial processes is important for understanding N availability, especially in the organic system.

To study microbial N dynamics more thoroughly following rewetting of dry soil, an experiment was conducted with cores of undisturbed soil in PVC cylinders taken from a conventional and an organic LTRAS tomato plot and set up in the greenhouse. To simulate furrow irrigation, water was fed simultaneously into all cylinders via tubes below the soil surface. Immediately after the wet-up, ^{15}N-nitrate was injected into the 0-5 cm layer of soil. At short intervals during 5 days, cylinders were dismantled for measurement of microbial biomass N and C, respiration rates, inorganic N and dissolved organic C. At the same time, denitrification rates were measured on a separate set of cylinders. The ^{15}N label will enable us to track the movement of nitrate and to compare denitrification rates with the overall N-budget of each cylinder. These data may show how soil C and N dynamics operate simultaneously, and how N availability changes in these soils subject to intermittent rewetting. Integration of the field and greenhouse work should provide information on the importance of pulse-type events for nitrogen cycling.

Computer Modeling of Soil Nitrogen

Hiroshi Hasegawa, a visiting scientist from Japan, concluded the “nitrogen session” of the symposium by presenting “Validation data to test the CERES models for predicting N release from winter legume cover crops.” In theory, these computer models can be used to predict crop yield, soil fertility, and leaching of nitrate, all of which are relevant to sustainability. But they have not been tested much in systems which obtain their N from winter legume cover crops. Hasegawa has collected field data (soil water, temperature, oxygen and mineral N content; biomass dry matter and N accumulations and crop yields) in the WLCC/maize, WLCC/wheat and fallow/wheat systems in 1996 and 1997.



Substantial amounts of inorganic N accumulated in the upper 80 cm of the soil during the summer fallow period, especially in the WLCC/wheat system (open circles, above), but most of this N was lost, during the first winter rains of 1996. The CERES models apparently underestimated N release after the incorporation of the WLCC (especially in the WLCC/corn system, not shown), but the models have not yet been corrected for the composition of the WLCC.

Molecular Signals or Substrates in Soil

Many of the processes that affect soil N are controlled by soil bacteria, but the factors controlling the bacteria themselves are not completely understood. **Don Phillips**, a faculty member in Agronomy and Range Science, described some interesting differences between systems at LTRAS with and without legume cover crops that may help to explain differences in microbial communities.

An improved method of extracting biologically important molecules from soil recovered significant quantities (mmol/kg) of nucleosides from both fallow/wheat and WLCC/wheat plots at LTRAS, with greater quantities in the WLCC/wheat system. Nucleosides are abundant in cells (e.g., in DNA), but intact bacterial cells accounted for less than 1% of the free nucleosides detected. These nucleosides may be available for use by some soil microbes and it is interesting that an increase in their abundance is already detectable in the WLCC/wheat system after only three years.

Soil Hydraulic Properties

The amount of nitrate and pesticides that leaches into the groundwater depends on the their concentration and on the rate of downward movement of water. Jan Hopmans, a faculty member in LAWR discussed his research on soil properties that affect movement and storage of water in soils at LTRAS. Soil cores were collected from the 25 cm and 50 cm depth and are being analyzed for soil water retention and unsaturated hydraulic conductivity. The goal of this study is to determine soil physical characteristics of all LTRAS plots, and to relate differences in physical characteristics to the soil and water management practices of the treatments. In addition to the hydraulic properties, soil texture and density will be measured. Moreover, it is suggested that the soil gaseous diffusion characteristics can be related to the hydraulic conductivity data. The measured soil hydraulic properties can be used as input to water flow and transport models. Moreover, they may serve as indicators for the monitoring of changes in soil quality of the LTRAS plots.

Corn Choices Confirmed

Yolo County Farm Advisor **Tom Kearney** described a three-year study conducted at LTRAS to determine the optimum corn variety and plant population (plants/acre) for corn grain production following a winter legume cover crop. On average, NC+4616 yielded 9% more under these conditions than Pioneer 3162, which is grown in our conventional corn/tomato system, although this apparent difference was not statistically significant. There was no significant effect of plant population over a range from 20,000 to 50,000 plants per acre, although yields were lower at 15,000 plants per acre. Our standard practice of using NC+4616 in the legume/corn/tomato system at 26,400 seeds per acre appears to be a good choice.

LTRAS in a Nutshell

LTRAS is now in the fourth cropping year of what is planned as a 100-year experiment. Long term experiments are important, as results from other long term 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 for a direct and unambiguous assessment of sustainability.

Researchers at LTRAS want to understand the relationship between sustainability and external inputs, especially irrigation water and nitrogen fertilizer. We are monitoring long-term trends in key soil properties, such as organic matter, weed seeds, pH, and salinity. Our 10 cropping systems (see below) differ in the kinds and amounts of nitrogen and water applied externally. 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 also expect to make important short-term discoveries of interest to farmers and researchers. Methods developed at LTRAS have already been applied in on-farm research. Information from LTRAS, together with other research at UC Davis and elsewhere, will be used to develop "leading indicators" for sustainability, such as computer models and new methods for soil and plant analysis. These improved research tools will help us to design new cropping systems with better performance. LTRAS is primarily a research facility, but it also contributes to UCD's teaching mission by hosting field trips, undergraduate interns and graduate student research.

The LTRAS Century is published approximately once a year. For a free subscription, send your name and address to:
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- Robert Norris; Weed Science.
- Richard Plant; Agronomy & Range Science.
- Louise Jackson; Vegetable Crops.

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.