The LTRAS Century

Long Term Research on Agricultural Systems

Issue 3 **University of California, Davis** **March, 1995**

LTRAS Seed Grant Program

The UCD Department of **Agronomy and Range Science** recently announced a one-time internal competitive "seed grant" program, to support UCD faculty doing research at LTRAS. Proposals to measure those "parameters and processes [most] likely to change significantly during the early years of the 100-year experiment" will be favored. The emphasis at LTRAS on long-term trends makes it particularly important to maximize sampling and field measurements during the first cropping cycle, which is now in progress.

Baseline funding for LTRAS is provided by the UCD **College of Agriculture and Environmental Sciences** (CAES) and the California **Division of Agriculture and Natural Resources** (DANR). Despite tight budgets, the college has made a long-term commitment to support a "core level of infrastructure" (staff salaries, farming operations and some essential data collection). However, CAES and DANR cannot provide the additional funds needed to fully exploit research opportunities at LTRAS.

We expect these additional funds to come mainly from external grants. For example, nine UCD faculty members recently submitted a $574,000 grant proposal to the USDA "Agricultural Systems" program to support research at LTRAS. Smaller grants, such as those recently received from **SAREP** and **WRC** (p. 5) are also important. A secondary objective of the LTRAS Seed Grant Program is to provide the preliminary data needed to write successful grant proposals.

Funds for LTRAS Seed Grants will be provided from a departmental endowment established in 1927 by **Mary J.L. McDonald**. In choosing among proposals of very similar quality and importance, proposals from faculty in Agronomy and Range Science will therefore have priority. Proposals including undergraduate research opportunities will also be favored. A request for proposals was sent to UCD Faculty on the LTRAS mailing list; additional copies may be obtained from Ford Denison at (916)752-9688.

Staff Changes at LTRAS

Dennis Bryant has been serving as Associate Director of LTRAS for the past year, taking on most of the responsibility for day-to-day project management in addition to his continuing involvement in field sampling and laboratory analysis. Dennis also often represents LTRAS in contract negotiations for sale of crops, major equipment purchases, etc.

After helping LTRAS get started, former LTRAS Farm Manager **Dave Mata** has returned to a position at the UCD Agronomy Farm. **Sean Eldridge** is the new Farm Equipment Manager at LTRAS.

Another recent addition is **Andy McGuire**, who is conducting his MS thesis research at LTRAS. He has established a two-year experiment (see plot map) examining the short-term effects of substituting a winter legume cover crop for the fallow year in rotation with winter wheat. His work complements the assessment of long-term effects in the main LTRAS experiment.

R. Ford Denison continues as LTRAS Director and **Akbar Abshahi** as Staff Research Associate. Phone numbers for permanent staff members are given on p. 4.

"That's Not Fair!" (part 2)

Issue 2 of *The LTRAS Century* explained that the systems approach used at LTRAS calls for "optimizing each [cropping] system within its own constraints." This approach prevents the errors that would result from forcing one system to work within the constraints of another, but it makes analysis of results more complicated, relative to more traditional (factorial) experimental designs.

For example, some delay in the seeding date for corn following a winter legume cover crop appears to be inevitable (at least with current technology), relative to corn receiving synthetic N fertilizer. (The delay includes the time required for maximum N accumulation by the legume cover crop, plus a three week delay after incorporation of the cover crop during which stimulation of the seed corn maggot by fresh cover crop residue makes seeding corn risky. Improvements in control of this pest, or development of a legume cultivar that could accumulate sufficient N in a shorter time, could allow earlier corn planting.) Delayed seeding of the conventional corn to match the seeding date of corn following a cover crop would underestimate the potential of the conventional system.

On the other hand, the corn cultivar best suited to the conventional system would not necessarily perform best in the two cover crop systems (see table on p. 4). Farm Advisor **Tom Kearney** recommended substituting a shorter-season cultivar, *NC+4616*, for the *Pioneer 3162* used in the conventional system.

Pioneer 3162 has consistently yielded very well with conventional management in the Sacramento Valley, but no information was readily available on the performance of *NC+4616* following legume cover crops. We therefore invited Tom Kearney to conduct a cultivar comparison for unfertilized corn following a vetch/pea cover crop (grown during the winter of 1993-94), using unassigned plot 8-6. The results supported his recommendation of *NC+4616* for the cover crop systems. *NC+4616* yielded 10,622 pounds per acre in 1994, relative to 9,686 pounds for *Pioneer 3162.* This experiment will be repeated in 1995, in plot 3-2.

Do the multiple differences between the conventional and alternative systems make comparisons among them "unfair?" Quite the contrary. Delaying planting of the conventional corn would have been "unfair" to that system, and it also appears that using *Pioneer 3162* in the cover crop systems would have been "unfair" to those systems. (This use of the word "unfair" is not intended to imply any *deliberate* bias, of course.)

Still, these multiple differences tend to complicate comparisons among the systems. It is easy enough to determine statistically whether the systems differed in yield, water use, etc. The difficulty is determining *why* the systems performed differently. Understanding *why* the systems differ is essential if we want to design improved cropping systems, possibly combining features of two or more of the existing systems at LTRAS.

Simplifying Complexity

To make sense of the differences in system performance, we need to move beyond statistics to an analysis based on a mechanistic understanding of ecological interactions among crop, soil, and climate. For example, the final yield of the corn crop depends primarily on the total photosynthesis of the crop during the growing season, and on what fraction of the photosynthate ends up in the grain (as opposed to other plant parts, or losses to respiration or insects).

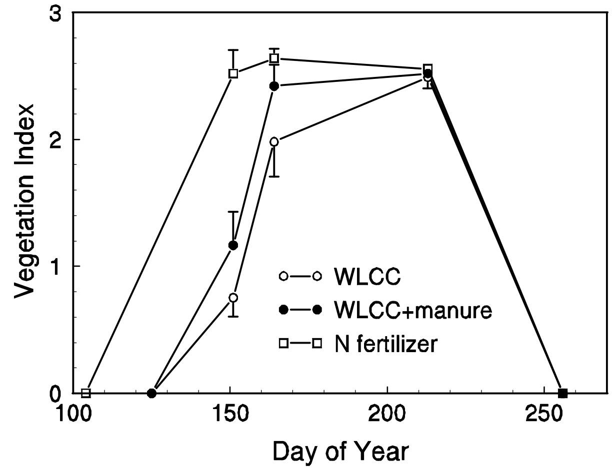

Figure 1. Vegetation index values (determined from infrared aerial photos) at three dates, plus seeding and harvest dates for corn supplied with N fertilizer, and corn following a winter legume cover crop (WLCC) with or without supplemental composted poultry manure.

One variable that sets an upper limit on total seasonal photosynthesis is the total amount of light intercepted by green leaves of the crop during the growing season. The fraction of available solar radiation on a given day that is actually intercepted by green leaves can be estimated from a "vegetation index," determined by infrared aerial photography.

Figure 1 shows the seasonal pattern of a vegetation index for corn crops at LTRAS in 1994, based on three aerial photos taken during the growing season. All three corn systems achieved a closed canopy of green leaves by August 1 (day 213), but the three systems differed considerably earlier in the growing season. The effects of seeding date and of supplemental manure are both apparent in Figure 1.

Because daily solar radiation varied by only about 10% during the period shown in Figure 1, total seasonal interception of solar radiation by green leaves can be estimated from the integral (area under the curve) of vegetation index over time. (And you never thought that calculus class would be good for anything!)

The results are shown (for individual corn plots) in Figure 2. With the exception of one no-compost cover crop plot, integrated seasonal vegetation index explains most of the yield differences among plots. This result emphasizes the importance of rapid establishment and long duration of a closed canopy of green leaves. Any light that was not intercepted (i.e., hit the ground instead of a green leaf) in the two cover crop systems early in the season could not contribute to photosynthesis and final yield.

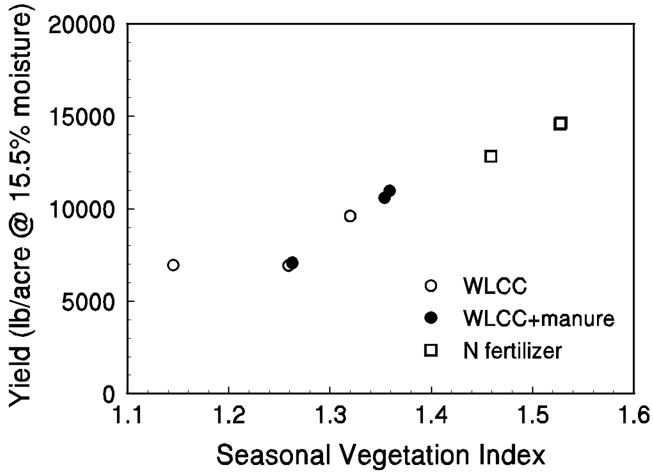

Figure 2. Relationship between corn grain yield and integrated seasonal vegetation index .

Results could be different in other years. For example, disease or water stress could reduce yields even in crops with high total seasonal light interception. Results from this first cropping year may underestimate the long-term ability of cover crop residues and manure to supply N to corn, because only a fraction of the total N in these organic sources is available in the first year.

Analysis of vegetation index data can be helpful in exploring the tradeoffs between maximum N accumulation by the cover crop (favoring later incorporation) and earlier establishment of a green leaf canopy by the corn (favoring earlier incorporation).

Any consideration of earlier incorporation of the cover crop will also have to consider total N budgets. For example, a "conventional" corn yield of 14,000 lbs/acre represents a removal from the system of approximately 224 lbN/acre, assuming an N content for corn grain of 1.6%. This is more than the approximately 180 lbN/acre contained in the legume cover crop, but less than either the 270 lbN/acre applied to the conventional corn as synthetic fertilizer, or the approximately 180+592=772 lbN/acre (cover crop + composted poultry manure containing 3.7% N @ 8 ton/acre) applied to the "organic" corn. We plan to gradually reduce the amount of manure applied to the organic corn, although perhaps not to the "one ton per acre of irrigated farmland" that would be available if all animal manure produced in California were uniformly distributed (p. 13, *Organic Soil Amendments and Fertilizers*, by D.E. Chaney, L.E. Drinkwater, and C.S. Pettygrove; published by UC Sustainable Agriculture Research and Education Program; UC Division of Agriculture and Natural Resources Publication 21505).

Nora Tamondong's measurements of soil nitrate beneath the three corn systems showed that none of them exceeded 5 ppm during the grainfilling period. These and other data, which she is collecting as part of an undergraduate research internship at LTRAS, will be discussed in a future issue of *The LTRAS Century*.

Rainstorm of the Century?

Akbar Abshahi and **Sean Eldridge** got the LTRAS on-site weather station up and running on January 6, just in time to record the 6.1 inches (15.5 cm) of rain that fell January 7 through 10, as part of what some local weather reporters have called the "rainstorm of the century." Also noteworthy was the 4.8 inches (12.3 cm) received March 8 through 11.

The flooding that ruined crops and damaged or destroyed hundreds of homes in the region did not spare LTRAS. Surface drainage ditches worked to capacity during storms and parts of several plots were inundated long enough to kill wheat plants that had emerged recently. Plots 8-1 and 6-6 were affected most.

The damage is being documented in aerial photos taken by **Bill Wildman**, of Wildman Photography. This will allow yields to be corrected for percent bare area of each plot. Uncorrected plot yields will also be reported.

Although last year's winter legume cover crops depleted soil water somewhat, relative to plots that were fallow last winter (Figure 3), it now seems unlikely that this will result in any water stress in this year's wheat crop. We might therefore see the nitrogen benefit from the cover crop without the associated water cost. Unfortunately, the flooding damage may obscure any nitrogen effects. Wheat yield data will be presented in the next issue of *The LTRAS Century*.

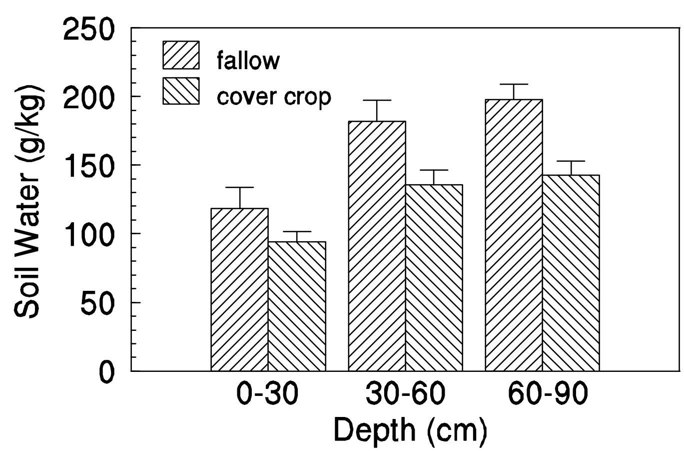

Figure 3. Fall 1994 soil water content, measured prior to seeding wheat in plots that were fallow or in a mixed vetch/pea cover crop during the winter of 1993-1994.

Cropping System	First Year	Alternate Year
rainfed wheat control	unfertilized rainfed wheat	fallow
rainfed wheat/legume	unfertilized rainfed wheat	rainfed legume cover crop
rainfed wheat/fallow	fertilized rainfed wheat	fallow
irrigated wheat control	unfertilized irrigated wheat	fallow
irrigated wheat/legume	unfertilized irrigated wheat	rainfed legume cover crop
irrigated wheat/fallow	fertilized irrigated wheat	fallow
conventional wheat/tomato	fertilized irrigated wheat	fertilized irrigated tomato
conventional corn/tomato	fertilized irrigated corn	fertilized irrigated tomato
legume/corn/tomato	legume cover crop followed by irrigated corn	fertilized irrigated tomato
organic corn/tomato	legume cover crop followed by corn w/ irrigation and compost	legume cover crop followed by tomato w/ irrigation and compost

Summary of the ten LTRAS cropping systems, including crops, nitrogen sources, and irrigation status. Both starting points of each two-year rotation are represented by three one-acre replicate plots, for a total of six plots per cropping system.

LTRAS in a Nutshell

The UC Davis Long Term Research on Agricultural Systems program (LTRAS) conducts field research on the sustainability and environmental impact of agriculture. We are now in the second cropping year of a 100-year experiment investigating the relationship between sustainability and external inputs, with emphasis on irrigation water and nitrogen fertilizer. Long-term trends in key soil properties (including organic matter, weed seeds, pH, and salinity) will be monitored. Resulting differences in yield, resource use efficiency, profitability, and environmental impact (such as leaching of nitrate or pesticides) will be used to evaluate the sustainability of ten cropping systems differing in external inputs of water and nitrogen (see table above).

Previous long term experiments at other locations found that some important soil parameters change over periods of decades rather than years. Up to 100 years may therefore be needed for a direct and unambiguous assessment of sustainability. LTRAS is also expected to make important contributions to agricultural science over a much shorter time period.

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 facilitate designing new cropping systems with better performance. LTRAS is primarily a research facility, but it also serves as a resource for extension outreach and for graduate and undergraduate teaching.

LTRAS Staff Directory

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- Dennis Bryant; Assoc. Director; 752-5368.
- Akbar Abshahi; SRA; 752-2763.
- Sean Eldridge; Farm Equipment Manager; 757-3162.
- Andy McGuire, Graduate Student.
- Melissa Duede, Steve Leas, & Nora Tomondong, undergraduate assistants.

Executive Committee

- Graham Fogg; Land, Air & Water Resources, UCD.
- Robert Miller; Land, Air, & Water Resources, UCD.
- Robert Norris; Weed Science, UCD.
- Richard Plant; Agronomy & Range Science, UCD.
- Carol Shennan; Vegetable Crops, UCD.

The LTRAS Century is an occasional publication of the Long Term Research on Agricultural Systems project at UC Davis. For a free subscription, send your name and address to:
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4 years good; 2 years bad?

The **University of California Sustainable Research and Education Program (SAREP)** recently awarded **R. Ford Denison** a grant for research at LTRAS on the effects of rotation length on weed and pest problems. First year funding is $10,000.

All of the current cropping systems in the 100-year annual field crop experiment at LTRAS are based on two-year rotations, such as corn/tomato or wheat/fallow. These relatively short rotations have some potential economic advantages relative to longer rotations, because the most profitable crop (processing tomato) is grown more often. However, several LTRAS collaborators and some outside visitors have suggested that disease and weed problems are likely to be more severe in two-year rotations relative to longer rotations.

Funding from SAREP will allow us to test this hypothesis, by establishing a new four-year rotation (e.g., corn/tomato/wheat/bean) in three "unassigned" plots that are not part of the main experiment (see plot map). The four-year rotation will be represented by three replicate plots, but with only one starting point. This contrasts with the main experiment, which includes both starting points of all systems, but we did not have 12 extra plots available! Once the new system is established, we plan to manage it according to organic guidelines, so the most direct comparisons will be with the existing two-year organic corn/tomato rotation. Biological differences due to rotation length will therefore not be masked by the use of pesticides. Cautious extrapolation to the problem of rotation length in conventional systems should also be possible.

To maximize the information obtained from this side experiment, the same plots will also be used for a study of changes in soil properties during a transition from conventional to organic management. In 1995 and 1996, the plots will be managed identically to our existing conventional corn/tomato system. The four-year organic rotation will begin in 1997, with farming practices for 1997 and 1998 (the first two years of the four-year organic system) identical to those in our existing two-year organic corn/tomato system. This experimental design will allow direct comparisons of systems differing *only* in the duration of organic management. Differences due to year-to-year variation in weather and the effects of increasing experience with organic practices will be eliminated. By better understanding changes in soil properties during transitions to organic farming, we hope to give farmers considering this option a better idea of what to expect and what they can do about it.

The Solution's Not Obvious

The **Water Resources Center** (WRC) recently awarded a grant to **Jan Hopmans**, **Graham Fogg**, and **R. Ford Denison** to support the development of improved technology (to be tested at LTRAS) for sampling soil water in the vadose zone for nitrate and pesticides. First year funding is $22,000.

In some parts of California, the concentration of nitrate in groundwater exceeds the 10 ppm federal standard for safe drinking water. It has been suggested that excessive fertilization of crops may contribute to this problem, but it is difficult to measure rates of nitrate movement from surface soil down through the vadose zone and eventually to groundwater. The WRC grant will support our efforts to solve this problem.

At LTRAS, we currently measure how much N is applied as fertilizer or composted manure and how much arrives in the irrigation water or rain. We measure N removal in the harvested crop. Over decades, we can measure how much N accumulates in (or is lost from) soil organic matter. But how much is lost in gaseous forms, and how much ends up in the groundwater? Does the gradual release of N from organic sources (compost or cover crop residue) prevent nitrate pollution? Or will some of this nitrate be released at times when crop growth is insufficient to take it up before it leaches below the root zone? These are some of the questions we hope to answer with support from the WRC grant. Stay tuned.

Vanishing Unassigned Plots

All but one of the unassigned plots at LTRAS is now in use for short-term research related to the main experiment (see plot map). These include **Andy McGuire's** cover crop research (p. 1) and the rotation/transition study discussed on this page. Plot 3-2 is being used for a comparison of pure vetch with our vetch/pea mixture, and will also be the site of the second year of **Tom Kearney's** corn variety trial (p. 2). Similarly, a wheat variety trial will use plot 3-6 until early summer.

More Help From Our Friends

We are grateful for the continuing generosity and contributions of seed, materials, or services from **Orsetti Seed Company**, **Pioneer Hi-Bred International**, **Lockwood Seeds**, and **Growers Ag Services**. We welcome the new support of **Greenheart Farms, Inc.** and the **J. Eldridge Ranch**. Special thanks also to **Susan and Ken Cassman** for a cash contribution to the LTRAS endowment fund.