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From the Director

Biotechnology

We hear much about biotechnology-about its "bright side" and its "dark side." Recently a full gamut of opinions about biotechnology was heard at a Sacramento meeting sponsored by the National Agricultural Biotechnology Council. Sentiments ranged from discussions of when biotechnology will deliver its promised results, to questions about whether the results would be what we want or expect. The intensity that such discussions can generate sometimes makes it hard to remember that biotechnology, like irrigation management, is a tool rather than a philosophy.

As an individual working in sustainable agriculture I hope that what biotechnology delivers will serve us all. In my opinion, biotechnology must be used within the general guidelines of the definition of sustainable agriculture, i.e., its end results (products or processes) must be economically viable, environmentally sound and socially just.

Much of the emphasis in biotechnology seems to be on product development, often with little understanding of how products will function in agricultural systems. Many questions have been raised about biotechnology: Is it acceptable for companies to develop herbicide-tolerant crops for use with herbicides that create health or environmental problems? Will companies develop products so they can dominate the market and ultimately the structure of agriculture? Is it wise to introduce organisms into the environment that are totally new and different? Will biotechnology threaten the genetic diversity of our plant and animal production systems and therefore the stability of the food supply? Is it wise to have so few scientists or companies making decisions for so many? Should universities invest substantial resources in biotechnology? If they do, will the research be for the general public rather than for a few private companies or individuals? Should universities invest substantial resources in product development for private companies?

I believe we need a dose of healthy skepticism as we examine biotechnology, but we also need to be open minded so that dialogue can continue. Those of us in sustainable agriculture continue to discuss and struggle with the concept of sustainability. I believe efforts to do the same with biotechnology will be helpful. As we become more sophisticated about technology and humans' role in the scheme of things, these questions are a natural outgrowth of our desire to discover where we should be going as a society. The Sacramento agricultural biotechnology meeting helped by providing a forum for such dialogue to continue. -*Bill Liebhardt, director UC Sustainable Agriculture Research & Education Program*

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SAREP Funds Economic, Public Policy Projects

Five projects focusing on the social, economic and public policy analysis that address the sustainability of California food and agricultural systems have been awarded $75,000 in grant money from the UC Sustainable Agriculture Research and Education Program (SAREP), according to **Bill Liebhardt**, program director. **David Campbell**, SAREP economic and public policy analyst, coordinated the grant process. The five projects include:

- a study to identify and analyze strategies including crop diversification and labor sharing which would contribute to a stable agricultural work force. Many California farm workers are part of an unstable, seasonal labor market which results in low annual incomes for workers and high turnover and uncertainty for farmers, and contributes to the development of unstable, poverty-ridden communities. Crop diversification, an environmentally sound practice which is encouraged in sustainable agriculture, presents an opportunity for improving labor practices. By incorporating consideration of labor management practices in production planning as well as issues of weed and pest control and marketing, labor conditions may be improved while contributing to the overall cost-effectiveness and environmental soundness of agricultural production. Strategies will be identified from: three farmers who offer extended or year-round employment and have succeeded in modifying their cropping systems, analysis of crop rotation data for employment management, interviews with 30 San Joaquin County growers, and case studies of labor and information sharing systems offering year-round employment. Strategies will be developed further through regional focus groups with farm advisors, farmers and non-profit farmer organizations and local businesses. Results will be published and presented to farmers in seminars. Investigators: **Suzanne Vaupel**, research agricultural economist, Sacramento; **Gary Johnston**, San Joaquin County Cooperative Extension director; **Gregory Billikopf,** personnel management farm advisor, Modesto; **Melissa Cadet**, Trans Tech Management, Sacramento; **Franz Kegel**, retired farm advisor, Stockton; **Steve Sutter**, personnel management farm advisor, Fresno. Cooperators: **Tom Haller**, executive director, California Association of Family Farmers; and three farmer-cooperators from throughout the state. $20,000 for two years.

- a comparison of the economic benefits, energy costs and social values of different vegetable production farming practices at the Rural Development Center (RDC) in Salinas, CA. Farmers at the RDC are predominantly Mexican farm laborers enrolled in a three year production and marketing training program in which low-input production practices are emphasized. The effect of these alternative

practices on the short- and long-term well-being of the enrolled families and the surrounding rural community will be determined and analyzed based on information from the fields, interviews and workshops. Investigators: **Paul L. Gersper**, Department of Soil Science, UC Berkeley; **Miguel Altieri**, Department of Entomological Sciences, Division of Biological Control, UC Berkeley. Cooperator: **Nestor Marin**, RDC director of farm operations, Salinas. $20,000 for two years.

- the formation of a coalition to ensure the vitality of sustainable agriculture in Santa Cruz County. Agriculture is a $196 million dollar industry in Santa Cruz County, second only to tourism. It is threatened by urban growth and development, groundwater depletion, and the movement of agricultural operations overseas where costs are lower. The community-based coalition will work with UC Santa Cruz to pool resources, expertise and political strength to assess needs, devise solutions and implement strategies for change. The project also aims to improve agriculture's environmental responsibility and economic strength, increase its responsiveness to the needs of those who work within the industry as well as to local communities, and strengthen its links to the local community. Investigators: **Stephen Gliessman**, Agroecology Program, UC Santa Cruz; **James Pepper**, Environmental Studies, UC Santa Cruz. $17,000 for two years.

- a survey identifying the logistical, social and regulatory barriers to sustainable food in Alameda County's food marketplace. A task force including wholesale and retail merchants, trade association members, consumers and environmentalists will be assembled to determine concerns of the food community about barriers to the movement of sustainable agricultural produce in the marketplace. A survey will be conducted to determine specific barriers. As part of the information dissemination plan, a public forum will be convened to discuss the barriers and identify solutions. Investigator: **Valerie Pelto**, executive director, Alameda County Food Planning Council. $15,000 for two year project.

- five workshops throughout Humboldt and Del Norte counties to address the topic of sustainable forestry management options for small landowners. The goal of sustainable forestry is shared by forest landowners, legislators and the public, yet is often difficult to define and achieve. Major changes in policies for the management of California's 14.4 million acres of private forest land are evident in new and proposed legislation. Past laws and regulations which influenced cutting practices combined with natural events including fire and flood have resulted in many forest lands in need of restoration and improvement. The costs of restoration plus the costs imposed by legislative restrictions often discourage small landowners from long-term planning. The workshops will look at current legislation and policy instruments for implementing sustainable forestry. A dialogue between landowners, regulators and legislators will be encouraged. Investigator: **Kimberly Rodrigues**, UC Cooperative Extension forest advisor, Humboldt and Del Norte counties. $3,000 for one year.

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Organic Growers Must Register

A new California law that took effect in October 1991 requires all organic growers to register with their county departments of agriculture. Assembly Bill 645, which implements the California Organic Foods Act of 1990, provides protection for producers, handlers, processors, retailers, and consumers of organic foods marketed in California. Standards for organic food will be enforced by the California Department of Food and Agriculture and the county agricultural departments.

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Long-Term Project Breaks Ground

By Lyra Halprin, SAREP

Last October's groundbreaking at UC Davis of the first 100-year irrigated farmland research site in a Mediterranean climate anywhere in the world was the culmination of years of preparation. Plans began in the early 1980s when California farmers and university personnel launched efforts to establish a statewide sustainable agriculture research and education program, including long-term research sites. In 1985 the Sustainable Agriculture Research and Education Act sponsored by Senator Nicholas Petris was passed, which requested that the University of California create a sustainable agriculture program. The UC Sustainable Agriculture Research and Education Program (SAREP) was established in 1987 and is housed on the UC Davis campus. Additionally, the College of Agricultural and Environmental Sciences at UCD established its own sustainable agriculture program in 1988.

In 1989 UC SAREP sponsored a grant competition to establish a long-term farmland research site. A multidisciplinary team of 18 scientists headed by former UCD Agronomy and Range Science Associate Professor **Kenneth Cassman** was awarded $150,000 in 1990 to begin its Long-term Research on Agricultural Systems (LTRAS) experiments. The project, which has grown to include 31 researchers, is now under the auspices of the UCD Sustainable Agriculture Program, directed by **Montague Demment**, an agronomy and range science associate professor. UC Davis' College of Agriculture and Environmental Sciences is providing institutional support to sustain the experiments for the long-term. SAREP's public advisory committee, which includes large- and small-scale and conventional and organic farmers, was actively involved in the design of the project. Crop management guidelines and strategies will be developed by a committee that includes both conventional and organic farmers, the investigators, a farm supervisor and a staff research associate. The 300-acre experimental site is located three miles west of the main campus on the newly acquired 1,600-acre Russell Ranch.

Beginnings

At the groundbreaking Demment lauded the efforts of the Committee for Sustainable Agriculture, California Action Network and California Certified Organic Farmers, which were instrumental in initiating the sustainable agriculture legislation. Demment also noted that UC faculty members and administrators, including **William Rains** of the UCD agronomy and range science department and **Robert Peyton**, director of the UC Office of Programs, Information & Analysis, were convinced of the importance of multidisciplinary research to investigate the way irrigated California agriculture has changed everything from farming practices to the weather in the last 80 years.

Demment said the LTRAS groundbreaking represents the UCD College of Agriculture and Environmental Science's commitment to the integration of two parts of its mission, agricultural and environmental sciences. He called the LTRAS "a magnet facility" with the capacity to serve as a model of balanced disciplinary and interdisciplinary research. "This project will partly answer the question of how to get good science from the laboratory to address problems in the field," he said. "It will help bridge that gap."

Demment called the LTRAS a laboratory for scientists. It includes fields, field maintenance and administration, and a core of data gathered by the UCD Sustainable Agriculture Program staff. "The LTRAS provides the contextual background for disciplinary research in a multidisciplinary setting," Demment said. A matrix of fundamental water, nitrogen and cropping system treatments will be established. Researchers will be able to examine their specific issues in the context of the larger experiment.

"We frame the large-scale question for the disciplinary scientist by the way the experiment is set up. The researcher can see the breadth of systems-how ten levels of input affect a cropping system," Demment said.

First Experiment

The first experiment on the site is a 60-acre study of annual cropping systems and their long-term effects. The experiment will compare the performance of cropping systems that differ in levels of irrigation water, nitrogen rates and sources, and cropping diversity. The land is prepared for a spring planting of Sudan grass, a cover crop that will be grown for one season, then harvested and analyzed to provide a background reading of the land's productivity. In the fall the first experimental winter cereal crops will be planted. They will be followed by Spring 1993 plantings of corn, tomatoes and legume cover crops. The project is described in detail in *Sustainable Agriculture News, Volume 2, No. 4, Summer 1990.*

Rothamsted Visit

As part of the preparation for the LTRAS start-up, Demment and six other UCD researchers involved in the project traveled to Southern England in the spring of 1991 to observe results and research at Rothamsted Experimental Station, one of the most important long-term farmland research sites in the world. The Rothamsted plots are examples of temperate humid sites where data on continuous cropping have been collected since 1843. Although continuous cropping systems had existed before, there had never been systematic data collection before the Rothamsted Classical Experiments.

"What was exciting about Rothamsted was the strong historical perspective of being in a place where a relatively intensive form of agriculture has affected a country for several thousand years," said Demment. "We also saw that it is important to start with large plots, because as time goes on, it will become important to divide them."

Richard Plant, professor and vice-chair in the agronomy and range science department who specializes in agricultural systems analysis, said visiting the Rothamsted Experimental Station gave him a sense of history.

"You have the sense that you really are in an historical place," he said. "Often we miss that perspective of the past. Rothamsted is a soil museum where you can do lively intellectual research even though many parts of the research may be derived from archival samples. Very often scientists work in isolation. It's nice to get a sense of our scientific culture. Rothamsted provided us with that shared heritage."

Plant said Rothamsted researchers stressed they are using information collected over the years for purposes never dreamed of by the site founders. "No one in 1843 could possibly have conceived of testing soil for the effects of nuclear testing or air pollution on agriculture," Plant said, noting that Rothamsted researchers are doing just that. He said the LTRAS must be planned carefully for future researchers.

"We're starting to design an experiment to collect data to use in 100 years for scientists to solve problems we can't even conceive of," he said.

Demment said that tests on lead deposits on Rothamsted soil underscored the importance of extremely long-term experiments: There were tremendous variations in lead deposits within various time periods, "but over a period of 150 years it was absolutely clear that lead depositions were decreasing," he said.

"There were 20-year time frames when the lead increased," Demment said. "Shorter time frames can give clearly contradictory trends from the 100-year pattern, especially in systems like ours at the LTRAS which has deep soil profiles and water. At the LTRAS, where we're looking at the movement of materials that may take 50 years to reach groundwater, long-term studies are necessary.

Carol Shennan, assistant professor of vegetable crops, said discussions at Rothamsted emphasized the importance of collecting exhaustive baseline data at the Davis site. "The first five years or so are critical for defining the systems at their inception," she said. "In particular we need to do a good job of defining initial soil conditions."

She noted that observing the Rothamsted research operation made it clear that these projects are more than just long-term experiments. "We will also be developing an historical record, building archives and having to continuously make decisions about management modifications, and approving specific studies that will use the site." She noted that this requires an effective administrative structure. "The people at Rothamsted have developed an impressive system

for sample collection and cataloging, and for ensuring that careful records are maintained of where measurements are made or samples removed, to avoid problems of excessive disturbance in particular treatments or locations," she said.

Shennan said the trip to Rothamsted brought up the issue of maintaining the relevance of the long-term experiment to current agricultural and societal concerns. "We need to ensure that the LTRAS does not become fossilized. This requires a carefully thought-out balance between maintaining sufficient continuity for answering long-term scientific questions, and adapting management to reflect changes in agricultural practices over time." She said a

combination of input from scientists, farmers and other interested people on advisory committees will be essential.

William Rains, a professor of agronomy and range science interested in nutrient cycling and plant/soil interactions, agreed that one of the most important issues for the visiting UCD scientists was discussion of experimental design. "We bounced ideas around with their experimental design people, plot managers and statisticians," he said. "That's when the real details came out."

Rains said the Davis researchers experienced the excitement of interdisciplinary research in their discussion with Rothamsted scientists. "People with different disciplines asked questions, raised points and identified issues I hadn't thought of, "Rains said.

Akbar Abshahi, a researcher working for the UCD Sustainable Agriculture Program, is the manager and research coordinator of the LTRAS, responsible for all experiments. At Rothamsted Abshahi was interested in soil and plant sampling, and how samples are compared.

"What are the results of planting one crop for many years in one place?" he asked. "What is the change in nutrients in each plot? How do both applied and naturally occurring nutrients leach down through the soil?" Abshahi said he is interested to see the differences that will exist between Rothamsted's unirrigated site and the irrigated Davis plots. Each of the 60 one-acre LTRAS plots has been leveled, making it possible to measure exactly how much water is used. In Rothamsted, researchers only measure the amount of rain that falls. UCD researchers were also impressed with the importance of proper storage: The first 20 years of Rothamsted soil samples were improperly stored.

Kate Scow, an assistant professor in the Department of Land, Air and Water Resources whose specialty is soil microbiology, was surprised at Rothamsted's proximity to London, approximately 40 miles from the urban center. "You can feel the sense of a city near the experimental site," she said. Scow noted that the closeness to the city underscores "a new reality about agriculture, especially in California, where the urban community is encroaching on agricultural lands."

Scow said the College of Agriculture and Environmental Science's support of the Davis long-term site is important for many reasons. "It is important to tie agricultural and environmental studies. They are very, very closely linked. At a place like Rothamsted, both in studies of nitrate leaching from agricultural practices, and studies of polyaromatic hydrocarbon accumulation from fossil fuel combustion, you can see how agriculture is both a source of pollution and a victim. They go together and there is a lot you can learn about either agriculture or the environment by understanding how they impact each other."

Stuart Pettygrove, a soil specialist in the land, air and water resources department, was particularly impressed by a discussion at Rothamsted on how to use the information the plots provide. "We saw how they use plots that had been differentially fertilized, then used as the basis of relatively short-term experiments," he said. "Because different nutrient levels evolved over 135

years in the original plots, modern researchers could leverage the information from those soils in short-term experiments (14-years) to obtain results that would otherwise have taken a much longer period of time."

Pettygrove said the LTRAS will eventually be able to provide such a setting for researchers. "The punchline for me was to see the long-term plots as laboratories. The benefit for future scientists is not only the stored soil samples, but the fact that the soils side-by-side in the LTRAS fields will have different nutrient levels, but in other respects will be the same."

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Worldwide Long-Term Research

Why study farmland for hundreds of years? Historically, societies that did not manage their natural resources have failed. The Babylonians salted themselves out of the Fertile Crescent with poor water management. Inappropriate management of slash-and-burn agriculture in Central America has gradually destroyed communities. These societies raise questions concerning the processes that influence the sustainability of agricultural resources. To understand these processes, it is necessary to gather information over long periods of time.

The idea of long-term farmland research sites is not new. Europe, North America, the Middle East and Australia are homes to long-term research. The "Mecca" of long-term farmland research is the Rothamsted Classical Experiments in Southern England. The plots are examples of temperate, humid sites where data on continuous cropping have been collected since 1843. An unirrigated Mediterranean climate long-term farmland research experiment began in 1880 at the Kybybolite Experimental Farm in South Australia.

Numerous long-term research sites in North America have been monitored since the late 19th century - 25 for more than 25 years. Of those, 12 have been monitored for more than 50 years. One hundred fifteen years of data on continuous cropping have been collected at the temperate humid Morrow Plots on the Urbana campus of the University of Illinois. The University of Missouri at Columbia's Sanborn Field was established in 1888. The Magruder Plots on the Stillwater campus of Oklahoma State University began in 1892, while The University of Nebraska at Scotts Bluff established a continuous study in 1912.

Other sites include six locations of the Auburn University in Alabama, the Breton Plots at the University of Alberta in Edmonton, Canada, and a crop residue study at the USDA-ARS in Pendleton, Oregon. New York, North Dakota, North Carolina, Minnesota, Kansas, Michigan and Wisconsin are the homes of other long-term research.

In California, 80 years of intensive agricultural management has imposed a whole new environment onto the land. The microclimates in huge sections of the state have been transformed from dry hot summers to more humid, irrigated environments. Researchers and farmers alike recognize that this creates a great potential for the destabilization of natural resources. The UCD site will demonstrate the effects of long-term farming practices in California's hot dry Mediterranean climate on an irrigated site. (UCD was the home of a 25-year irrigated covercrop trial; initiated in 1924 on the site of the Veterinary Medicine Teaching Hospital, it compared the use of cover crops with clean-cultivated orchards through 1948.)

Long-term farmland research sites are field laboratories for on-going studies

of fundamental mechanisms that influence the sustainability of agricultural systems. While the emphasis of long-term studies is on research and data collection over a long period, it is not necessary to wait 50 years for the results to be useful; information can be gathered and distributed continuously. Education is a critical product of long-term farmland research.
-*Lyra Halprin*

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Citrus Herbicides & Groundwater Quality

By Chuck Ingels, SAREP

(Editor's Note: This is the first part of a two-part series on citrus production and groundwater contamination. Part 2 will appear in Sustainable Agriculture News Vol.4, No.3, Spring 1992. Information from this series will be included in a SAREP citrus publication due out at the end of 1992.)

The issue of groundwater contamination will face California citrus growers even after the effects of the freeze and drought have subsided. Citrus production is not the sole source of pollution. However, increasing numbers of wells in concentrated citrus districts are contaminated with herbicides used on citrus groves-simazine, diuron and bromacil. Nitrate contamination is a concern for growers of all crops, yet fertilization techniques have been developed for citrus that can greatly minimize the pollution potential.

UC SAREP organized a meeting among selected growers, farm advisors, and consultants in September 1991 to explore methods of preventing groundwater pollution. While numerous solutions were proposed, nearly all techniques discussed have tradeoffs which may hinder their adoption. The following discussion on solutions to groundwater contamination by herbicides is derived from the meeting, individual contacts, and literature on the subject.

Complete nontillage management is practiced in more than 90 percent of California's citrus groves, with unwanted vegetation largely controlled by preemergence (residual) herbicides (Pehrson, 1988). Nontillage is used because cultivation can damage the shallow tree roots and increase soil compaction, while floor vegetation can predispose citrus to frost damage and can compete with trees for water and nutrients. The use of residual herbicides has been economical, simple, and for the most part, effective. For more than three decades, there has been no strong motivation for the majority of growers to use any other technique.

The discovery of herbicides in groundwater (even small quantities) is but one indication that current production practices are not sustainable. Sustainability implies that, among other things, materials and practices used on the farm do not harm the surrounding environment. Environmental and social pressures brought about by groundwater contamination will eventually override the economics of complete herbicide management.

Weed Control Alternatives

Few truly "sustainable" techniques have been developed as viable alternatives to current floor management practices. Currently there are four methods of preventing or reducing groundwater contamination by herbicides: 1) management of weeds or cover crops through mowing, tillage, or minimum

tillage, 2) improved irrigation management, 3) modified use of herbicides, and/or 4) prevention of direct streaming from the surface.

Vegetation management: Cover crops. One obvious way to prevent herbicides from leaching is not to use them. Simply mowing the weeds, however, may result in a competitive perennial grass sod cover. And repeated tillage kills tree roots and reduces water infiltration. Planting selected species of ground cover, however, can help suppress weeds. In addition, cover cropping can add or conserve nitrogen, provide food for beneficial insects, improve water infiltration, and add organic matter. There are numerous obstacles to growing cover crops successfully, including frost concerns, tillage, water use, and shading. Several management strategies exist to alleviate many of these concerns (see UC SAREP's *Components Vol. 2, number 3).*

At the September 1991 meeting cover crop establishment was discussed by **John Freeman**, previous foreman of the organic orchards at Paramount Citrus. He recommended that growers first consider the soil type and depth; cover crops are easier to manage on sandier soils. Growers must also be prepared for problems that maybe associated with cultivation (if used), such as compaction and dust. Also, a substantial cover crop or implements may not fit between closely planted rows (22 feet). Rows should be oriented north-south to enhance sunlight penetration. Consider the method of irrigation: Furrow is the easiest system for managing cover crops; dragline sprinklers may be the next best. Freeman also noted that herbicide residues in the soil can be a serious problem in the first year or two of cover cropping. The toxicity can be at least partially overcome by adding bulky organic amendments and using a large-seeded mix. Grasses are the most tolerant to herbicide residues, although an annual grass/vetch mix would probably be appropriate.

Some growers are using the following reduced-tillage cover crop management strategy. First, the soil is lightly tilled in early fall. Seeds of winter annual legumes and/or grasses are then drilled in the aisles. One or more irrigations follow to germinate the seeds (low volume sprinklers can be moved into the aisles temporarily). The cover crop is mowed periodically during the frost season. Allowing the cover crop to grow during late spring can suppress weed growth. A final mowing in late spring provides a mulch that can conserve soil moisture.

Irrigation. Applying water for frost protection is effective and relatively inexpensive, so it is unlikely that this practice will be modified substantially. However, limiting irrigation depth during the growing season and using under-tree irrigation will reduce leaching and save water.

Depth of wetting. Short and frequent irrigations limit water to the depth of the root zone and help prevent pesticides from moving downward into the groundwater. Limiting the depth of the wetting also keeps herbicides in the upper soil levels where organic matter breaks them down. It is to the grower's advantage to precisely manage irrigations in this manner, as short and frequent irrigations reduce tree stress and save water and money. (For information on scheduling irrigations, see Pehrson, 1985.) In many areas of Southern California, saline irrigation water can lead to a buildup of salts in

the soil. Excess water (known as leaching fraction) must be applied to move these salts below the root zone.

Under-tree irrigation involves placing one (360 degree) or two (180 degree) low-volume emitters near the tree trunk so that irrigation water is being supplied under the canopy only. This technique is gaining in popularity and has many benefits. Excellent summer weed control may be possible without residual herbicides, since all sunlit areas remain dry (weeds thrive only where the sun shines on watered soil). Well-timed spot treatments with a contact herbicide could be used to control weed escapes brought up by spring rains. Other advantages to under-tree irrigation include reduced water use, movement of salts away from the root zone, enhanced frost protection, and less damage to the emitters by workers and equipment. Tree "skirts" should be pruned up off the ground to use this method effectively. "Skirting" can also aid in the control of Fuller rose beetle, snails, and brown rot; it also makes it easier to inspect emitters.

There are some potential problems associated with under-tree placement. With frequent wetting of the trunk and crown of the tree, some people believe that the incidence of root diseases may increase. While many growers have not found this to be the case, using two 180 degree emitters will eliminate this potential problem by keeping the crown area dry. However, using two emitters increases costs and may increase clogging. Also, it becomes difficult to use cover crops, compost or manures effectively without wetting the aisles. Researchers in Southern California are testing the application of manure under the trees, where leaching would move nutrients down.

Prevention of direct streaming. It is likely that both leaching through the soil and direct "pipelines" transport herbicides into the groundwater. Simple preventive measures should be used to prevent direct streaming, including 1) mixing and storing pesticides and moving tank-loading facilities away from wells, 2) installing anti-siphon valves where spray tanks are filled (required by law), 3) sealing cracked wellheads, 4) capping and berming abandoned wells, and 5) constructing berms around irrigation wells and "dry wells" (drainage sumps installed in many orchards up until the 1970s).

Modified herbicide use. Considering the increasing pressures to severely reduce or eliminate pesticide use, simply modifying herbicide use may not be viable in the long run. Yet for the vast majority of growers who currently rely on nontillage with residual herbicides, several alternative practices show promise in reducing herbicide leaching.

Spring applications. A 1988 survey showed a strong correlation between the use of irrigation for frost protection and the frequency of well water contamination in Tulare County (Pickett et. al., 1990). Fall-applied residual herbicides probably move through the soil with the large quantities of winter-applied water. Therefore replacing the fall herbicide application with a spring treatment is a partial solution. Spring applications would also enhance control of summer weeds, especially marestail and fleabane. The primary tradeoffs are that rainfall, which is required to activate or fix the herbicide, is far less dependable in the spring than in the fall; winter weeds are not adequately controlled and require a "burndown" contact application in the spring; the

orchard floor may be too wet for spring equipment use, and spring treatments may be phytotoxic to the trees.

Split application, applying half of a leachable herbicide in the fall and half in the spring, is an approach used by many growers. It also offers the possibility of using different materials for cool- and warm-season weeds. Less herbicide may be needed if only the irrigated areas are treated in the spring. If top rates are used in both treatments, however, more total herbicide might be used than with a single application.

Contact sprays. If only preemergence herbicides are being found in wells, why not simply use contact sprays? This approach is attracting increasing interest, but it also has problems. For example, spray timing is critical, and wet soils may hinder access during optimum times. Also, contact sprays require a minimum of four applications per year, which may be more expensive and cause more soil compaction than using other herbicides. Some growers have observed that eliminating residual sprays has led to increased earthworm activity, a desirable side effect for soil tilth and fertility.

Alternative preemergence herbicides are available, but probably do not offer a long-term solution because they, too, may find their way into groundwater. Those currently available are also more expensive and more selective than the herbicides they are meant to replace.

Growers of all crops are being challenged to produce safe, inexpensive food without damaging the soil, the air, or the water. They must also maintain their economic stability. In the long term, however, economic stability is dependent on environmental and social well-being. Citrus growers are confronted with numerous obstacles to sustainability. Some alternative weed management practices have already been developed to minimize environmental impacts, and much more needs to be done. (References will be listed at the end of Part 2, *Sustainable Agriculture News, Vol.4, No.3, Spring 1992.)*

Resources

The Food-Production System Connection

Chicken Little, Tomato Sauce and Agriculture: Who Will Produce Tomorrow's Food? by **Joan Dye Gussow**. This 152-page book explores the economics, nutrition and ecology involved in bringing food to the table. Nutrition scientist Gussow makes connections between America's food supplies, environmental problems and what many consider the increasingly unsustainable food production system. Gussow is the Mary Swartz Rose Professor of Nutrition and Education at Teacher's College, Columbia University, and is the author of many books. Published by The Bootstrap Press, Suite 3C, 777 United Nations Plaza, New York, NY 10017, (212) 953-6920. Cost: $15.50 (includes $3 shipping cost).

Soil Publications

Nutrient Cycling In Soils. Publication on nutrient cycling and sustainable soil fertility concepts. *Soil Biology.* Overview of soil biology including the role of soil organisms, decomposition, and environmental factors affecting soil organisms. *Sustainable Fertility Management.* Information package providing overview and specific information on soil testing record keeping, assessing nutrient needs, and soil fertilizers and amendments and their application. Free publications by **Donna Doel**, available from Appropriate Technology Transfer for Rural Areas (ATTRA) in Memphis, TN. Call (800) 346-9140.

NRI Analysis

Research for Sustainability? The National Research Initiative's Social Plan for Agriculture. **Elizabeth Ann. R. Bird** is the author of an analysis of the National Research Initiative (NRI), a significant reorganization and expansion of the USDA's Competitive Research Grants Program. The NRI will support basic and applied research focusing on national and regional research needs, and methods to transfer the research into practice. Bird's report assesses whether the NRI will contribute significantly to the shift toward a more sustainable system or agriculture. For copies of the report contact the Center for Rural Affairs, Box 405, Walthill, NE 68067, (402) 846-5428. The $8 ($13 overseas) cost includes postage and handling.

Ag Panel Recommendations

Sustainable Agriculture in the National Research Initiative. Recommendations of a panel of 30 scientists convened in August 1991 by the Center for Rural Affairs and the USDA Sustainable Agriculture Research and Education (formerly LISA) program. The document includes general

recommendations for fostering sustainable agriculture, multidisciplinary and mission-linked research; specific recommendations related to the 1990 U.S. Farm Bill's National Research Initiative (NRI) program areas in the Request for Proposals; and specific recommendations about NRI structure and procedures. For copies of the document contact the Center for Rural Affairs, address above. The $5.00 ($8.00 overseas) cost includes postage and handling.

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Agricultural Books Catalog. agAccess Research and Information Service's new free 88-page catalog is now available. It contains hundreds of reviewed titles on horticulture, vegetable crops, fruit production, pest management, water and irrigation, soil fertility, biotechnology, sustainable agriculture and other topics. agAccess services include the mail order catalog, specialized booklists, information services, and a Davis retail store. For more information contact agAccess, 603 Fourth St., Davis, CA 95616, (916) 756-7177, FAX (916) 756-7188.

Sustainable Ag Guide

Sustainable Agriculture in California: A Guide to Information, by **Steve Mitchell** and **David Bainbridge**. This 200-page guide, funded by UC SAREP and The Librarians Association of the University of California, is aimed at helping farmers, ranchers, researchers, farm advisors, planners, gardeners and consumers find information about sustainable agriculture. Includes bibliographies on cover crops, ley farming, agroforestry, range management, weed and pest control, specialty crops, gardening, on-farm research, and farm worker safety. Order Publication No.3349 ($12) from UC ANR Publications, University of California, 6701 San Pablo Ave., Oakland, CA 94608-1239, or call (510) 642-2431.

Technical Sustainable Ag Newsletter

Components, the technical newsletter of UC SAREP presents a wide range of research and information on topics of interest to researchers, farm advisors, and other agricultural consultants. It includes technical summaries and notes based on journal articles, books, reports and material presented at meetings, conferences and workshops. Free subscriptions available from UC SAREP University of California, Davis, CA 95616, (916) 752-7556.

Symposium Proceedings

Proceedings/Sustainable Agriculture in California: A Research Symposium, includes 23 papers ranging from practical crop production and pest control systems to developing computerized information distribution systems, and transcripts of a panel discussion on sustainability. From the spring 1990 SAREP symposium on sustainable agriculture research and extension. Publication No. 3348, available for $15 from UC ANR Publications, see *Sustainable Ag Guide* above for ordering information.

UC SAREP Progress Report

Progress Report 1986-1990, reviews the work of UC SAREP. It includes summaries of the 51 SAREP-funded projects. Free copies are available from UC SAREP, University of California, Davis, CA 95616, (916) 752-7556.

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Sources of Funding

USDA Sustainable Agriculture Research & Education Program

The USDA Sustainable Agriculture Research and Education (formerly LISA) program has issued a call for proposals for the Western Region of the United States. The deadline for proposals for the West is February 28, 1992. The program expects to fund one whole-farm systems proposal for $150-300,000 per year. It is possible that a whole-farm systems project would be jointly funded by the Environmental Protection Agency's Agriculture in Concert with the Environment (EPA/ACE) Program, if components of the project meet the EPA/ACE criteria. Additionally, the ACE Program will be funding an undetermined number of projects in 1992. Proposals are requested for studies that will identify, evaluate, and interpret indicators of agroecosystem health. In addition to the commonly used indicators of productivity, projects supported by ACE must consider indicators of the function or disfunction of the agroecosystem, including measures of environmental quality, ecological soundness and species diversity, as well as socioeconomic viability. To be added to the mailing list or for further information contact **Denise Bodie**, University of California, Division of Agriculture and Natural Resources, 300 Lakeside Dr., 6th Floor, Oakland, CA 94612-3560, (510) 987-0033.

Charles Lindbergh Fund

The non-profit Charles A. Lindbergh Fund supports the goals of aviator Charles Lindbergh who believed that the future depends upon a balance between the environment and technological progress. Each year the Lindbergh Fund provides grants of up to $10,580 (a symbolic amount representing the cost of "The Spirit of St. Louis") to individuals whose work furthers this balance. Categories for the awards are: 1) aviation/aerospace, 2) agriculture, 3) the arts and humanities, 4) biomedical research, 5) conservation of natural resources, 6) exploration, 7) health and population sciences, 8) intercultural communication, 9) oceanography, 10) waste disposal management, 11) water resource management, 12) wildlife preservation. Grants will be limited to research or educational projects that focus on a balance between the advancement of technology and preservation of the human/natural environment. Grants are directed at individuals rather than institutional programs. The Fund welcomes candidates who may or may not be affiliated with an academic or non-profit institution. It does not provide support for tuition, scholarships, fellowships or related travel. The Lindbergh Grants Program is international; all application materials must be submitted in English and be postmarked by June 16, 1992. For applications and more information contact **Marlene K. White**, The Charles Lindbergh Fund, Inc., 708 South 3rd St., Suite 110, Minneapolis, MN 55415, or call (612) 338-1703 or FAX (612) 338-6826.

Mosquito Research Program

The UC Universitywide Mosquito Research Program invites research proposals on control methods for mosquitos and related topics for the 1992-93 academic year. To be considered for funding, proposals must be received no later than Friday, January 17, 1991. The goal of the Mosquito Research Program is to conduct research which will provide improved methods of managing pest and disease-transmitting mosquitos. Emphasis is on principles of integrated pest management, including practical biological control strategies and other approaches which are not disruptive to the environment. Proposal categories include: chemical control methods (including application technology), mosquito biology and ecology, integrated pest management (including biological control), and public health. For complete application information contact **Bruce Eldridge**, director, Universitywide Mosquito Research Program, Department of Entomology, University of California, Davis, CA 95616, (916) 752-6983.

Toxic Substances Program

The UC Toxic Substances Program will provide seed funding for innovative grants in any area of research relevant to problems of toxic substances in California. The emphasis in this call for proposals is on the development of new ideas by investigators in any discipline. The Program is especially seeking strong research proposals dealing with studies of the economics of toxic substances issues, potential public policy implications of toxic substances issues, source reduction, and coastal and marine toxic substances issues. Investigators are particularly encouraged to seek funding for the development of preliminary data that will provide the basis for subsequent applications to extramural funding sources. Those projects should be able to be completed in a year or less and require a direct cost budget of less than $50,000. Proposals related to toxics curriculum development are also encouraged. Applications must be received by January 31, 1992; however, it is recommended that proposals be submitted to the UC Davis Office of Research by January 25, 1992. For complete application information contact **Melissa Mardesich**, Toxic Substances Program manager, California Regional Primate Research Center, University of California, Davis, CA 95616, (916) 752-2099.

$1000 Organic Article Award

The Organic Farming Research Foundation will award $1,000 to the author of the best article published in 1991 aimed at educating the general public about organic farming. Articles must be published between January 1, 1991 and December 1, 1991 in a regularly published newspaper, journal or magazine. Applications should include 15 copies of the article, including date published and page numbers; name address and telephone number of the author(s); and information about the periodical in which it was published, including exact title, how long it has been in publication, purpose and audience, and circulation (15 copies). Applications must be received by January 10,1992 at Organic Farming Research Foundation, P.O. Box 440, Santa Cruz, CA 95061. For more information contact the Foundation at (408) 426-6606.