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the Cultivar

The CENTER for AGROECOLOGY & SUSTAINABLE FOOD SYSTEMS

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in this issue:

Make the Most of Water Resources with Careful Irrigation Practices

Drip irrigation has reduced water use and weed pressure at the Center's on-campus farm.

In Santa Cruz's Mediterranean climate we rely on irrigation throughout our dry summers to produce most of the crops on the Center's 25-acre organic farm. Located on the UC Santa Cruz campus, the farm includes row crop acreage cultivated with a small tractor, as well as hand-worked raised garden beds and several fruit orchards.

Water conservation is a way of life in our climate, and an important component in any food production system. However, many growers working at both field and garden scales don't know how much water they're applying when they run an irrigation set, and often the tendency is to over irrigate their crops.

As well as wasting water, over irrigation leads to unnecessary weed pressure, nutrient leaching, nitrogen loss to the atmosphere, disease pressure, and soil compaction. Conversely, water stress from too little irrigation can decrease yields and increase the crop's susceptibility to pests and pathogens. Crop plants that reach the permanent wilting point, where no water is available to the plants, often will not recover.

In this article I'll try and take some of the guesswork out of deciding how much water to apply to a growing crop. I'll first describe the sprinkler and drip irrigation systems we use at the Center's on-campus farm, then discuss the idea of water budgeting and provide some equations for calculating water application rates. I'll also talk about ways to estimate soil moisture and schedule irrigation to optimize water use.

Although the information presented here is geared to field-scale irrigation, much of it can also be applied on a garden scale. A comprehensive understanding of water scheduling and delivery is crucial in order to make the best use of this key resource and to produce a healthy, abundant harvest.

SPRINKLER IRRIGATION

At the UCSC Farm we use sprinklers to pre-irrigate open row-crop ground, and to irrigate orchards, seedbeds, and summer cover crops such as buckwheat, perennial rye grass, sudan grass, and vetch. Our standard sprinkler set up includes 20-foot-long sections of 2-inch diameter aluminum pipe with

> *continues on page 2*

either rain bird (for orchards) or adjustable plastic sprinkler heads (for row crops). Sprinkler irrigation allows us to irrigate our gently sloping fields easily, and with good uniformity.

Sprinkler systems also have some drawbacks. They can create high humidity situations that can trigger or exacerbate fungal growth in crops such as onions, tomatoes, cucurbits (cucumbers, squash, etc.), potatoes, and strawberries. Care must be taken when managing these crops with overhead irrigation to allow for extended dry periods before and after irrigation sets.

Some crops, such as sweet corn, are not practical to overhead irrigate because of height. In other crops, weed infestations can be enhanced because of the extent of soil surface wetting. Overhead irrigation should be avoided on windy days, when you can actually lose up to half of your applied water to evaporation (see *Application Efficiency and Uniformity,* page 17).

DRIP IRRIGATION

A series of dry years through the mid 1970s and again through the mid 1980s and into the 1990s has contributed to water conservation consciousness in California. As a result, drip irrigation technology, developed in the deserts of Israel in the late 1960s, has gained popularity. Drip irrigation is now a major part of our water delivery system and has helped significantly reduce our annual water use over the past 10 years, even though we have greatly increased the acreage in production.

We use drip irrigation on corn, beans, beets, winter and summer squash, pumpkins, potatoes, peppers, and strawberries, as well as garlic, onions, and other row crops. The drip line we primarily use (called T-tape) is a high-flow 8 mil tape with emitters spaced 8 inches apart.

We typically leave the lines on the surface, or we bury them very shallowly in corn, beans, and peppers by setting the cultivator to throw a little dirt over them on the last cultivation. High gopher pressure dictates surface use because gopher damage can be easily located and repaired when the lines are on or near the surface.

The T-tape is designed to be operated at low pressure (7–10 pounds per square inch) and should either be run level or on a slight downhill slope (the greater the slope, the poorer the uniformity of application, with more water ending up on the lower end of the slope; see *Application Efficiency and Uniformity*).

Some growers are concerned about the start-up costs for installing a drip system. The initial investment in drip lines and headers can range from $400 to $800 per acre, but if the system is well maintained (e.g., the drip lines are rolled up and stored indoors during winter) it should last up to five years.

Trouble-shooting Drip Systems

When using drip irrigation, it's always a good idea start up the system, then check pressure at the end of each line to see if lines are fully operational. If the system isn't coming up to pressure there's probably a large leak. If you find a line that is not dripping, then walk the entire line, inspecting it at intervals until you find the problem.

Jim Leap

Drip irrigating with T-tape directs water to the crops' roots and keeps water off of the vegetation, helping reduce diseases.

When T-tape is laid directly on the soil surface, it tends to expand and contract with the daily temperature fluctuations, which can lead to problems such as kinking and line separation at splices or headers. Often drip-line needs to be repositioned for proper function. When using T-tape on strawberries we pin the line in place with wire clips.

Clogged emitters are a common problem with many drip systems, especially in areas where water is high in mineral salts or particulates. Most systems will require a filter, which is usually installed at the pump.

Advantages of Drip Irrigation

Successful drip irrigation requires pressure regulation, water filtration, good monitoring, and good system design. Drip irrigation has helped cut our water use, while allowing us to maintain production.

Besides cutting water use, other advantages of drip irrigation include reduced levels of fungal diseases on certain crops because the foliage is not wetted, decreased weed pressure because much of the soil surface remains dry, and ease of harvest and tractor cultivation because of reduced surface wetting.

In general, drip systems require less labor than most other types of irrigation systems, but need closer management to maintain efficiency and function. State-of-the-art drip systems are set up on automatic timers and use fertilizer injection systems. The use of buried T-tape in permanent beds is gaining popularity but requires specialized tillage equipment.

WATER BUDGETING HELPS REFINE IRRIGATION PRACTICES

In its simplest terms, irrigation scheduling or water budgeting—i.e., deciding how often and how long to irrigate—is based on the idea of replacing water extracted from the soil. This extraction is a function of *evapotranspiration* (Et)—a combination of evaporation from the soil and transpiration as water is transferred to the air through the stomata, or respiratory pores, of the growing crop. Factors affecting Et include crop growth stage, soil type, and climate.

The typical evapotranspiration rate for a full canopy crop on the UCSC Farm during the summer and early fall is about one inch of water per week. So in general we want to apply about one inch of irrigation water per week for an actively growing crop, including orchards, during the warm part of the growing season in order to replace water lost through evapotranspiration. Obviously, an unusually hot week might generate the need for as much as a two-inch replacement, while a cool, foggy week would have a very low replacement rate. Note also that a newly germinated crop will have a low Et rate; it is critical not to over-irrigate young crops.

Irrigation frequency should correspond to the time required for the soil in the crop's root zone to dry to approximately 50% of field capacity, where field capacity is defined as the amount of water that the soil will hold against the pull of gravity (see Estimating Soil Moisture chart, page 18). In other words, if it takes three days for the soil to dry down to 50% of field capacity, irrigation should take place every three days.

This rule of thumb will vary depending on the crop. Given their shallow root systems and increased susceptibility to water stress, annual crops often require more frequent irrigation (2–3 times per week for many crops). Conversely, established orchards with deep root systems often require less frequent but larger volumes of water to be delivered in each irrigation. In both situations the amount of water lost through evapotranspiration is replaced, but the frequency of irrigation is different.

Calculating Evapotranspiration Rate

In California, the California Irrigation Management Information System (CIMIS) provides information on evapotranspiration for regions throughout the state. This information is available on the CIMIS web site, www.cimis.water.ca.gov, or call 800.922-4647.

Calculating a Water Budget for Your Farm

Once you know your region's Et rate, you can develop a water budget for your farm by calculating the output rate (gallons per minute, or gpm, of water applied) of your sprinkler or drip system and determining how long the system must run in order to replace the water lost through evapotranspiration.

One point of confusion I've encountered when explaining the water budget idea is: Where is the starting point? When calculating a water budget, assume that you are starting at field capacity (see Estimating Soil Moisture chart). A good analogy is to think of a person (plant) with a glass of water and a straw (roots). You can't start extracting water (via evapotranspiration) unless you start with a full glass. Then every time you extract water, you replace it with the same amount of water that was drawn out (water budget/irrigation schedule). Ideally, just before you take your last sip you harvest the crop.

Jim Leap

Sprinkler irrigation delivers uniform coverage to the gently sloping fields of the UCSC Farm.

Sprinkler Irrigation Water Budgeting

The following three steps show how to calculate the time needed to replace water lost through Et from a 1-acre block of vegetables in full canopy using sprinkler irrigation—

Step 1: Calculate evapotranspiration in a 1-acre field in Santa Cruz –

- Daily average summer evapotranspiration rate for an actively growing crop in full canopy in Santa Cruz = 0.15 inch/day (from CIMIS data)
- Multiply this by 7 days/week = ~1.05 inches/week
- There are 27,154 gallons of water in an acre inch (an acre inch is the amount of water needed to cover an acre to a 1-inch depth)
- An acre = 43,560 square feet (roughly 208 feet x 208 feet)
- Multiplying 1.05 inches/week (Et) x 27,145 gallons/acre inch = **28,512 gallons/acre** of water lost each week through evapotranspiration in an actively growing crop in full canopy.

Step 2: Calculate sprinkler irrigation output (the sprinkler system's output rate is based on sprinkler head orifice size and system pressure) –

- Flow rate from a 1/8-inch nozzle running at an operating pressure of 45 pounds per square inch (psi) is about 3 gallons per minute (gpm)
- There are roughly 109 sprinkler heads per acre using 20-foot pipes set 20 feet apart (20 feet x 20 feet = 400 square feet. 43,560 square feet/acre divided by 400 = 109)
- 109 sprinkler heads x 3 gpm each = 330 gallons per minute
- 330 gallons/minute x 60 minutes/hour = **19,800 gallons/hour/acre**

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from the

director

Spring brings the end of the rainy season to California's central coast, where our Mediterranean climate means a long, dry summer before the fall rains arrive. Even in non-drought years, conserving water is a high priority for farmers and gardeners. At the Center's UCSC Farm and Alan Chadwick Garden, drip irrigation systems and carefully timed irrigation sets save water while ensuring crops receive optimal moisture. In this issue's cover story, Farm manager Jim Leap shares ideas for developing "water budgets" to fine tune irrigation practices.

Jim will also be involved in a new study of garden symphylans (*Scutigeralla immaculata*), recently funded by the US Department of Agriculture's Western Sustainable Agriculture Research and Education program (*page 9*). The Center's farm will serve as one of five research sites in California and Oregon for studying potential organic control options for this persistent soil pest.

The Center's social issues research will also be expanding in the coming months. A new project, funded by UCSC's Center for Global, International and Regional Studies, teams social issues staff and other UCSC academics with activists from NGOs to look at ways of promoting social justice in the food system (*page 8*). Patricia Allen, who directs the Center's social issues research, has also initiated a study with UCSC Community Studies professor Julie Guthman to examine school food policies. They are particularly interested in identifying programs that have successfully addressed concerns about children's nutrition and have provided a secure market for local small-scale growers (*page 10*).

Also in this issue, social issues researcher Phil Howard explores the social context of genetic engineering (GE), looking at some of the factors that have created the economic incentives for this new technology and the way that these incentives have influenced GE research.

Publication of our training manual, *Teaching Organic Farming and Gardening: Resources for Instructors*, has generated widespread interest and positive feedback (*page 13*). As we'd hoped, this publication is serving a wide audience, including college and university instructors, to cooperative extension agents, to farmers with apprenticeship programs, to those working in overseas development programs.

I received a warm reception at Yale University earlier this year, where I presented a paper on the Center's history and work as part of the Yale Agrarian Studies Colloquium series. Widespread interest among the colloquium participants in the Center's unique combination of research, education, and outreach reminds me that the Center is truly a model and inspriration for those developing programs that combine practical training with academic research and public education efforts.

- Dr. Carol Shennan

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On the UCSC campus, the Center manages the 25-acre Farm and 2-acre Alan Chadwick Garden, both open daily to the public. For more information about the Center and its activities, please contact us at:

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Killer Tomatoes versus Golden Rice: The Social Context of Genetic Engineering

Thousands of demonstrators from environmental and anti-globalization groups took to the streets of Sacramento, California this June to protest a U.S. government-sponsored summit on GE (genetically engineered) food and other aspects of industrial agriculture. Conference organizers billed the meeting as an attempt to increase understanding of agricultural technology and showcase its potential to alleviate hunger and improve nutrition. Protesters countered that the conference was a thinly veiled effort to prop up the biotechnology industry by painting a false picture of its benefits while ignoring its negative impacts and the true causes of hunger.

In an interview with *The Guardian* newspaper, Mary Bull of the anti-GE group Killer Tomatoes said, "The United States is trying to coerce poor African nations into taking [GE foods]. It is a really significant conference from that point of view and we have to show that food can be distributed in a just and equitable way and not in the form of corporate-controlled and pesticide-driven agriculture," (Campbell 2003).

How did we get to this point in the evolution of genetic engineering, with citizen groups pitting themselves against corporations such as Monsanto in a showdown over control of the food supply?

Ironically, the first scientists to splice foreign genes into DNA—the technique used to develop GE products—were concerned enough about the technology's potential negative effects that they chose to put limits on their own research. This concern was quickly overridden by researchers' fears that non-scientists would legislate the direction of gene manipulation studies. Troubling experimental results were downplayed so as to alleviate any potential legal controls on gene-splicing research.

Financial incentives for researchers developed in step with biotechnology's advances. The patenting of living organisms led to investor interest, and industry funds began to underwrite the majority of university research on genetic engineering. Within two decades of GE's debut, chemical companies were buying up seed companies at exorbitant prices to consolidate their hold on the manufacture and "bundling" of GE seeds and pesticide inputs. Today, the entire food chain—from seeds to processing and distribution—is being increasingly consolidated by a handful of multinational corporations.

In this article I review the social context of genetic engineering and summarize the developments that have led to the current standoff between those concerned about the economic, social, and environmental impacts of GE technology and those who will profit by increasing the distribution of GE products.

FEAR OF RESEARCH LIMITATIONS OVERRIDES EARLY CONCERNS

In the early 1970s, the first techniques were developed for splicing foreign DNA into bacteria using newly discovered enzymes. The scientists involved in this research quickly became concerned about the possibility of creating new diseases. By 1974 many of these scientists called for temporary restrictions on their own lines of research, a move unprecedented in the history of biology outside of human experimentation. Paul Berg, a leading researcher and chair of biochemistry at Stanford said at the time, "It is the first time I know of that anyone has had to stop and think about an experiment in terms of its social impact and potential hazard," (Wade 1974).

A hurried meeting was held at Pacific Grove, California's Asilomar Conference Center in 1975 to figure out how to implement these restrictions. The scientists agreed on voluntary safety guidelines, such as strict containment and working with disabled bacteria. National Institutes of Health (NIH) then adopted these guidelines for projects they funded.

The scientists' concern led citizens to become interested in the issue. Regulations even more stringent than the NIH guidelines were soon enacted in a dozen cities, including a citizen oversight commission in Cambridge, Massachusetts, home of the Massachusetts Institute of Technology and Harvard University. Removing oversight of experiments from the NIH to an outside committee was also being proposed at this time through federal legislation sponsored by senator Ted Kennedy.

Scientists felt their freedom was being threatened by these impending legislative controls on their work. In response, they organized and engaged in a public relations campaign. Their primary strategy was to exaggerate the benefits of genetic engineering and downplay the risks (Buttel 1993).

In 1976 scientists serving on an NIH committee investigated the danger of infection from GE organisms. However, instead of testing the worst-case scenario, they used weakened bacteria so that results would be more favorable and thus head off any attempts to regulate the field.

Here are a few quotes from this committee –

> *continues on next page*

"By using known pathogens, it seems to me we go politically in the wrong direction even though scientifically it does make more sense."

"If we want to get these experiments done so we can go about our work quickly, maybe one shouldn't introduce problems of this level."

"It's molecular politics, not molecular biology, and I think we have to consider both, because a lot of science is at stake." (cited in Wright 1994)

Despite designing the experiments in this way, some of the bacteria did cause tumors in animals. However, these results were never published. In 1979 the NIH held a press conference to announce that "this form of research is perfectly safe." The NIH regulations that had placed limits on GE experiments were soon relaxed. The strategy of downplaying risks and exaggerating benefits had proved effective in addressing the political threat to genetic engineering research.

FINANCIAL INCENTIVE OF GE TECHNOLOGY

In 1980 two major events occurred that shaped the subsequent path of the science and industry of genetic engineering. First was the U.S. Supreme Court decision in Diamond v. Chakrabarty. This 5-4 ruling allowed patents on living organisms that were genetically engineered. Second, Congress passed the Bayh-Dole Act, which allowed universities to patent and commercialize publicly funded research applications.

By this time the exaggerated claims of genetic engineers had begun to attract the interest of Wall Street venture capitalists. As a result, some cell biologists became millionaires literally overnight by starting their own companies, even while remaining employed by a university. An almost unintended side effect of the political battle to keep GE free of regulation was a strong economic interest in continuing to exaggerate its potential benefits, such as those made for the product Golden Rice[1], and minimize its risks.

Industry funding of academic research increased by over 800% during the next 20 years, triggering a growing potential for conflicts of interest. In a study of 800 scientific papers published in biomedical and life science journals in 1992, more than a third of the authors had an undisclosed financial interest in the results (Krimsky et al. 1996).

CHEMICAL COMPANIES SEE PROFITS IN SEEDS

By the 1990s, the effects of the legal and legislative actions noted above were clearly evident in the structure of the seed industry. No chemical companies were in the seed business ten years ago, yet today five gigantic chemical corporations are among the world's largest seed companies. These are Monsanto, DuPont, Syngenta (formed by a merger of AstraZeneca and Novartis), Aventis (now a subsidiary of Bayer), and Dow. Monsanto and DuPont have a biotechnology sharing agreement and together control 15% of the world's commercial seed market, including 73% of U.S. seed corn sales (ETC Group 2002).

The past two decades have seen tremendous consolidation in the industry, with global seed sources dwindling from 7,000 companies in the mid 1980s to 1,500 in the late 1990s (Madeley 2003). This dramatic decline has resulted directly from the "Gene Giants" buying up seed companies, usually at highly inflated prices. Monsanto spent $6 billion buying seed companies in 1996 and 1997 alone. DuPont paid $7.7 billion for Pioneer Hi-Bred Seeds. The only explanation for the amounts paid, which cannot be justified by seed company earnings, is a deliberate strategy to control the food supply in the expectation of eventual monopoly profits.

For example, in 1994 Agracetus filed a patent claim on *any* soybean that was developed through *any* process of genetic engineering. Monsanto opposed this patent until they acquired Agracetus in 1996. In May of 2003 the European patent office upheld this claim, which had been in the appeal process for nine years. Jim Thomas of the Action Group on Erosion, Technology and Concentration (ETC) said, "It's a bit like publishing a badly written cake recipe and then claiming ownership of any cakes baked by anybody using any recipe any time in the future," (ETC group, 2003). Monsanto currently controls 100% of genetically engineered soybeans and approximately 91% of genetically engineered seeds overall. Almost all the rest of the market is controlled by just four other massive chemical companies (Madeley 2003).

Unlike hybrid seeds, which are covered under the Plant Variety Protection Act, patented genetically engineered seeds cannot legally be saved by the farmer. Farmers who have saved GE seeds are being fined millions of dollars in some cases, and have even been sentenced to prison. Private investigators hired by corporations that sell seed are checking up on farmers (sometimes illegally) to enforce their "intellectual property rights," even for non-GE hybrid seeds.

In Canada a court ruled that even if the seeds get in your fields accidentally, you are required to pay the technology fee or remove them. The farmer involved in this case, Percy Schmeiser, recently learned that the Canadian Supreme Court will hear his appeal of this decision. Not content to rely on their political power, corporations are currently developing technologies to prevent seeds from germinating or expressing key traits unless the grower applies the company's proprietary chemicals.

CORPORATIONS TAKE AIM AT FOOD SUPPLY

Genetic engineering is driving the corporate takeover of the rest of the food supply. Robert Fraley, co-president of Monsanto's agricultural sector, described his company's strategy in the magazine *Farm Journal* (October 1996): "What you're seeing is not just a consolidation of seed companies, it's really a consolidation of the entire food chain."

[1] Developers of "Golden Rice"—a rice strain genetically engineered to express Vitamin A—claim that their product will alleviate sight loss and other diseases linked to Vitamin A-deficiency. However they omit the fact that according to their own figures, an adult would have to eat nearly 20 pounds of cooked rice a day to satisfy his or her Vitamin A requirement from the initial introduction of Golden Rice (Brown 2001).

Cargill, which had one of the largest seed businesses in the world, sold its operation to Monsanto because it did not have access to genetically engineered varieties. Cargill then entered into a joint venture with Monsanto to obtain access to GE technology. Together, these two corporations control everything from seeds, pesticides, chemicals, grain collection and processing, to meat production and processing (Heffernan et al. 1999).

Genetically engineered seeds are being tied to other inputs to lock farmers into the four or five major chemical/GE seed players. For example, Monsanto's Roundup Ready seeds can only be used with Roundup herbicide, even though cheaper versions of this herbicide are available. Pioneer DuPont seed gives better interest rates on financing, depending upon how much "approved" products the farmer buys; approved chemicals include those from Syngenta, Bayer/Aventis, and Dow. The precedent set with patented genetically engineered seeds is also being extended by "bundling" chemicals and other inputs with conventional seeds. For example, Syngenta in the United Kingdom recently began selling a non-GE hybrid barley *only* in conjunction with their pesticide. No pesticide, no barley.

Monsanto spent half a billion dollars each on Roundup resistance and recombinant bovine growth hormone by 1995. Very few companies can afford these development costs. If public acceptance of genetic engineering were more widespread, we would almost certainly have even greater corporate control of the food supply.

ANOTHER STEP ON INDUSTRIAL AGRICULTURE'S TREADMILL

Almost 100% of GE crops are straightforward extensions of industrial agriculture: they are bred to tolerate herbicide applications or to produce pesticides. A tiny minority is designed to resist viruses—a way to patch up problems caused by monocultures, which are more susceptible to disease. GE researchers are developing products to fix other problems stemming from industrial agriculture, such as soil salinization. None of these "fixes" address the real problems of industrial agriculture, such as pollution from pesticides and fertilizers, soil erosion, groundwater overdraft, and loss of biodiversity.

Increased yields are another area of GE research. However, even if yields were successfully increased this would only contribute to the treadmill of production, where the earliest adopters of new products receive temporary benefits from increased production. Subsequently the increase in supply leads to price drops, and other farmers are forced to increase their yields just to survive financially. Despite the claim by GE supporters that this technology is needed to feed the world, there is already enough food being grown to provide everyone with adequate nutrition. The problem is not one of production, but one of distribution and people's ability to buy food (Lappé et al. 1998).

But even the GE industry's shortsighted efforts haven't worked very well. Despite claims, genetic engineering has not increased yields, and there have been numerous problems such as crop failures and the emergence of superweeds that are resistant to herbicides (Ho and Ching 2003). The biotechnology industry lost $11.6 billion in 2002, a 71% increase from the year before. Only 20 of 318 public biotechnology companies have had sustained profitability in the last three years (Hamilton 2003).

Nearly 30 years after it was first developed, genetic engineering has yet to deliver on the promises scientists made in order to avoid regulation of their research. Instead, GE has helped to centralize corporate control of food, agriculture, and publicly funded research, while creating a backlash from consumers, farmers, and others unwilling to see GE technology dominate the food system's future.

– Phil Howard

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Academics and Activists Team to Promote Social Justice in the Food System

Social justice issues in the agriculture and food system have often taken a back seat to efforts aimed at improving growing techniques, finding alternative marketing outlets, and saving the family farm. Overlooked have been issues such as labor relations, gender inequities, and access to productive resources. This is particularly true in California, where much of the country's food is produced, yet many of those who grow and harvest it go hungry as their families live in poverty.

Partly as a result of this stark juxtaposition of social inequity and unparalleled abundance, the California sustainable agriculture movement has begun to tackle social justice issues that have been shunted to the side for far too long in the interest of production-oriented technical advances. Within several key organizations, political will now exists to address the inter-related problems of food cost and accessibility, wages and working conditions on farms and in food service, and the viability of farms that incorporate agroecological practices.

Social issues researchers from the Center for Agroecology and Sustainable Food Systems (the Center) have worked for many years to address social as well as environmental issues, and to bring these topics into the conversation about developing a truly "sustainable" agriculture and food system—a system that sustains people as well as the land.

A $3,000 grant made this spring by the UC Santa Cruz Center for Global, International and Regional Studies (CGIRS) will provide seed funding for a project in which UCSC academics will work with non-governmental organizations (NGOs) to address social issues in the agrifood system. The Center is providing additional funding to support this project, which seeks to improve the accessibility and relevance of academic research. The objectives of the project are to—

1. forge better understandings of the institutional context in which each group works in order to better support each others' work;
2. share lessons, insights, and findings from research and activism that has already been done;
3. create a shared research and education agenda;
4. establish tangible and specific institutional ties, including cross-group advising and governance roles, ongoing networking structures, and specific project collaborations;
5. seek funding that would support specific research and the ongoing collaboration of these groups.

The project brings together a number of UCSC academics with interests in social issues in the agrifood system. They include—

- Julie Guthman, assistant professor, Community Studies
- Patricia Allen, associate director, Center for Agroecology and Sustainable Food Systems
- Melanie Du Puis, associate professor, Sociology
- Phil Howard, postdoctoral researcher, Center for Agroecology and Sustainable Food Systems
- Jan Perez, postgraduate researcher, Center for Agroecology and Sustainable Food Systems
- Carol Shennan, professor, Environmental Studies, and director of the Center for Agroecology and Sustainable Food Systems
- Keith Warner, graduate student, Environmental Studies

Work will focus on collaboration with California NGOs, such as the California Sustainable Agriculture Working Group (CSAWG) and the California Food and Justice Coalition. CSAWG is a statewide coalition of organizations dedicated to strengthening the movement for a sustainable and socially just food system in California. The member organizations include family farmer, environmental, organic agriculture, consumer, farmworker, public health, community food security, pesticide reform, and local advocacy groups. The California Food and Justice Coalition is a new organization that grew out of a food security summit held in June of 2003. This statewide membership coalition is committed to the basic human right to healthy food while advancing social, agricultural and environmental justice.

Plans for the project include holding meetings with NGO leaders who are working on sustainable food systems to establish working relationships, discuss shared agendas, and plan a one-day workshop for January 2004. This workshop will be held in conjunction with the Ecological Farming Conference in Asilomar, California (see *Events*, page 20), a conference attended by most California NGOs working on sustainable food systems. NGO staff and university-based researchers interested in social justice issues in the agrifood system will be invited to take part in a workshop focused on strategic planning to deepen and expand the collaboration.

– Patricia Allen
Martha Brown

Center to Take Part in Study of Garden Symphylans Control Options

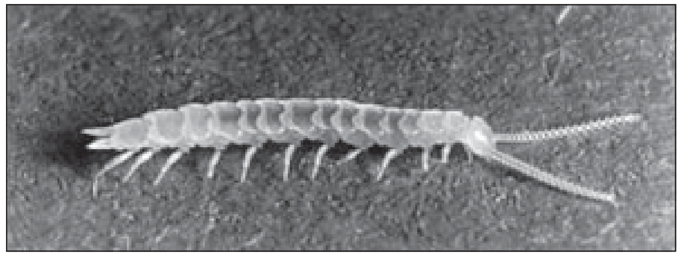
The garden symphylan (GS), *Scutigerella immaculata*, is a key pest of over 100 crops in Oregon, California, and Washington. Populations of this tiny centipede-like organism feed on the roots of developing plants, weakening or killing the plants, or increasing their susceptibility to soilborne diseases such as the *Verticillium* soil fungus.

Organic growers have few management options when it comes to suppressing garden symphylans, beyond avoiding infested ground, tilling extensively to physically disrupt populations, and planting large transplants that can outgrow feeding symphylans. Because there are no organically approved pesticide treatments for symphylans, organic farms are particularly vulnerable to the pest. This is compounded by the fact that GS populations tend to flourish in soils with good structure and high levels of organic matter—a hallmark of many organic farms.

For the past several years, Center for Agroecology and Sustainable Food Systems farm manager Jim Leap has worked with Jon Umble of Oregon State University to improve monitoring techniques for symphylans and has experimented with various crop rotations to see whether certain crops naturally suppress the pest's populations (see "Symphylans challenge growers and researchers," in *The Cultivar*, volume 19, no. 1, Spring/Summer 2001).

Umble has found that symphylan populations remained generally stable when corn or no crop was grown, but increased substantially in the presence of spinach and lettuce crops. Leap and Umble have also observed that potato crops appear to suppress GS populations, thus limiting or eliminating symphylan damage not only to the potato crop itself, but also to crops that follow potatoes in the rotation. This suppressive effect of potatoes has been duplicated at other farms and in the laboratory.

Based on these promising results, Umble recently received a grant from the US Department of Agriculture's Western Sustainable Agriculture Research and Education program (WSARE) to pursue work on the effect of potatoes and other *Solanum* species (e.g., tomatoes, peppers) on the garden symphylan. The research effort will also include improving GS monitoring techniques so that growers will be better able to evaluate the levels of GS in their soils and make appropriate management decisions. The Center's farm at UC Santa Cruz will serve as a research site for the study, along with the organically managed Student Farm at UC Davis, the conventionally managed Oregon State University Horticulture Farm in Corvallis, and two private farms in Oregon (one organic and one conventional). All of the sites have experienced crop damage from GS.



The garden symphylan (GS) is translucent to white in color and less than a 1/4-inch long, with 10 to 12 pairs of leg. When unearthed from the soil they move rapidly away from light.

This WSARE-funded study will focus on isolating and analyzing the mechanism that causes the observed decrease in symphylan populations when potatoes are grown, and will evaluate the potential of growing potatoes and other *Solanum* species, or using potato alkaloid-derived compounds, to manage GS. It will also examine whether the population decrease that the researchers observed also occurs when a known symphylan host, such as a weed species or GS-vulnerable crop like broccoli, is grown with the potatoes. This issue has broad implications, both for evaluating the effectiveness of the potato crop reduction tactic when weed hosts of symphylans are present and for evaluating other potential applications of the potato crop reduction tactic (e.g., using potatoes as an intercrop).

STUDY DESIGN

The field study will include four treatments: 1) a weed-free potato cropping system, 2) a potato cropping system with a planted "weed" host (broccoli), 3) an additional *Solanum* species crop determined to supress symphylans (based on laboratory tests), and 4) a control (broccoli). The treatments will be established next spring (year 1) at each of the 5 study sites in plots identified as having high symphylan populations. In year 2 all of the plots will be planted to broccoli. The research group will evaluate the effect of the treatments by comparing GS densities and broccoli health in year 2 among the treatments.

In addition to field tests, Umble will conduct greenhouse and laboratory tests to determine whether the suppressive effect of potatoes is caused by symphylans feeding directly on the plants and tubers, or by exposure to chemicals exuded by the potato plants' roots or tubers.

> *continues on page 16*

Research Updates

New Center Project to Analyze School Food Policies and Programs

Nationwide, schools serve 6.5 billion meals each year, affecting children, parents, teachers, and food producers and processors. Since their inception in 1946, school food programs had undergone little change. But in the past several years, fiscal crises of school districts along with concerns about child nutrition and economic concentration in the food system have led to various innovations in school food programs and policies.

These innovations include banning on-campus sales of fast foods, soft drinks and other foods high in fat and sugar—even though sales of these products have created an important revenue stream for schools. For example, new California legislation specifies fat and sugar content limits for elementary school meals. In addition, some school districts have joined with the sustainable agriculture movement to develop farm-to-school food requisitioning programs, bringing together two seemingly unrelated issues—child health problems and the viability of small farms. Farm-to-school programs aim to increase the nutritional value of children's school meals while simultaneously providing a secure market option for small-scale growers.

A new study coordinated by Patricia Allen, the Center's associate director and social issues specialist, and Julie Guthman, assistant professor of Community Studies at UC Santa Cruz, will examine some of California's innovative school food projects to determine how school food programs are determined and developed.

Guthman and Allen will address a variety of questions, including: How and why are different school food projects and programs developed? What roles are played by community demographics and locality? How are school policies negotiated among various constituents? Who gets included and why? How do some districts become innovators while others do not? How do budgetary considerations and/or entitlement availability affect what takes place? How do federal and state policies and programs shape what can be done?

In addressing these questions, the researchers hope to identify some of the most effective school food programs and pinpoint what has made them successful. This preliminary work will form the basis of a broader research effort to assess the potential of school programs in furthering the development of sustainable food systems.

Study Examines Effects of Annual and Perennial Cover Crops

With the increase in organic farming along California's central coast, new land is being converted from conventional production and certified to meet organic standards. Certification requires a three-year transition period during which prohibited inputs cannot be used; however, there is usually no price premium for crops grown during the transition time. This may be a window during which growers can improve their soil using perennial cover crops.

At the Center's UCSC Farm, manager Jim Leap has developed a seven-year crop rotation that includes an 18-month fallow period. During the fallow, he grows a perennial rye grass cover crop to build soil organic matter. In 2002, Center researchers and affiliated faculty established trials at the Center's Farm to compare two cover cropping strategies: a one-year fallow treatment cover cropped with perennial rye grass, overseeded after a few months' growth with crimson clover, versus an annual winter cover crop treatment (bell bean, vetch, oat grass mix). No additional compost was added to either treatment following the cover crops' incorporation.

The researchers were particularly interested in the levels of organic matter generated by each treatment, the nitrogen available to crops following the cover crops' incorporation, and the soil respiration rates throughout the cover crop season and subsequent cropping season.

Researchers found that the amount of available nitrogen in the perennial cover crop treatments was consistently lower through most of the experiment, suggesting that less nitrogen was available for loss through leaching, but also less available to the developing crop. Much of the

Jon Kersey

Blocks of broccoli and potatoes were grown following cover crop incorporation.

overseeded crimson clover was eaten by slugs, further lowering the amount of nitrogen available from the perennial cover.

Yields of broccoli—a particurly nitrogen-sensitive crop—planted after the cover crops were incorporated were significantly lower in the perennial cover crop treatment. In contrast, potato yields were not affected by the different cover crop treatments. Soil respiration rates remained higher in the perennial cover crop treatment even after it was turned under, suggesting the persistence of a more active soil microbial community. This may reflect higher levels of carbon available following the perennial rye treatment.

Despite the impact on yields, the goals of organic production , such as improving soil organic matter levels and decreasing nitrogen loss from the soil system) may justify the use of perennial covers and fallow periods to improve soil quality, especially in systems undergoing the transition from conventional to organic management. The research group will continue to modify perennial cover crop treatments and examine ways to optimize soil-building techniques.

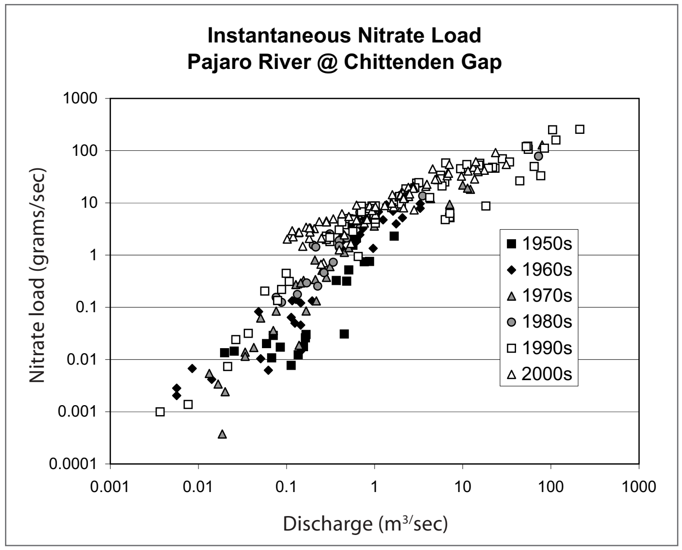
Center Presents Water Quality Monitoring Results to Local Growers

One aspect of the Center's Central Coast Project investigates the impact of farming and other land uses on water quality in the Monterey Bay watershed (see "Study examines agriculture's impact on central coast water quality," *The Cultivar*, Fall/Winter 2001, vol.19 no. 2) . This effort seeks to increase the sustainability of agriculture on California's central coast by helping farmers understand the impact of their practices on water quality, and suggesting ways to improve soil and fertility management to protect natural resources. The project team includes Center director Carol Shennan, and Center researchers Marc Los Huertos, Lowell Gentry, Claire Phillips, and Alex Fields.

Although previous data suggested that various central coast land use practices, including agriculture, had an impact on water quality, strong conclusions could not be drawn because data sets had not sampled a wide area over an extended time period. Therefore it was difficult to make conclusive statements about the links between land use practices and impaired waterways.

As a result, growers in the Monterey Bay watershed have been understandably apprehensive about the prospects of new farming regulations based on preliminary conclusions. Nevertheless, with the Farm Bureau's help, growers have organized themselves into watershed working groups with the explicit goal of developing water quality plans for their farms and ranches.

In coordinating these working groups, Center researchers have taken on a unique role in the region to summarize existing water quality data while explaining and exploring the data limitations and what conclusions can and cannot be drawn from them. After nearly three years of sampling,



Sampling shows an increasing level of nitrates in the Pajaro River from the 1950s to the present.

the Center now has one of the most robust water quality data sets in the region (a summary of this data will appear in the next issue of *The Cultivar*).

Last winter, Marc Los Huertos was invited to present water quality data for the watershed working group in the Pajaro Valley. As shown in the figure above, nitrate concentrations have been increasing in the Pajaro River for several decades. Samples from numerous locations in the study exceed the drinking water standard of 10 mg/L (ppm). Nitrate concentrations at this level often adversely impact aquatic ecosystem function and when found in drinking water are considered to be a human health risk. The increase in the concentrations of nitrate occurs as waterways pass through agricultural areas, which suggests that agriculture is a likely source, although other sources cannot be ruled out.

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Lowell Gentry

Researchers measure nitrate and phosphorus levels throughout the Monterey Bay watershed in areas with different land uses, including forested regions, urban areas, and sites adjacent to agricultural land.

In addressing the working group, Los Huertos discussed how inorganic phosphorous (ortho-P) can also impair waterways by triggering noxious algae production in freshwater systems. Currently, there are no numeric goals established by the Regional Water Quality Control Board to limit phosphorous contamination, but it is likely that goals may be approximately 0.2 ppm ortho-P. In other words, discharge into the creeks and rivers along the central coast should be below this target figure. However, the Center researchers found ortho-P concentrations higher than 0.2 ppm in Corralitos Creek, in a location that drains a redwood forest with no obvious human-caused sources of phosphorous.

These data highlight the importance of careful testing and negotiations over how water quality data and water quality regulations are interpreted, in order to avoid placing an unnecessary regulatory burden on growers.

Study of Aphid Impact on Broccoli Continues

Diego Nieto, a research assistant in the Center's Farm Extension program, began his second season of work this spring examining the dynamics of cabbage aphid (*Brevicoryne brassicae*) infestations of organically grown broccoli. The cabbage aphid is the principal pest for broccoli growers on California's central coast. The study, which is part of Nieto's master's research in biology for San Jose State, takes place at Pure Pacific Farms in Monterey County and at the Center's UCSC Farm.

Nieto is examining variables that affect whether or not aphids will damage the broccoli head enough to make it unharvestable. These variables include the plant's location in the field, the impact of wind direction, the growth stage of the broccoli when the aphids arrive (arrival time), and the location of the aphid colony on the plant itself. At the UCSC Farm, he is experimenting with caged plants to isolate aphid arrival time and location of the aphid infestation as factors that affect harvestability of broccoli. For instance, he is simulating early arrival time by introducing aphid colonies to a broccoli plant, then caging the plant to isolate it from additional infestations.

At the Monterey County site, Nieto is also examining the effect of planting a "good bug blend" of over a dozen species, mostly clovers, cornflowers, and poppies, adjacent to the broccoli crop to see whether it can attract sufficient beneficial insects to help control aphid infestations.

Results thus far indicate that the earlier aphids arrive on a plant, the less likely it will be harvestable at the end of the season. An aphid colony's location on the plant has also proven to significantly influence whether or not a broccoli's head is harvested. So far, the parasitism that occurs depends on the density of aphids present, with higher numbers of parasites occurring with a high density of aphids. The research will continue through a third cropping season.

Center

Notes

Center Staff Participate in Farm Bureau's Focus Ag Program

Christof Bernau, who manages the hand-worked gardens at the Center's UCSC Farm, and Nancy Vail, the Center's Community Supported Agriculture coordinator, are taking part in this year's Focus Ag program sponsored by the Santa Cruz County Farm Bureau. Focus Ag informs community leaders, policy makers, and educators about agricultural issues in Santa Cruz and Monterey Counties. The program was developed after a survey demonstrated a lack of knowledge about agriculture among people in the region—a region where agriculture and tourism are the leading economic activities.

Says Bernau, "The gamut of things we are learning about include water issues, land use planning, abalone farming, timber practices, crop production, genetic engineering, the farming and wildlife interface and other salient issues." During the nine-month program, participants are exposed to the range of the region's agricultural products and practices, including organic agriculture, with the hope that they will come away with a better understanding of the role agriculture plays in the area.

Vail has found the program a valuable source of material for her teaching work at the Center. "Attending Focus Ag has been a wonderful opportunity to hear first hand about the issues, challenges, and opportunities involving agriculture in Santa Cruz County. Learning about the complexities around water, land use, and relationships between farmers and environmentalists has already helped me become a better-informed instructor in organic and sustainable agriculture. I'm looking forward to upcoming sessions and having the opportunity to share more with the apprentices."

Others taking part in this year's Focus Ag program include a congressional aide to U.S. Representative Sam Farr, a field representative for State Senator Bruce McPherson, directors from the Second Harvest Food Bank and the Grey Bears, a division chief from the California Department of Forestry and Fire, and district director for Assemblyman Simon Salinas.

Center director Carol Shennan recently began serving on the Focus Ag Board of Directors, which helps plan the program and carefully reviews feedback from participants. According to Shennan, Focus Ag is seen as a model for improving the visibility of agriculture, and has been contacted by a number of counties interested in developing similar programs in their areas.

Center Work Presented at Yale Colloquium Series

Center director Carol Shennan was invited to present a seminar at the Yale Agrarian Studies Colloquium series at Yale University earlier this year. In her presentation, entitled "Bridging disciplines and the theory/practice divide: The challenges and successes of the UC Santa Cruz Center for Agroecology & Sustainable Food Systems," she discussed some of the influences that have shaped the Center's work and mission, and raised questions about the role of public universities and science in social change, particularly within the food and agriculture system.

According to Shennan, the seminar was well received, with lots of interest from students and faculty. As a result she was asked to advise efforts to develop an urban farm on the Yale campus, as well as a compost production effort (using food waste from college kitchens). Both projects serve as educational resources for students and the community. One of the colleges at Yale has also committed to serving organic food in its dining facility.

Training Manual Receives High Marks

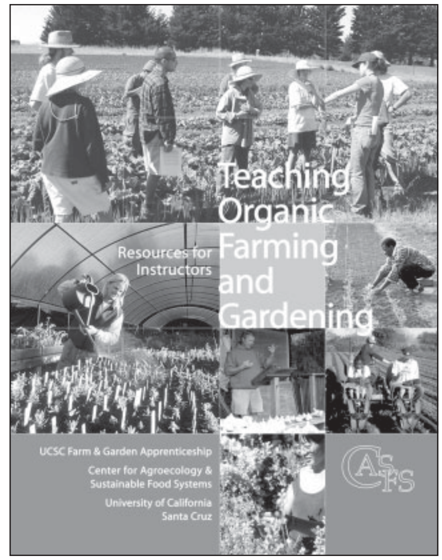
In January 2003 the Center published a training manual based on the course material presented in its six-month Apprenticeship training program (see Apprenticeship program announcement, next page). *Teaching Organic Farming and Gardening: Resources for Instructors* covers practical aspects of organic farming and gardening, applied soil science, and social and environmental issues in agriculture. Units contain lecture outlines for instructors and detailed lecture outlines for students, field and laboratory demonstrations, assessment questions, and annotated resource lists. Although much of the material has been developed for field or garden demonstrations and skill building, most of the units can also be tailored to a classroom setting.

In reviewing the training manual, Raymond Poincelot, editor of the *Journal of Sustainable Agriculture,* noted that "Both the Center for Agroecology & Sustainable Food Systems and the UCSC Farm & Garden Apprenticeship have been in the forefront of organic farming and gardening for many years. Their track record has been excellent and this resource guide is no exception. [It] is likely to become the benchmark for such materials and promises to be very useful to educational, extension, research and other professional institutions and programs interested in training organic farmers and gardeners."


Marci Krass

Teaching Organic Farming & Gardening: Resources for Instructors includes classroom and hands-on lessons on garden- and field-scale compost production.

Center staff and seven invited authors developed the lectures, demonstrations, and hands-on exercises in the 600-page training manual.



Other feedback we've received includes the following from a rural development project organizer in Kenya, who wrote: "This manual looks like the very best resource yet that I have come across to help us develop training modules for local farmers. Thank you for making it available." A number of college and university programs and Cooperative Extension offices from around the country have also ordered the manual; one North Carolina Extension employee wrote to say, "I appreciate your willingness to make such a valuable resource available via the internet, and without charge. Efforts like yours are what help too-often-underfunded Extension offices move forward on agricultural sustainability and support for organic agriculture. Many thanks."

The 600-page manual is designed to be placed in a 2-inch, 3-ring binder so that sections can be easily removed and copied for class use. It is available from the Center for $45. Price includes tax, shipping, and handling; binder not included. To order, send a check or money order made payable to UC Regents to: CASFS, 1156 High St., Santa Cruz, CA 95064, attn: Teaching Manual. Please be sure to include your mailing address.

The manual is also available to download in PDF format for free from the Center's web site (www.ucsc.edu). If you have questions about the resource guide, or questions about ordering, please send email to TrainingManual@ucsc.edu or call 831.459-3240.

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Marci Krass

Propagation techniques are among the many skills that apprentices develop during the six-month training course held at the Center's Farm & Garden on the UCSC campus.

2004 Apprenticeship Announced

The Center's six-month Farm & Garden Apprenticeship course provides training in the concepts and practices of organic gardening and small-scale farming. This full-time program is held annually at the 25-acre UCSC Farm and 2-acre Alan Chadwick Garden on the UCSC campus. The Apprenticeship course carries 20 units of UC Extension credit for the approximately 300 hours of formal instruction and 700 hours of in-field training and hands-on experience in the greenhouses, gardens, orchards, and fields.

Each year 35 to 40 apprentices come from all regions of the U.S. and abroad for the six-month course. Most apprentices choose to live on the Farm in their own tents, sharing cooking and other community responsibilities in a common kitchen/dining facility. Tuition is $3,250 and there are several scholarships available for people of color and/or low-income.

Graduates of the program have gone on to run their own farms and market gardens; teach in garden education, community gardening, and horticultural therapy programs; work in the sustainable agriculture and food policy arenas; and develop their own apprenticeship-based training programs. Many graduates also take part in the Peace Corps and other international development projects.

The next Apprenticeship course will run from April 12 to October 15, 2004. Application deadlines for the 2004 program are September 1, 2003 for international applicants and November 1, 2003 for U.S. and Canadian citizens. For more information, contact—

Apprenticeship Information
CASFS, UCSC
1156 High Street
Santa Cruz, CA 95064
831.459-3240
apprenticeship@ucsc.edu

Detailed program information and application materials are available on the Center's web site—

www.ucsc.edu/casfs/training/index.html

Grants Help Extend Apprenticeship's Impact

The Center's Apprenticeship training course received a $20,000 grant from the Kellogg Foundation through the California Food, Fibers, and Futures (CF3) project. The grant will allow Center staff to work with a consortium of California university and college farm managers and educators interested in sustainable agriculture and the use of college farms for practical training and course labs.

The consortium includes college farm instructors, faculty, and administrators from California's three higher education systems (California State Universities, UCs, and Community Colleges). The goal of the project is to create an introductory sustainable agriculture course that incorporates practical training and labs at college and university farms. It would result in a course outline and instructional resource list for farm-based coursework that can be adapted for use across a range of California post-secondary institutions.

The CF3 project also provided $3,150 to assist the Apprenticeship with statewide distribution of its new training manual through the California Agriculture Teachers Association (CATA) Conference this June. Apprenticeship Coordinator Diane Nichols made a presentation to community college instructors about the newly-published guide, *Teaching Organic Farming and Gardening Resources for Instructors* (see page 13), and sold and gave away copies at the conference's "Farm Show."

A $5,000 grant from the Organic Farming Research Foundation (OFRF) will help the Apprenticeship staff to complete a second training manual, this one focused on

Marci Krass

Thanks to a scholarship from the Margoes Foundation, Lydiah Gatere traveled from Kenya to take part in the 2001 Apprenticeship course and stayed on as an assistant instructor in 2002. She is now at Cornell University pursuing a Master's degree in international agriculture.

direct marketing and small farm viability. The OFRF grant will supplement a $5,000 seed grant from the Foundation for Sustainability and Innovation that helped initiate the project last year, and a $15,000 grant from the True North Foundation. The True North Foundation has also provided continuing support for the Community Supported Agriculture (CSA) training and demonstration project with a $10,000 grant. The new direct-marketing manual, focusing on CSAs, will be published next spring and will be available for sale in print, and for free in PDF format on the Center's web site.

For the seventh consecutive year, the Margoes Foundation has provided sponsorship for African participants in the apprenticeship training course. This year's scholarship recipients are Anyankor Benjamin Sowah and Leonard Avanya Kofi Borklo-Hadjah, both from Accra, Ghana.

Earthbound Farm has once again generously supported the Apprenticeship and the UCSC Farm & Garden through its "Benefit Chef Walk" program. These benefits bring a celebrity chef to Earthbound's Carmel Valley farm for a tour and cooking demonstration. This year's guest chef was Traci Des Jardins, executive chef-owner of Jardinière in San Francisco. Her restaurant features organic produce and socially progressive employment practices.

Christof Bernau

Students in the apprenticeship training course install a new collection of ornamental plants in the border adjacent to the UCSC Farm's hand-worked garden beds.

New Perennial Border Planted

Thanks to a grant from the Stanley Smith Horticultural Trust, the Center's on-campus farm has a beautiful new perennial border demonstration area at the entrance to the one-acre hand-worked garden. The new project serves as an educational resource for both apprentices and the many visitors to the UCSC Farm.

Garden manager Christof Bernau chose the new border's plants to demonstrate a range of flower form, color, and plant architecture. Many of the plants are drought tolerant and a number of them will attract beneficial insects to the border and adjacent garden. "Ninety percent of these plants are new to our site, making them a valuable teaching tool and source of material for propagation," says Bernau.

recommended Resources

Farming with the Wild: Enhancing Biodiversity on Farms and Ranches, **by Dan Imhoff.** This new book presents a compelling view of a future in which farming and ranching operations are integrated into regional networks of protected wildlands. Imhoff traveled throughout the U.S. to find farmers, ranchers, government agencies, and nonprofit organizations that are striving to develop and renew successful agricultural practices that are compatible with healthy, wild ecosystems.

Examples include regional conservation movements and farmland habitat initiatives, as well as economic incentive programs, such as ecolabels and local marketing initiatives, that encourage conservation-based agriculture. Profiles of individual farms provide examples of the many ways that ranchers, orchardists, and farmers are integrating their operations with surrounding natural areas and providing wildlife habitat on their land.

A section on "Getting Started" offers concrete ideas for mapping the farm and surrounding habitats, and techniques for managing farms and ranches for wildlife. It also lists landowner incentive programs—including financial support, technical assistance, and help in negotiating bureaucracies—as well as USDA conservation programs.

Illustrated with more than 200 color photos, *Farming with the Wild* provides valuable information and resources for anyone interested in a sustainable future both for agriculture and wildlife populations. It is available from www.watershedmedia.org, by calling 707.4321-2936, or through local bookstores.

Wild Farm Alliance Briefing Papers. The Wild Farm Alliance (WFA) was established by a group of wildlands proponents and ecological farming advocates who share a concern for the land and its wild and human inhabitants. The group's mission is to "promote agriculture that helps to protect and restore wild Nature, creating a sustainable agriculture in which community-based, ecologically managed farms and ranches seamlessly integrate into landscapes that accommodate the full range of native species and ecological processes."

WFA has produced a series of briefing papers on topics that include grazing for biodiversity, agricultural cropping patterns that integrate wild margins to enhance wildlife habitat, financial programs for preserving wildlife habitat via conservation incentives that cultivate a stewardship ethic, and water management practices to protect water

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quality, limit erosion, and enhance nutrient cycling. These 4- to 6-page briefs include specific strategies for farmers and consumers to improve wildlife habitat, and examples of farms, ranches, and projects whose practices protect and enhance species diversity.

WFA Briefing Papers are available free in PDF format on the Wild Farm Alliance web site, www.wildfarm alliance.org. They can also be purchased for $5.00 per copy by contacting WFA at 406 Main St., Ste 213, Watsonville, CA 95076, or email to wildfarms@earthlink.net.

State of the States, 2nd Edition. Organic Farming Systems Research at Land Grant Institutions, 2001-2003, **by Jane Sooby.** This second edition of *State of the States* updates the original report released in 2001 by the Organic Farming Research Foundation (OFRF). *State of the States II* catalogues organic research, education, and extension projects currently in place at the nation's 68 public land grant agriculture schools, at public research stations, and through Cooperative Extension.

According to the report, although the total number of organic research acres in the U.S. land grant system more than doubled between 2001 and 2003, research acreage is not keeping pace with the growth of commercial certified organic acreage in the U.S. The report states that organic research occupies only 0.13% of available research acreage in the land grant system (up from 0.07% in 2001), while 0.3–2% of U.S. farmland is certified organic, depending on crop type. The acreage of research land that has been certified organic by an independent certification agency is only 0.06% of the total research acreage available, up from 0.02% in 2001.

State of the States II is a useful resource for farmers, scientists, students, and others seeking information on current work in organic agriculture. According to the author, it also serves to measure the level of commitment each public agricultural institution has to serving organic growers with research and extension services. This report is particularly suited for use in an electronic format, as it contains links to many web sites. Information is presented by state, and is organized primarily by the following topics: research, production; research, consumer/economic; Extension; education. To find research in particular topic areas, use the search tool in the Adobe Reader.

To see the report on-line, visit the Organic Farming Research Foundation's web site at www.ofrf.org. To order a copy of *State of the States II*, contact OFRF at PO Box 440, Santa Cruz, CA 95061-0440, 831.426-6606 (phone), 831.426-6670 (fax), or email research@ofrf.org.

International Journal of Agricultural Sustainability (IJAS), **Chief Editor: Professor Jules Pretty.** IJAS is a new cross-disciplinary, peer-reviewed journal dedicated to advancing the understanding of sustainability in agricultural and food systems. The IJAS publishes both theoretical developments and critical appraisals of new evidence on what is not sustainable about current or past agricultural and food systems, as well as on transitions towards agricultural and rural sustainability at farm, community, regional, national and international levels, and through food supply chains.

The editors and board welcome original, high-quality contributions from all countries, and from scientists and practitioners from both the natural and social sciences. The editors and board neither include nor exclude any agricultural technology for ideological reasons.

The publishers will use a three-tiered pricing structure based on the UNDP Human Development Index (www.undp.org). Libraries in over 100 countries will be able to receive the *International Journal of Agricultural Sustainability* either free of charge or at a substantially reduced rate.

For further details on submitting a paper, the three-tiered pricing structure, and how to subscribe, contact the publisher, info@channelviewpublications.com or visit their website, www.channelviewpublications.com.

You can also receive a free email newsletter, which will give full details of the contents of forthcoming issues and links to their abstracts, by sending email to news@channelview publications.com stating "subscribe agriculture."

Symphylans Study

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Symphylans will be introduced into pots with potato roots, and will be exposed in Petri dishes to six of the primary products of the two primary alkaloids found in potatoes, alpha-solanine and alpha-chaconine. Finely ground soil will be used as a control, and researchers will monitor the number of symphylans surviving over the course of three weeks of exposure.

The third part of the study will compare two sampling techniques for symphylan populations: traditional soil sampling and a recently developed bait sampling method. Soil sampling requires collecting soil and sifting through it to search for symphylans—a time-consuming process. Bait sampling involves placing a cut piece of beet or other crop that will attract symphylans on the soil surface, then returning later to see how many of the pests are on or under the bait. This technique is relatively quick and measures only the feeding symphylans in the soil, which is the population of interest to growers.

However, Umble has found that the presence of vegetation in the field can skew bait-sampling results because symphylans may come to the bait in lower numbers when roots are in the soil. Thus the researchers will attempt to calibrate soil and bait sampling results, both in the presence and absence of other vegetation, in order to gauge the accuracy of bait sampling techniques.

- Martha Brown

Irrigation Efficiency

continued from page 3

Step 3: Calculate irrigation requirements –

- 28,512 gallons/acre are lost through evapotranspiration each week from an actively growing crop in full canopy. The sprinkler system is capable of delivering 19,800 gallons/hour/acre @ 45psi.
- To calculate the amount of irrigation time required to replace the amount of water lost through Et:

  Divide 28,512 gallons/acre (Et rate) by 19,800 gallons/hour/acre (irrigation system application rate) = **1.4 hours** of irrigation time required each week, assuming 100% delivery efficiency (see section on *Application Efficiency and Uniformity*, below).

Running the one-acre sprinkler system for 1.4 hours each week will apply 28,512 gallons/acre (~1.05 inches/acre), the amount needed to replace water lost through Et. This total of 1.4 hours/week should be divided in to 2 to 3 evenly timed irrigation sets/week of 40 or 30 minutes respectively.

Drip Irrigation Water Budgeting

Knowing how much water to apply with T-tape is a bit of an art, but we can approach it using the water budgeting system and actually be quite precise with our application rates.

The following steps show how to calculate the time needed to run a drip irrigation system in order to replace the water lost through evapotranspiration from a 1-acre block of vegetables in Santa Cruz—

Step 1: Calculate evapotranspiration in a 1-acre field in Santa Cruz – same as given in the sprinkler irrigation example = **28,512 gallons/acre** of water are lost each week through evapotranspiration in an actively growing crop in full canopy.

Step 2: Calculate drip irrigation output –

- Flow rate of high flow T-tape drip irrigation ribbon with 8-inch emitter spacing at 10 psi = 0.74 gallons/minute/100 feet
- There are 14,520 feet of row per acre when beds are spaced 36 inches center-to-center
- To determine gallons/hour/acre emitted from one acre of drip irrigation tape, divide 14,520 (the number of row feet/acre) by 100 = 145 (the number of 100-foot lengths of drip irrigation tape in 1 acre). Multiply 145 by 0.74 gallons/minute/100 feet (the amount of water delivered through each 100 feet of tape) = 107.4 gallons/minute/acre
- 107.4 gallons/minute x 60 minutes = **6,446 gallons/hour/acre**. Two lines of drip tape per bed would provide twice this volume, or 12,893 gallons/hour/acre.

Step 3: Calculate irrigation requirements –

- 28,512 gallons/acre are lost through evapotranspiration each week from an actively growing crop in full canopy. The drip system described above is capable of delivering 6,446 gallons/hour/acre @ 10psi.
- To calculate the amount of irrigation time required to replace the amount of water lost through Et complete the following:

  Divide 28,512 gallons/acre (Et rate) by 6,446 gallons/hour/acre (irrigation system application rate) = **4.4 hours** of irrigation time required each week.

Running one acre of single line drip irrigation with 8-inch emitter spacing for 4.4 hours each week will apply 28,5112 gallons/acre (~1.05"/acre). This total of 4.4 hours/week should be divided into 2 to 3 evenly timed irrigation sets.

The drip line manufacturer will normally give you information on flow rates expressed as "gallons per minute per 100 feet" within a range of normal operating pressures. As shown above, our high flow tape is rated at 0.74 gallons/minute/100 feet @ 10psi.

If you can't find information on the flow rate for your particular drip line, you can figure out the flow rate by placing a cup below a drip emitter and running the system for one hour. Measure the volume of water in the cup and multiply that amount by the number of emitters in 100 feet of line to get output in gallons/hour/100 feet. Divide this number by 60 to get gallons/minute/100 feet. Plug this number into the above equation to get gallons/hour/acre (note that there is quite a difference in flow rates depending on operating pressure).

MONITORING AND ESTIMATING SOIL MOISTURE

Although water budgeting using evapotranspiration rates gives you a good sense of how much water should be replaced each week, it's still important to monitor soil moisture. The best monitoring tool is a good soil auger, which let's you look below the often dry-appearing surface to make a decision on whether to irrigate.

Monitoring skills also include knowing crop needs and rooting depths, and knowing how to judge the range of soil moisture from permanent wilting point to field capacity (see Estimating Soil Moisture chart). By observing the plants daily, you'll develop an eye for the subtle changes in color and appearance that can signal the need for irrigation.

Irrigation scheduling must also take into account the needs of the specific crop or crops (see sidebar, page 19).

APPLICATION EFFICIENCY AND UNIFORMITY

When determining application rates for any type of system, it's also important to consider the system's overall efficiency. If you're applying water through a sprinkler on a hot, windy day, and you've figured your rate of application based on nozzle size and pressure, you will also have

> *continues on next page*

Estimating Soil Moisture by Feel

SOIL MOISTURE LEVEL (% OF FIELD CAPACITY[1])	COARSE (SAND)	LIGHT (LOAMY SAND, SANDY LOAM)	MEDIUM (FINE, SANDY LOAM, SILT LOAM)	HEAVY (CLAY LOAM, CLAY)
0 –25% No available soil moisture. Plants wilt. Irrigation required. (1st range)	Dry, loose, single grained, flows through fingers. No stain or smear on fingers.	Dry, loose, clods easily crushed and will flow through fingers. No stain or smear on fingers.	Crumbly, dry, powdery, will barely maintain shape. Clods, breaks down easily. May leave slight smear or stain when worked with hands or fingers.	Hard, firm baked, cracked. Usually too stiff or tough to work or ribbon[2] by squeezing between thumb or forefinger. May leave slight smear or stain.
25 –50% Moisture is available, but level is low. Irrigation needed. (2nd range)	Appears dry; will not retain shape when squeezed in hand.	Appears dry; may tend to make a cast[2] when squeezed in hand, but seldom will hold together.	May form a weak ball[3] under pressure but will still be crumbly. Color is pale with no obvious moisture.	Pliable, forms a ball; will ribbon but usually breaks or is crumbly. May leave slight stain or smear.
50 –75% Moisture is available. Level is high. Irrigation not yet needed. (3rd range)	Color is darkened with obvious moisture. Soil may stick together in very weak cast or ball.	Color is darkened with obvious moisture. Soil forms weak ball or cast under pressure. Slight finger stain, but no ribbon when squeezed between thumb and forefinger.	Color is darkened from obvious moisture. Forms a ball. Works easily, clods are soft with mellow feel. Will stain finger and have slick feel when squeezed.	Color is darkened with obvious moisture. Forms good ball. Ribbons easily, has slick feel. Leaves stain on fingers.
75% to field capacity (100%) Soil moisture level following an irrigation. (4th range)	Appears and feels moist. Color is darkened. May form weak cast or ball. Will leave wet outline or slight smear on hand.	Appears and feels moist. Color is darkened. Forms cast or ball. Will not ribbon, but will show smear or stain and leave wet outline on hand.	Appears and feels moist. Color is darkened. Has a smooth, mellow feel. Forms ball and will ribbon when squeezed. Stains and smears. Leaves wet outline on hand.	Color is darkened. Appears moist; may feel sticky. Ribbons out easily, smears and stains hand, leaves wet outline. Forms good ball.

[1] Field capacity is the amount of water that the soil will hold against the pull of gravity.

[2] Ribbon is formed by squeezing and working soil between thumb and forefinger.

[3] Cast or ball is formed by squeezing soil in hand.

General Rules of Field Capacity Needs

- During the flowering and fruit set stages of crop development, plants are most sensitive to drought/ water stress.
- Most crops require irrigation when the soil moisture in the root zone of the plant has decreased to approximately 50% of field capacity. See the chart at left, Estimating Soil Moisture by Feel, to help you determine the moisture content of the soil.
- Seed beds containing small-seeded, directly sown crops require light and frequent water applications. Apply water each time 50% of the surface soil has dried down, showing discoloration.
- Seed beds containing large-seeded, directly sown crops require less frequent water applications. Apply water each time the soil at the depth of the seed has dried to 50% of field capacity.
- Addenda to the above general rules–

1. Potatoes: Phase 1 and phase 4 (the planting and maturation stages) require the full soil moisture fluctuation between 50% and 100% of field capacity. Phase 2 and phase 3 (tuber initiation and enlargement) demand less of a fluctuation, responding favorably to a moisture swing between 75% and 100% of field capacity
2. Other Solanaceae family crops (e.g., tomatoes, peppers, eggplant) respond favorably to a full swing between 50% and 100% of field capacity
3. Cut flowers: Irrigation 24 hours prior to harvest will help assure full turgor pressure at harvest time and increase the vase life of the stems or bouquets
4. Leafy greens: 50% of field capacity minimum
5. Alliums: 50% of field capacity minimum
6. Established fresh beans and peas: 50% of field capacity minimum
7. Celery: Responds favorably to a moisture swing between 75–100% of field capacity

to figure for the evaporative loss from the wind and heat. This loss could be as much as 50%.

Uniformity also comes into play. If your system is not uniformly applying water, then you will have to over-apply in some areas to get enough water to other areas. The best you can usually expect from a sprinkler system is about 80% efficiency. This is why it's important to monitor your application with some type of rain gauge, and use as many rain gauges as possible to compensate for lack of uniformity.

Sprinkler distribution uniformity (DU) can be easily determined by setting out rain gauges in a grid pattern under your sprinkler set and using the following formula—

$$\frac{\text{Average rate of lowest quarter}}{\text{Average rate of others}} \times 100 = \%\text{DU}$$

Set out a minimum of 12 rain gauges (or any straight-sided cylinder capable of holding water) under your sprinkler system in a uniform grid pattern. After the set has been run, measure the depth of water that collected in each of the gauges. Then take the average depth recorded from the lowest 25% of the gauges and divide that by the average depth recorded from the other gauges. In other words, if you were to set out 16 gauges and measure 1.5 inches of water in 4 of the gauges and 2 inches of water in the remaining 12 gauges, then your average of the lowest quarter would be 1.5 and your average from the remaining gauges would be 2 —

An information packet on the scholarship program will be sent those calling Tom Haller's number and leaving their name and address.

$$\frac{1.5}{2} = 0.75 \times 100 = 75\% \text{ DU}$$

You can see from this example that if you had collected 2 inches from all 16 gauges your distribution uniformity would be 100%.

The most common problems that result in poor uniformity (<75% DU) are inadequate pressure, worn nozzles, improper line and nozzle spacings, and poorly designed sprinkler heads. Inadequate pressure will create a non-uniform sprinkler pattern, with most of the water forming a doughnut pattern around the outermost circumference of the spray pattern. Adequate pressure is characterized by a uniform "misting" pattern of fine water droplets falling from the riser all the way out to the outer circumference of the spray pattern.

Uniformity in drip systems can be an issue as well, especially when drip lines are run downhill on slopes greater than 1 or 2%. Drip system uniformity on slopes can be easily determined by placing small cups below the emitters at various points along the line and comparing collected amounts after enough volume has accumulated to measure easily. A well-designed and maintained drip system can easily operate at between 80% and 90% efficiency.

THE ART AND A SCIENCE OF IRRIGATION

Knowing when and how much water to apply to a newly planted or growing crop is both an art and a science. There are many variables to consider, including soil type, specific crop requirements, delivery system, and weather patterns.

The art of irrigation comes into play when, based on years of experience, the gardener or farmer knows what factors to look for that will indicate whether or not a crop needs water.

The science of irrigation scheduling using water budgeting techniques, as described above, should be thought of as a tool to help both experienced and inexperienced growers fine tune their water delivery and optimize the use of one of our most precious resources.

– Jim Leap

Santa Cruz area

events

▸ **Preparing the Winter Garden,** Saturday, September 6, 12 noon–3 pm, Louise Cain Gatehouse, UCSC Farm. Fall marks the start of the Monterey Bay region's "second gardening season." Come and learn how to prepare your garden beds for the winter and get the most out of your fall-planted crops. Learn about cover cropping, best-performing vegetable varieties and more. $5-$10 (sliding scale) for Friends' members; $15 for non-members, payable the day of the workshop.

▸ **Fall Plant Sale,** Friday, September 12, 12 noon–6 pm, and Saturday, September 13, 10 am–2 pm, Barn Theater Parking Lot, UC Santa Cruz. Fall is a wonderful time to plant vegetable crops to extend your gardening season and give perennials a good head start for spring. The region's best-suited varieties of organically grown winter vegetables and landscape plants will be available. Proceeds support the Apprenticeship in Ecological Horticulture program. For more information, call 459-3240.

▸ **Seed Saving,** Saturday, September 20, 10 am–12 noon, Louise Cain Gatehouse, UCSC Farm. Seed saving expert Zea Sonnabend from the Ecological Farming Association will show you how to save seed from your garden at this hands-on workshop. Learn how to improve your garden and save money through seed saving. $10 for Friends' members, $15 for non-members, payable the day of the workshop.

▸ **Harvest Festival,** Saturday, October 11, 11am–5 pm, UCSC Farm. Join us for our annual Farm celebration. Great music, food, apple tasting, an apple pie bake-off, garden talks, hay rides, kids' events, tours, displays by local farmers, and an all-around good time are in the works. Free for Friends' members and kids 12 and under; $5 for non-members.

▸ **Friends Fall Benefit Dinner** at Blacks Beach Cafe , Tuesday, November 11, 7 pm. This popular annual fundraiser helps kick off the fall holiday season. Enjoy a wonderful five-course meal created by Blacks Beach Cafe owner Robert Morris and guest chefs. All proceeds from the dinner support the Friends' community education and scholarship projects. $70, includes wine. For more information and to reserve your seats call 459-3240 or reserve directly with the restaurant at 475-2233. Blacks Beach Cafe is located at 15th Ave & E. Cliff Dr. in Santa Cruz.

California

▸ **14th Annual Bioneers Conference,** October 17–19, 2003, Marin Center, San Rafael. This conference features a number of sessions related to farming and food systems, including talks on food justice, biodynamic farming, organic food standards, and much more. For registration information and program details see www.bioneers.org

▸ **24th Annual Ecological Farming Conference,** January 21–24, 2004, Pacific Grove. This annual four-day winter forum features prominent keynote speakers and more than 50 workshops on the latest advances in agricultural production, marketing, research, and important issues. The conference takes place at the Asilomar Conference Center on the Monterey coast.

For more information, contact the Ecological Farming Association at 831.763-2111, info@eco-farm.org or see their web site at www.eco-farm.org.

▸ **California Farm Conference/ North American Farmers' Direct Marketing Conference,** February 2–8, 2004, Sacramento. More than 1,000 farm direct marketers are expected to attend the North American Farmer Direct Marketing Conference and California Farm Conference to be at the Sheraton Grand Sacramento Hotel and Sacramento Convention Center. The theme of this joint conference is "A Bounty of Golden Opportunities".

The 2004 conference includes a three-day farm tour, an extensive trade show, featured speakers, special workshops, and some 40 breakout sessions. Some of the most innovative direct marketing farmers from around the U.S. and Canada will be among the more than 120 speakers.

Conference participants will hear presentations about a variety of direct marketing options: certified farmers markets, roadside stands, entertainment farming, and direct sales to restaurants, schools, and the public.

Further details and registration information are available on the web at www.californiafarmconference.com or www.nafdma.com. You can also send e-mail to Marcia@WhiteLoafRidge.com or leave a message for Tom Haller at 530.756-8518 ext. 16. A limited number of scholarships are available for low-income California farmers.

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