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the Cultivar

The CENTER for AGROECOLOGY & SUSTAINABLE FOOD SYSTEMS

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in this issue:

Symphylans Challenge Growers and Researchers

Seedlings are particularly vulnerable to symphylans, which feed on new root growth. Damaged plants will grow slowly or fail to develop.

They're tiny, voracious, unpredictable, and difficult to detect, and they can give farmers fits. The garden symphylan *(Scutigeralla immaculata)*, sometimes called the garden centipede, is often the unseen culprit in seedling die-offs and poor crop performance.

Measuring just 1/4–long, and unable to make their own burrows, these fast-moving centipede relatives wriggle through the soil via pore spaces between soil particles, earthworm burrows, and old root channels. They come to the top layer of soil to feed on germinating seeds and developing roots, stunting and killing young plants and transplants. The pits that symphylans form on plant roots can also open the way to secondary infections. Researcher Jon Umble from the University of Oregon describes heavily infested areas as looking "bombed out," with even weeds unable to survive (see graphic, page 3). More often, growers notice plants performing poorly in a particular part of a field, even though plants in an adjacent section may show no signs of damage.

Now a research group studying organic control measures for symphylans reports that no simple practice or material they tried reduced populations by a significant amount. However, their experience showed that knowing more about the habits of these vexing pests may help growers manage their fields to reduce or avoid symphylan damage.

Researchers from the Center for Agroecology & Sustainable Food Systems (the Center), UC Cooperative Extension, and UC Davis have been working to monitor and control symphylans since 1998. In 2000, a grant from the Organic Farming Research Foundation supported an expanded effort to monitor and suppress symphylans in the field and to study different control options in laboratory trials. The research team includes Jim Leap, manager of the Center's on-campus farm; Mario Ambrosino of UC Cooperative Extension in Salinas (now a graduate student at Oregon State University); and Mark Van Horn, manager of the Student Experimental Farm at UC Davis.

Because suppressive cover crops, tillage, shrimp shells (thought to boost populations of fungi that feed on symphylans), and biological controls have all been proposed

> *continues on page 2*

as potential techniques for controlling symphylan infestations, the research group focused on these approaches in designing their study.

EXPERIMENTAL DESIGN

Field Studies

The seeming randomness of symphylan infestation makes establishing field trials a challenge. According to Leap, the sporadic pattern of symphylan occurrence makes it difficult to know whether a test bed will even have symphylans to study. The researchers chose test beds based on a history of severe symphylan infestation, hoping that this would guarantee measurable populations and allow evaluation of treatment effects.

In the spring and summer of 2000, Van Horn, Leap, and Ambrosino established field trials to compare replicates of the following treatments: at the UC Davis site, treatments included water suspensions of commercial micronized shrimp shell (two additions at 50 pounds/acre), incorporated cover crops ('Martagena' mustard, 'Micah' barley, a mix of Common, Purple, and 'Lana' Woolypod vetches), a late winter crop of broccoli and cabbage with imported brassica trash incorporated later, and a weed fallow. Following incorporation of the cover crops, the central 80% of the disked 'mustard' and 'brassica incorporation' plots were tarped with standard industry clear tarp (within 24 hours of incorporation), which remained in place for 20 days. Tomato starts were machine transplanted in all plots on May 4 in 30"-wide rows with an in-row spacing of 18".

At the UCSC Farm site, 4 treatments with 4 replicates were established: a vetch-oat-bell bean cover crop mix (40, 7, and 50 lbs/acre, respectively), 'Micah' barley at 100 lbs/acre, and a weed fallow. Half of the vetch-oat-bell bean plots received an "extra" tillage before crop planting in the spring. Following flailing and spading, the plots were bedded up, and the extra-till plots were rototilled to 8" in depth. Broccoli was direct sown into the various treatments on June 12.

Data were collected on symphylan surface numbers by surface baiting (see sidebar, page 3) at monthly intervals for a total of 7 dates, with the exact dates determined by the treatment applications and management manipulations (e.g., cover crop planting, incorporation, crop planting).

Laboratory Trials

Laboratory trials were also conducted to test the effects of various inputs on symphylans maintained in fluffed Super Soil or coco peat. The researchers evaluated modifications of soil pH, a variety of neem formulations, the commercial product Farewell, and mustard seed extracts (ground 'Martagena' seed) in trials with four replications. Ten symphylans were taken from the field and placed into closed 1-pint containers. After 13 days, each container was opened and the number of live and dead symphylans recorded. Results were compared with a water-only control.

The lab studies also evaluated three species of predatory nematodes (*Heterorhabditis marelatus, Steinernema feltiae,* and *S. carpocapsae*) in a trial with three replications. These were compared to a control of water only.

RESULTS CONFIRM DIFFICULTY OF STUDYING, CONTROLLING SYMPHYLANS

Field Studies

None of the field treatments used at either UC Davis or UC Santa Cruz successfully reduced symphylan numbers in an agronomically significant way. According to Van Horn, several reasons may explain the lack of control. "Either the treatments really didn't have a significant biological effect, or there may have been some small impact on the populations, but it may take more than one season of treatment for the effect to be agronomically meaningful," he says. The research group also thought that symphylan movement between plots might have masked any treatment effects.

Even when significant differences between treatments occurred, the effect did not carry over through the season. For example, at the UC Davis farm, significantly higher symphylan numbers were found feeding on the surface baits in the 'Micah' barley plots in the last sampling (9 April) prior to mowing and disking (Table 1). These numbers dropped to the lowest levels of all the treatments shortly after transplanting the tomato crop, but the barley did not seem to help the performance of the tomatoes as the season progressed.

"One explanation for this seemingly inconsistent result is that, compared to the other cover crops, barley somehow stimulated the symphylans to move closer to the soil surface late in the cover crop treatments, and the tillage that occurred at this time reduced this surface population," says Van Horn. "However, either this reduction wasn't enough to limit damage to the subsequent tomato crop, or symphylans from deeper in the soil migrated to the surface and caused damage during the cropping season."

At the UC Santa Cruz trial, tillage also seemed to have some effect on populations of symphylans near the soil surface, although this effect was not significant. According to the researchers, two treatments temporarily resulted in fewer symphylans: an extra tillage of the vetch-oat-bell bean mixture before crop planting in the spring, when symphylans were observed near the surface, and a 'Micah' barley cover crop with only regular tillage.

Table 1. Mean number of symphylans per bait station on four sample dates.

Treatment	*12 Mar	9 Apr	11 May	18 May
Vetch	0.071 a	1.071 a	14.142 b	20.964 b
Mustard	1.476 a	2.381 a	22.714 c	30.571 c
Weed	1.250 a	2.036 a	13.000 b	20.178 b
Shrimp	2.000 a	2.821 a	10.857 b	19.321 b
Brassicas	7.000 b	3.607 a	11.679 b	17.964 b
Barley	6.321 b	13.429 b	1.357 a	5.179 a

*Values in a column followed by the same letter are not statistically different (P=0.05) by Duncan's Multiple Range Test.

Sampling for Symphylans

Do you have symphylans in your fields? A simple sampling method developed by researchers in Oregon can be used to determine the presence or absence of this pest in the soil's surface layer. Sampling can be important if you're trying to time your plantings to avoid periods when symphylans numbers are high near the soil surface.

Place 1/4"- to 1/2"-thick slices of beets or potatoes on the soil surface. You may need to remove a dry or crusty layer of the soil to get the beet or potato piece in good contact with moist, intact, non-crusty soil and/or cover the bait with a piece of wood (6" x 6") or 6" diameter PVC cap to prevent the bait and soil from drying.

Check the bait piece in one or two days by picking up each piece and looking quickly at the soil below the bait for symphylans rapidly moving into the soil voids. Immediately examine the bait piece itself for symphylans crawling around on its surface.

To sample for symphylans deeper in the soil, carefully look through shovel-fulls of soil. This method can be time consuming and care must be taken not to destroy the small, fragile symphylans in the process.

Laboratory Trials

In the trial comparing seven commercial azadirachtin- (neem-) based materials with four replications, all of the treatments appeared to have around 75% mortality. However, both the distilled water and spreader-sticker controls also generated this mortality rate.

In contrast, in the laboratory trial comparing one neem product with other chemical and plant extract treatments, the neem had significant effect on the symphylans, as did the farewell treatment and the mustard seed extract. However, treatment with three predatory nematode species did not produce any reductions in symphylan numbers.

LESSONS FOR GROWERS

Although the results of this particular study did not point to a clear organic method for controlling symphylans, the research team offers the following ideas and caveats based on their experiences and discussions with other growers –

• Symphylan populations commonly move vertically in the soil in what appears to be an annual cycle. Although the seasonality of this cycle is generally consistent, significant annual variation may occur. For example, in some locations with hot summers, surface symphylan numbers are typically high in the spring, but decrease dramatically in early summer. However, the timing of this decrease can vary by several weeks from one year to the next. Since symphylans are most damaging when feeding on roots of young plants near the soil surface, planting crops after the symphylans have left the surface layers of the soil can allow successful crop production, even in fields with significant symphylan populations. Even so, the researchers warn that it is not possible to predict precisely when the symphylans will leave the soil surface for deeper layers. Monitoring with beet or potato slices (see sidebar, left) will indicate whether symphylans are present at the surface.

• Aggressive soil tillage when there are symphylans near the soil surface may sometimes reduce their numbers by either directly killing some of them and/or hastening their movement deeper into the soil. But because symphylans can move rapidly, individuals from below the tillage zone can quickly recolonize the surface, which may limit the effectiveness of tillage.

• Because symphylans feed heavily on plants' small feeder roots, using healthy transplants with large, vigorous root systems, and keeping young plants well watered can sometimes help a crop survive symphylan feeding in the early season. However, irrigation may also make the surface environment more favorable to symphylans. With prolonged feeding in areas of heavy symphylan populations, these strategies are usually not sufficient to allow the crop to survive and grow well.

• Since the researchers' observations confirm that symphylans are attracted to and feed on beets and carrots, and it has been shown elsewhere that symphylans successfully reproduce on fresh plant material, it is advisable to remove as completely as possible all unharvested beets and carrots (or similar root crops) prior to the end of the season to minimize food sources that could potentially increase symphylan populations. But it should also be noted that established populations can persist for long periods with very little or no input of fresh plant material.

GROWERS SHARE EXPERIENCES, FRUSTRATIONS

As part of the study's outreach component, Van Horn, Leap, and Jon Umble met with approximately 50 growers and other participants at this year's Ecological Farming Conference in Asilomar, California, to talk about their experiences with symphylans and help refine future research and extension goals. Discussion at the meeting confirmed

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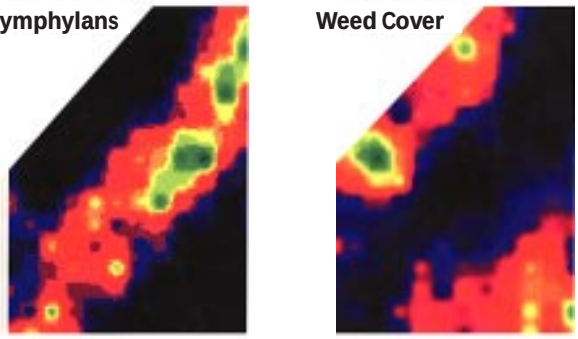

Left: Symphylan infestation in a field at the UCSC Farm. Lighter areas indicate higher concentrations of symphylans. Right: Weed cover in the same field. Darker areas indicate lower weed density. Where symphylan numbers are high, weed cover is low or absent.

from the
director

Spring and summer mark the quickening of activities at the Center. The farming season gears up, spring classes get underway, visitors programs reach their peak, and the new group of apprentices arrives to begin their six-month training program. Research projects follow the farming cycle, with much of our research staff now spending their days at farms throughout the region as well as at the Center's on-campus research sites.

Good news came this spring in the form of renewed funding from the US Department of Agriculture that will underwrite our work on Central Coast water quality issues, organic farming, and food systems. In the *Research Updates* section we give a brief overview of the progress of the water quality work to date, with more details on the overall project to come in the next *Cultivar*. We also learned from the UC Office of the President that the Center's budget will receive a permanent augmentation. As salaries and costs increase, this will help us maintain core Center support functions and enable us to strengthen and expand program activities. We appreciate the work that the campus administration did on our behalf to secure this critical funding.

Genetic engineering continues to draw headlines and controversy. In this issue we profile a new book by Center faculty affiliate Deborah Letourneau of UCSC's Department of Environmental Studies *(page 8)*. She has collaborated with Beth Burrow, head of the Edmonds Institute, to edit a volume on research that assesses environmental and human health effects of genetically engineered organisms.

A project by the Center's social issues group received funding from the UC Sustainable Agriculture Research and Education Program this spring. Headed by Center associate director Patricia Allen, the social issues research team will study the effectiveness of the many civic groups that have developed alternative food system initiatives in California *(page 7)*. Other articles in this issue report on symphylan research, strawberry variety trials, and no-till experiments, projects on which we've teamed with UC and USDA researchers to address the needs of the region's growers.

I also worked with Carolee Bull of the USDA–Agricultural Research Service this spring to form the Monterey Bay Region Organic Researchers group. This group meets monthly to share ideas and updates on a variety of organic farming and food systems topics. We hope that this forum will improve our ability to serve local growers and the larger sustainable agriculture community.

- Dr. Carol Shennan

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The Center for Agroecology & Sustainable Food Systems is located at the University of California, Santa Cruz. Through our research and educational efforts we seek to increase understanding of the social, economic, political, and ethical foundations of agricultural sustainability; to establish the ecological and agronomic basis for sustainable production systems; and to demonstrate and facilitate the use of information critical to the adoption of these systems.

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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Research

Updates

Cover Crops Tested in Conservation Tillage Study

Tests of various options for conservation tillage practices continued this season at the Center's on-campus organic research fields. Conservation tillage techniques reduce or eliminate pre-plant and in-season tillage in an effort to save money on tractor time, reduce soil disturbance, and improve soil tilth. Reducing tillage can also conserve organic matter in the soil, helping reduce emissions of carbon dioxide into the atmosphere. Conventional growers use herbicides to control weeds in their no-till or conservation tillage systems, but organic growers rely on cover crops planted in the fall and knocked down or mowed in the spring to create a weed-suppressing mulch into which crops are planted.

Last fall, Center farm manager Jim Leap worked with Jeff Mitchell of UC Cooperative Extension to establish a trial testing three cover crop treatments for use in conservation tillage systems. Ideally, cover crops grown for conservation tillage produce a large amount of biomass to suppress weed growth, but die back when crops are planted into the knocked down cover crop to minimize competition with crops for nutrients and water.

Leap planted four replicates each of three cover crop combinations: 1) Triticale/Merced Rye/Common Vetch; 2) Lighting Persian Clover/Paradana Balansa Clover/Antas Subclover; and 3) Barley/Common Vetch. Each treatment was either stalk chopped or flail mowed several times in early spring, 2001.

Jim Leap

Cover crops in no-till test plots: front left and center, low-growing clovers. Front right, barley/common vetch. Back plots (center three), rye/triticale.

Jim Leap

UC Extension researcher Jeff Mitchell samples cover crops in the no-till trial plots at the UCSC Farm.

In mid June, Leap used overhead irrigation to get good soil moisture prior to opening a "strip" in the chopped or mowed covers. "Lacking a no-till planter, we hand planted sugar pie pumpkins into the conservation tillage treatments, then laid out drip lines and germinated the seed with drip irrigation," explains Leap. "My preference would have been to pre-irrigate with the drip lines and then flame weed prior to planting the seed into moisture, but the surface mulch would have been a fire hazard," he says. A tillage treatment was established and the performance of winter squash will be compared to that of squash in the no-till plots.

According to Leap, the cereals outperformed the clover treatment in producing a thick surface mulch. "We got a nice cover on the triticale and barley treatments, with approximately equal amounts of biomass," he says. In contrast, the subclover treatment didn't create a cover thick enough to suppress weed growth. And although stock chopping is thought to limit regrowth of cereals more effectively than flail mowing, Leap saw little difference between the chopping and mowing treatments. The cereal treatments each had to be cut three times before they stopped growing.

Although he's encouraged by the progress of this year's no-till trial, Leap acknowledges that there's "a huge learning curve" involved in the process, noting "This is such a new concept in organic farming that it will take many seasons to work all of the bugs out."

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Nitrogen Concentrations in Central Coast Watersheds Examined

Last fall, Center researchers Marc Los Huertos, Lowell Gentry, and Carol Shennan began monitoring nitrate-N levels in coastal creeks to assess impacts of land use activities on water quality. This work is part of a larger study of the Central Coast's farming practices and food systems (*The Cultivar,* Vol. 18 No. 2). Working in the Pajaro River and Elkhorn Slough watersheds, both of which border the Monterey Bay Marine Sanctuary, the research group collected water samples at 35 sites, focusing on nitrate-N concentrations in creeks bordering grazing lands, oak woodlands, and forests, as well as urban areas and agricultural lands. They also collected samples from several agricultural ditches in areas of intensive crop production, including those receiving runoff from underground drainage pipes ("tiles") located 1 to 2 meters below the soil surface.

The researchers found nitrate-N concentrations were <1 mg N L^{-1} in grazing lands, oak, woodlands, and forests, but increased to a range of 3 to 5 mg N L^{-1} as surface waters passed through agricultural lands. In several agricultural ditches—especially those receiving tile drainage—very high nitrate concentrations (>50 mg N L^{-1}) occurred. Some of the agricultural ditches remained high in nitrate both during and after rain events, which indicates that nitrate is not being flushed out of the soil profile. The researchers hypothesize that the shallow groundwater beneath the tile-drained fields is nitrate saturated due to long-term nitrogen loading from agricultural practices.

Results of this monitoring work will be used to help landowners and resource managers understand the relationship between land use activities and local water quality, and to help growers modify practices to reduce nitrate runoff. Further details of the Central Coast study will appear in the next issue of *The Cultivar.*

Lygus Trap Crops Tested

As part of an ongoing study of alternative pest management techniques in strawberries, Center researchers are manipulating "trap crops" to determine their impact on populations of the strawberry pest *Lygus hesperus* (lygus bugs). Planted along the edges of fields and as rows within the fields, trap crops are designed to attract lygus away from the strawberry plants and "trap" them in an area where they can then be removed or the trap crop managed with mowing, spraying, or vacuuming. Six growers in Monterey and Santa Cruz counties are cooperators on the study.

"This season, rather than plant a single trap crop containing lots of different plant species, we separated the plantings into early-season and late-season crops," says Center researcher Polly Goldman. The early season trap crop consisted of mustard and radish, which blooms in the late winter and early spring. "This mixture had matured and was senescing [dying back] by the time the lygus population began to increase. We then cut it and pulled it out of the field to remove any lygus eggs that had been laid," says Goldman.

Jon Kersey

Researcher Amanda Lewis collects insect samples from an alfalfa trap crop bordering a Monterey County strawberry field.

Now blooming is a trap crop of alfalfa and sweet alyssum that should attract lygus bugs through the late season. The research group plans to "vacuum" one set of this late-season crop with a tractor-mounted vacuum device, known as a "bug vac," to see if they can remove lygus bugs from the field.

Bug vacs are a large-scale version of the hand-held machines (see photo, above) the researchers use to collect insect samples for monitoring. Although organic strawberry growers routinely use bug vacs to control pests within production fields, the machines can disrupt populations of beneficial insects as well as those of pest species. By using a bug vac in the trap crops, where lygus bugs are known to congregate, Center researchers hope to develop a technique that will target lygus and not affect populations of beneficial insects in the fields themselves. For comparison, they'll monitor lygus numbers from unvacuumed trap crops in the same fields. This portion of the work is being supported by a grant from the Organic Farming Research Foundation.

Center research staff are also testing the effectiveness of two lygus nymph parasites, *Peristinus stygicus* and *P. digoneutis.* "Researchers on the East Coast are working with these beneficial insects as a classic biological control agent—that is, they're establishing *Peristinus* populations that would decrease the total populations of *Lygus lineolaris,* which is a pest of many crops there. Initial work has show that they may also be effective against *Lygus hesperus* nymphs here in the west," says Goldman.

Working with USDA entomologist Charles Pickett, Center research staff have released the parasite species into a trap crop that will be left in place for two seasons, to see whether they will become established and control lygus nymph populations.

The trap crop study is part of a larger project dubbed BASIS/OASIS (Biological Agriculture Systems in Strawber-

> *continues on page 14*

UC SAREP Funds Alternative Food Initiatives Project

People are increasingly concerned about food—how it is produced and distributed, the health effects of industrially produced food, the environmental consequences of chemically-intensive farming practices, and the political and economic implications of a concentrated and globalized food system. Addressing these issues are a growing number of alternative food initiatives (AFIs) organized by consumers, activists, and farmers. These groups seek to incorporate values such as regionalism, seasonality, community, environmentalism, and food security into the food system. This summer, the Center's social issues researchers received a grant from the UC Sustainable Agriculture Research and Education Program (UC SAREP) to study a number of the groups and programs spearheading AFI efforts in California.

AFIs range from farmers markets, eco-labels, regional food labels, community supported agriculture projects, and urban gardens to farmer-school projects, alternative training programs, and community-based food systems. A number of groups are behind the various AFIs that have emerged, many within the past decade. They include farmers and consumers looking to develop closer ties and greater support for local, small-scale growers; community activists who use institutional food purchasing to improve nutrition and generate greater interest in local agriculture; and community food security groups working to ensure that all people have access to sufficient, nutritious food. According to Center issues specialist Patricia Allen, the organizations involved in these projects complement on-farm efforts to promote sustainable agriculture by connecting these issues with economic, social, and policy aspects of the food system beyond the farm.

Coordinated by Allen and faculty affiliate Margaret FitzSimmons, this research will complement and extend an ongoing study of the insights and effectiveness of AFIs in California. "We want to find out what participants in AFIs have learned through their concrete practices about how the food system works and how they can change it," says Allen.

The Center's research effort will include interviews with leaders of community organizations, and focus groups involving members or clients of selected programs. From these interviews, the researchers will assess the different visions of food system, alternatives that the organizations propose, the issues and problems they confront, and the strategies they use in their projects. The types of projects studied include –

- farmers' markets
- food policy groups
- microenterprise initiatives
- regional food labels
- urban agriculture
- community supported agriculture
- rehabilitative programs
- agrifood education and apprenticeships

Allen emphasizes that this research is intended to assist the farmers, consumers, environmentalists, activists, and citizens working to develop agrifood alternatives. Committed people are working in many different areas in the food system to effect change, yet significant analysis of the intentions, and insights, and implications of these efforts is lacking. This kind of analysis is crucial for helping groups to accomplish their goals and to minimize potentially contradictory outcomes.

Yet leaders of community-based organizations rarely have the opportunity to perform in-depth studies of their efforts, and it is even more unusual for them to be able to conduct comparative analysis of like organizations. This project will engage the resources of university-based people who are positioned to conduct research in collaboration with the organizations themselves.

"The leaders and clients of the various AFIs are central to this effort, and their input will be key," says Allen. "The groups themselves are our audience. We want to provide the members of these innovative programs with information that will make their efforts more effective. We plan to explore with them what works, what doesn't work, and what the best paths to a sustainable food system might look like."

- Martha Brown

Social issues researchers Patricia Allen (left) and James Murrell will interview leaders and clients of a number of alternative food initiative organizations to help assess the effectiveness of these programs.

Don Harris

No Easy Answers in GE Food Debate

A gaping chasm divides the two sides in the debate over genetically engineered (GE) food. According to one side, the technological marvel of directly manipulating a crop plant's genome promises environmentally friendly food production for all the world. According to the other, GE food is an ecological disaster waiting to happen, and possibly a corporate strategy to increase profits at the expense of the already downtrodden farmer.

Both extremes, and those in the middle, have thrown untold resources into the chasm. Biotech companies have spent billions developing and promoting their wares. Environmentalists have volunteered personal time and money to publicize their opposition to the technology. And scientists have tossed in significant research funds and shifted their focus to experiments on the products of biotechnology, amounting to what one researcher has called a "brain drain."

Deborah Letourneau, professor of Environmental Studies at the University of California, Santa Cruz, is trying to bridge the chasm. Her latest piece of that bridge is the forthcoming book, *Genetically Engineered Organisms: Assessing Environmental and Human Health Effects* (CRC Press). Letourneau's co-editor is Beth Burrows, an activist at the Edmonds Institute in Edmonds, Washington. Among scientific volumes, such a collaboration is rare, if not unique.

No matter where you stand on the GE technology, this book offers challenges. Lay readers of *Genetically Engineered Organisms* should be prepared to tackle technical language and ideas. But the greater challenge is the authors' exacting analysis, which upsets the belief that there are easy answers in the GE debate.

BETTER RESEARCH REQUIRED TO ASSESS GE'S EFFECTS

Letourneau, a faculty affiliate of the Center for Agroecology & Sustainable Food Systems, studied cell biology as an undergraduate at the University of Michigan, but turned to ecology after a tropical biology course piqued her interest. She earned a Ph.D. in Entomology from UC Berkeley in 1983 and joined the UCSC faculty in 1984. Her graduate school advisor was Professor Miguel Altieri, a prominent advocate for sustainable agriculture.

Letourneau shares Altieri's skepticism at the rapid approval of GE crops, an approval that has allowed these crops—mainly corn, soybeans, and cotton—to sprout on 90 million acres in the United States in 1999. But she professes a greater allegiance to the pursuit of good science as a means of refining and eventually resolving the GE debate. And with her seats on the federal Agricultural Biotechnology Risk Advisory Committee and a National Research Council subcommittee, she is in a position to make people listen.

Letourneau's message is simple: ignorance is the real enemy, no matter where on the political spectrum it occurs. Environmentalists often don't stop to think about exactly why they believe what they do. "For example, some of the students in my rain forest ecology class know that we're supposed to save the rain forest, but they don't know why or how or who pays," Letourneau says. On the other side, agricultural biotechnology companies often don't carry out the rigorous research necessary to truly test the safety of their products, she says. In both cases, the answers require a serious commitment to understanding complex environmental issues.

She would prefer if these companies used the "precautionary principle,"[1] which gives weight to gaps in knowledge on the side of precaution and puts the burden on companies to prove their products safe, rather than on the public or government to prove them unsafe. This principle has been the rallying cry of anti-GE advocates, but the federal Food and Drug Administration contends that most engineered food meets the criterion of "substantial equivalence" (i.e., it is similar enough to the unaltered version) and therefore does not require further testing prior to approval.

Rather than trumpet her belief in the precautionary principle, however, Letourneau has chosen to point out the gaps in scientific knowledge and to call for more thorough testing. "The standards that industry is held to for their studies are just not comparable to the standards of publishable scientific research," she says. For example, one research group fed pollen from GE crops to adult honeybees to test the crops' safety, ignoring the fact that adult honeybees don't even eat pollen, which, as Letourneau notes, is mainly collected for their young.

Letourneau has encountered stiff resistance to her pleas for better research, even among scientists. Two such encounters came while she was applying for research grants to study the environmental safety of insecticidal GE crops.

The first time, she proposed to evaluate the possible effects of the insect-killing trait Bt *(Bacillus thuringiensis)*, the toxin currently engineered into corn and cotton to infect feeding caterpillars. Letourneau wanted to find out what would happen if the Bt trait escaped into wild relatives of engineered crop species, which often grow near farms and sometimes become weeds. Her proposed method was to spray the wild relatives with Bt insecticide and measure the effect of reduced feeding damage on the plants' seed output and population density. This information would indicate whether acquiring the Bt gene would affect plants' fitness, the biological term for their ability to pass their genes to the next generation. A change in fitness could pose a risk of increased weediness or invasion and disruption of natural plant communities.

The USDA did not fund the project, in part because the scientists on the grant committee said the research would not be realistic enough unless she actually created the GE plant whose safety she was trying to test. But if that GE trait in weedy plants were to increase plant fitness and invasiveness, Letourneau says, that would have defeated the

purpose of her research and posed a potential safety risk. The message was that she should accept the safety of the GE trait before she even began to study it.

The second instance came when Letourneau applied for a grant from the Sustainable Agriculture Research and Education program (SARE), USDA's sustainable agriculture branch. This time, she wanted to use a wild relative of broccoli as a "trap crop" that would attract pest insects, keeping them off of the edible broccoli crop. As part of the experiment, she proposed spraying some of the trap crop with Bt to determine whether genes from GE crops, if they were to escape into wild relatives, would affect the fitness of those relatives. Letourneau said the reviewers were not in favor of this proposal in part because it "seemed to support GE crops." No, Letourneau says, it was just an attempt to investigate their safety. But the SARE scientists must have been so sensitive to the mention of GE crops that they interpreted any attempt to study them as an endorsement of their safety.

AUTHORS EXAMINE GE'S COMPLEXITY

Reflexive side-taking is common to partisans of all kinds, even within organizations that are supposed to be objective. Letourneau recently joined with activist Beth Burrows in an attempt to build bridges of understanding across the GE chasm. Their collaboration as co-editors of *Genetically Engineered Organisms* brings together a scientist and an activist to work on a scientific volume. "We're trying to prove a point by doing this together, that the interests of activists, environmentalists, and scientists can overlap," Letourneau says.

Letourneau and Burrows began forging the link between academics and activism in 1998 at a brainstorming session on risk assessment of GE crops. The objective was to map out all the information that would be necessary to declare GE food "safe." *Genetically Engineered Organisms* is the natural next step in the process because it attempts to show how much of that information is available from the latest science, and what gaps still remain.

The book's 15 chapters are written by different sets of scientists, each tackling their own field of expertise. Although all the authors—none of whom are industry scientists—regard genetic engineering with a skeptical eye, they don't reject it out of hand. On the contrary, most recognize that the technology has tremendous potential; their purpose is to make sure it is also reasonably safe.

The topics cover an enormous range of organisms and safety issues. There's a chapter from the scientists who reported the threat to monarch butterflies from insecticidal corn. And there's one on the more obscure topic of releasing mosquitoes engineered for malaria resistance to control that disease in the tropics. These intricate subjects can be slow going for a reader without a college science degree, despite efforts by the authors to reach out to anyone reasonably interested. Lay readers should be prepared for an ocean of science with very little to help them stay afloat. The words and concepts are challenging, and the lack of a strong narrative flow is disconcerting. As with any scientific publication, the goals here are thoroughness and accuracy, not storytelling.

Endurance has its rewards, however. Even without completely grasping the science, the reader gets a front row seat on the issue's full-blown complexity. Perhaps more importantly, the authors show just how much work there is left to do to understand the full implications of GE technology. Genes, it seems, can misbehave in ways that most people have never imagined.

The best example of the vast unfinished project of risk assessment is in the chapter on virus-resistant crops by Alison Power of Cornell University. She dives into her three major categories of risk (recombination, encapsidation, and hybridization; don't worry, there are definitions), but she provides a clear structure for her argument and a fascinating introduction to the array of interactions that occur between plant genes and viruses. For instance, it turns out that one virus's genetic protein coat can sometimes encapsulate the genetic material of another virus. The implication is that virus-resistant transgenic plants, which resist viruses because scientists inject them with genetic material from a virus, might donate a protein coat to another virus. "Under those conditions," Power writes, "transgenic plants expressing the coat protein of one virus might allow the transmission of a second virus by an herbivorous insect that would not normally be a vector."

The upshot: genes are not as simple as you think. Biotechnology companies have long argued that events such as the one described by Power are extremely unlikely. The reply from Power and the other authors is, "low probability events are difficult to detect, but still may result in significant ecological impacts." Where biotech urges us to rest easy and environmental activists urge prohibition, these scientists ask us to get all the facts first.

William Muir and Richard Howard of Purdue University describe another set of unexpected ecological risks in their chapter on genetically engineered fish. Most fish engineering has aimed at ramping up the level of growth hormones to produce super-fish that grow up to twice as fast and up to 15 times as large as regular fish. Industry and the U.S. Department of Agriculture have argued that if such fish escape or are released into the wild, they will not harm wild populations because their rapid growth is not evolutionarily adaptive. Since natural selection did not produce fast-growing fish, they reason, fast-growing fish cannot outcompete natural fish.

Muir and Howard point out that even if this is so, the consequences of escape may be dire. The GE fish could disrupt the mating and feeding of wild populations, and if they interbreed with wild fish, they could trigger a "Trojan horse" effect. Under this scenario, augmented growth hormone levels may infiltrate the population if, for example, wild females are more inclined to mate with the larger GE males than with small, wild males. In the worst case, the result could be the spread of the detrimental gene for rapid

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Center
Notes

Center Web Site Expanded

The Center's Web site has undergone a major makeover, thanks to the support of Jim Burns, assistant director in UC Santa Cruz's Public Information Office, and the efforts of Web site designer Joshua Salesin. Visit the site at www.ucsc.edu/casfs to learn more about the Center. There you can review recent and ongoing research efforts, see our annual calendar of public events, order and download publications, and find information on the Center's history.

Those interested in the Center's six-month Apprenticeship training program will find a description of the course as well as application materials. Undergraduate and graduate students can read about classroom, fieldwork, and grant opportunities. International research and classes sponsored by Center staff and faculty affiliates are also described. Other features include a staff bibliography, directions to Center facilities, information on our public workshops and tours, and links to a variety of sustainable agriculture groups.

We welcome feedback on ways to continue to improve the Center's Web site; send comments to martha @zzyx.ucsc.edu.

Center Welcomes New Staff and Visiting Researchers

Winter and spring brought an influx of new staff members and international researchers to the Center. William Settle joined the Farm Extension group as a specialist and is helping coordinate and conduct a number of on-farm research projects, including biocontrol options in strawberries and broccoli. He has an extensive background in international sustainable agriculture efforts and has coordinated a variety of "training-the-trainer" programs to promote farmer-to-farmer dissemination of pest control knowledge. Much of his work has focused on reducing the use of synthetic chemical pesticides in rice-growing systems in Asia.

Also joining the Farm Extension group are Diego Nieto and Ohri Yamada. Diego worked for the group last summer while an undergraduate at San Jose State University. Since May, he has been working full time as a lab assistant, focusing on biocontrol in broccoli (see *Research Updates*, page 14), and helping with the cotton and strawberry projects. He is also working on a soil fertility project located at the former Ft. Ord site.

Ohri, a student at Institut National Agronomique de Paris-Grignon (National Agronomic Institute of Paris – Grignon), is doing a summer internship on the efficacy of lygus control in strawberries using tractor-mounted vacuum devices (see *Research Updates*, page 6).

Ann Lindsey, who has coordinated the Apprenticeship in Ecological course for the past seven years, moved into a fundraising position with the Center this summer. We welcome Erin Barnett as the new Apprenticeship course coordinator. Erin has worked for the Community Alliance with Family Farmers (CAFF) for many years, as well as at Camp Joy Gardens, and most recently was part of the internet small business world where she designed the Local Harvest website that promotes direct marketing for small-scale growers (www.localharvest.org). Erin is also finishing a Master's degree in psychology and counseling.

John Fisher, the Center's community outreach coordinator, will also switch roles this summer as he moves into a new job with the Life Lab Science Program as their Garden Classroom program coordinator (see below). John will be in charge of programs based at the new garden and will continue to work with the Center on children's programs. We will be hiring a new person to take on many of the outreach activities John was coordinating (see next page).

This spring Antonio Abboud joined us during his sabbatical from the Universidade Federal Rural do Rio de Janeiro, Brazil, where he is a profesor in the Department of Crop Sciences. He is studying nutrient cycling in the many cropping systems here at the Farm, as well as helping with cover crop research.

Julie Francis, an extension officer with Australia's Department of Natural Resources and Environment, also spent time at the Center this spring as part of a nation-wide tour of sustainable agriculture programs .

"Garden Classroom" Takes Root

Spring and early summer have been marked by bulldozer noise, dust, and piles of soil and rubble as a new children's garden takes shape near the entrance to the Center's on-campus Farm. A project of the Life Lab Science Program, the "Garden Classroom" will fulfill a long-held goal of Life Lab and the Center to provide a state-of-the-art garden for local students and for teachers attending workshops on garden-based learning. When completed this summer, the garden will also serve as a wonderful destination for local families.

The Garden Classroom will contain seasonal beds for student plantings, adaptation gardens to showcase how plants adapt to different environments, plantings to attract pollinators, edible landscaping, a weather station, student work areas, and more. The County of Santa Cruz Division of Public Works has funded a compost demonstration area that will feature different compost models, including vermicomposting and a chicken house. The Packard Foundation, the Richard and Rhoda Goldman Fund, and the Stocker Family Foundation provided support for the project.

2002 Apprenticeship Announced

The Center's six-month *Apprenticeship in Ecological Horticulture* 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 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 $3,000 and there are several scholarships available for people of color and/or low-income.

The next Apprenticeship course will run from April 15-October 18, 2002. Application deadlines for the 2002 program are September 1, 2001 for international applicants and November 1, 2001 for U.S. and Canadian citizens.

For more information and an application, contact:

Apprenticeship Information
CASFS, UCSC
1156 High Street
Santa Cruz, CA 95064

(831) 459-3240
email, apprenticeship@cats.ucsc.edu.

Information and application materials are also available on the Web: www.ucsc.edu/casfs.

Center Seeks New Outreach Coordinator

The Center will be hiring a new outreach coordinator to develop and coordinate public education programs, network and collaborate with other organizations working in sustainable food and agriculture, coordinate links within the UC Santa Cruz campus, and represent and promote the Center to various audiences. The job description is currently being finalized. Application information will be posted on the Center's home page (www.ucsc.edu/casfs) as soon as it becomes available.

Center Funds Study of Apprenticeship Movement

The age-old tradition of apprenticing to learn a craft is alive and well in the organic farming community. Apprenticeship arrangements often help make small-scale organic farms economically viable, providing an inexpensive labor source to operations on the economic margin. Apprenticeships also help develop more organic growers, as "mentor" farmers pass on their skills and values to apprentices who go on to start their own farms—and often take on their own apprentices.

Andrew Marshall, a graduate student in UCSC's Environmental Studies Department, is studying farm apprenticeship programs to better understand their role in sustainable agriculture. With funding from the Center's Collaborative Grants programs, Marshall is examining the apprenticeship movement in New England and the Pacific Northwest, where the oldest and most developed apprentice placement networks are located.

As part of his background research, Marshall has found that apprenticeships range from tuition-based programs offered by educational institutions, such as the Center's *Apprenticeship in Ecological Horticulture*, to semi-formal or informal relationships on individual farms. Often state or regional organic groups maintain a database of available apprenticeships and help bring growers and apprentices together. Apprentices tend to be young, white, upper middle class, and well educated, and are typically from non-farm backgrounds.

Marshall estimates that 25% to 75% of organic farms —particularly small- to medium-sized mixed vegetable operations—use apprentice labor. This reliance on apprentices can be a potential problem, especially as organic agricul-

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Apprentices learn by working side-by-side with farmers. Here instructor Christof Bernau (left) plants out seedlings with Kasozi Godfrey, a participant in the Center's six-month training course.

Don Burgett

Variety Trial Tests Performance of Strawberry Cultivars

With methyl bromide scheduled for a 50% use reduction this year and elimination by 2005, conventional strawberry growers are looking for the best ways to produce this economically important crop without the standard soil fumigant. Methyl bromide, in combination with chlorpicrin, is currently used on nearly all of California's 25,000 acres of conventional strawberries.

Plant pathologist Carolee Bull of the USDA's Agricultural Research Service has teamed with Jim Leap, the Center's farm manager, Steve Koike of UC Cooperative Extension, and other scientists and growers in the Monterey and Santa Cruz regions to test the performance of strawberry cultivars in organic systems. This is the first time such a study has been conducted. The team is also evaluating the effectiveness of mycorrhizal inoculants and examining disease management in organic systems. This information will help conventional growers making the transition to methyl bromide-free production, as well as organic growers looking to optimize their management practices.

CULTIVAR EVALUATION

In her report on the project's first year, Bull writes, "Although choice of variety is very important for success, a study to determine how strawberry cultivars perform in organic production fields is non-existent and farmers are left to extrapolate from conventional systems. Our first objective was to demonstrate the relative performance of standard California cultivars grown under organic management." Organic strawberry growers from the Central Coast chose the cultivars to be tested.

The research group established variety trials at four sites —two in San Juan Bautista, one in Salinas, and one in Santa Cruz at the Center's on-campus farm. At three of the sites (including the Center's site), yield was measured in replicated experiments, with four replications of each cultivar. Both fresh market-quality fruit and total yield were evaluated on 20 plants for each replication. At the fourth site, a demonstration of several cultivars was conducted in larger blocks with no replication.

"According to the average of rankings across all experiments, Aromas, Pacific, and Seascape were the best performers in organic production fields." reports Bull, who notes that growers and pickers also preferred the taste of Seascape to that of the other varieties. Figure 1 shows the yield of cultivars tested at the Center's on-campus farm.

EFFECT OF COMMERCIAL INOCULANT

Inoculation of strawberry plant roots with mycorrhizal fungi has the potential to boost plant yield. These beneficial fungi create a symbiotic relationship with plant roots, converting otherwise insoluble nutrients (especially phosphorous) into a form plants can use, and in turn receiving carbohydrates from their host plant.

As part of this study, the research group tested a commercial inoculant containing *7* species of mycorrhizae, treating half the plants in each replicate with the inoculant prior to planting.

The researchers found that the inoculant treatment did not increase colonization by mycorrhizal fungi at any of the study sites, nor did it have an effect on yield.

Bull speculates that organic fields support naturally occurring populations of inoculum that colonized the roots of untreated plants, explaining the fact that both treated and untreated plants had equal levels of mycorrhizal colonization.

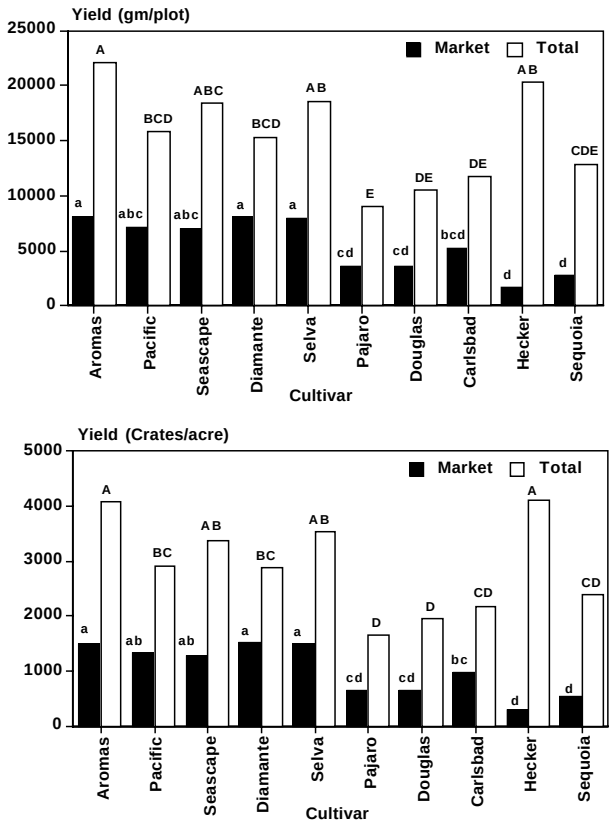
DISEASE OCCURRENCE

Plant diseases such as powdery mildew, Phytopthora root and crown rot, and Verticillium wilt (caused by the soil fungus *Verticllium dahliae*) can severely limit strawberry production as well as kill the plants. The researchers and growers were therefore interested in monitoring these diseases to assess their impacts on the various cultivars.

Each of the study sites was tested for the presence of *V. dahliae* prior to planting, but the fungus was not detected at any of the sites. According to Bull, each location had either had a long rotation of other crops since strawberries were last planted, or had used broccoli to "biofumigate" prior to planting strawberries. A number of organic growers use this technique; broccoli may act as a natural soil fumigant by releasing plant chemicals that suppress soilborne disease organisms such as *Verticillium*.

None of the study sites experienced plant loss due to disease during the season, though there were some early losses associated with gophers and transplant conditions. Says Bull, "Other yield-limiting diseases such as Botrytis

Figure 1. Yield of cultivars tested at the UCSC Farm research plots.



Means with the same letters were not significantly different at the P=0.05 level according to Tukey-Kramer HSD.

fruit rot were not detected in high levels at any of the locations or on any of the cultivars." She notes that more study is needed to assess the impacts of non-lethal, non-specific pathogens on organically grown strawberry plants, as these organisms may limit yield by causing root damage without actually killing the plants.

CURRENT EFFORTS

With a second year of funding from the California Department of Pesticide Regulation, the strawberry variety trial is being repeated at the Center's research fields this season. Nine of the ten cultivars trialed in the first year are again being tested, with Oso Grande substituted for the Hecker cultivar in response to grower's requests. Seven different commercial mycorrhizal inoculants are also being evaluated in field experiments for their effect on mycorrhizal colonization and strawberry yield. However, a high incidence of *Verticillium* in the UCSC research plots in 2001 will affect year-to-year comparisons.

One offshoot of the study has been interest by a commercial seedling producer in developing a line of organic strawberry starts. Currently, only conventionally produced strawberry transplants are available; organic growers are allowed to use them because no source of organic starts exists. However, this will likely change in *2002* when the federal organic rules go into effect and organic starts are required for certification. Bull has initiated a project with the commercial seedling company to produce organic strawberry transplants.

- Martha Brown

Martha Brown

Second-year apprentice Angie Tomey and farm manager Jim Leap plant strawberries for the second year of the variety trial at the UCSC Farm's research plots.

GE Book

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growth, and the decline and extinction of the resulting population.

Letourneau's own chapter—co-written with Joy Hagen of UC Santa Cruz and Gaden Robinson of the Natural History Museum in London—is a two-part review of Bt crops. The Bt insecticidal protein is the second most common genetically engineered trait in American agriculture, after herbicide resistance. The first part of the chapter assesses the numerous field experiments and farm surveys that often claim to reveal benefits of Bt crops: higher yields, reduced use of insecticides, and economic benefits to farmers. The authors rightly point out the complexity involved in what might seem to be a simple GE vs. non-GE comparison.

Letourneau and her coauthors object to the haste with which GE researchers, including some from the USDA, draw conclusions. "Experimental plot studies may not accurately reflect results for commercial operations, whereas, on the other hand, wide-ranging farm surveys confound a number of important variables," they write. Furthermore, even if such extrapolations are valid, they may end up comparing apples and oranges. For example, "because Bt-toxins are engineered into a company's top varieties, they will inevitably rank among the highest yielding varieties in a yield trial," thus confounding benefits of GE with those of more conventional plant breeding.

The second part of Letourneau's chapter deals with the likely routes by which the Bt trait could affect the fitness of crop's wild relatives if it were to escape from crop plants. As with so many of the other chapters, the reader is struck by the abundance of information on some topics and the lack of data on others. For instance, research has found that, "376, 185 and 98 [butterfly and moth] species are documented as feeding on corn, soybean and tomato, respectively." Yet when it comes to foretelling whether wild relatives will become weedy or "invasive," researchers have little information to go on, and the issue's complexity makes an easy prediction unlikely. The authors write, "external abiotic and biotic factors can influence the success of an invader and its new associated plant species enough to obscure any predictability with respect to future invasions."

The other chapters present a similar smorgasbord of possibility and uncertainty, along with an impressive body of scientific knowledge that the authors hope will be used to reduce the uncertainty. The approach is exhaustive and at times taxing. But committed readers will find in this book the straight dope on GE crops, uncensored and unabridged. More importantly, they will find steadfast resistance to the twin impulses of panic and blind faith in technology that have created a chasm of misunderstanding over genetic engineering.

But be careful. Although the book has lessons to teach, it may also shake the reader's cherished opinions, regardless of whether they perceive GE crops as miracle or menace. As Letourneau says, "the more people read, the more in the middle they'll be."

- Ben Shouse
UCSC Science Communication Program

Genetically Engineered Organisms: Assessing Environmental and Human Health Effects, will be available from CRC Press in late September. For ordering information, call 1-800-272-7737 or send a fax to 1-800-374-3401. From outside the continental U.S., call 1-561-994-0555 or fax to 1-561-989-8732. Information is also available by email, orders@crcpress.com. Order online at www.crcpress.com.

[1]For a review of the precautionary principle see –
Barrett, Katherine, and Gabriela Flora. 2000. *Genetic Engineering and the Precautionary Principle: Information for Extension*. A publication of The Science and Environmental Health Network and the Institute for Agriculture and Trade Policy, available at www.sehn.org/ge%20pp%20final.doc, or from Gabriela Flora, gflora@iatp.org.

Research Updates

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ries/Organic Agriculture Systems in Strawberries) to develop alternative management techniques for strawberries that could potentially replace methyl bromide and other synthetic chemical inputs.

Beneficial Habitat in Broccoli Tested

Center researchers Diego Nieto, Janet Bryer, and Polly Goldman are conducting a new trial of beneficial habitat plantings in broccoli crops. The trial is located at the former Ft. Ord military base in Monterey County, where UC Santa Cruz leases land to Dynasty Farms for organic vegetable production.

Aphids and cabbage loopers are both major pests of broccoli. Center researchers are testing beneficial habitat mixes to see whether the plantings will attract the natural enemies of these pests. "Unlike some crops, such as strawberries, a broccoli crop doesn't provide the floral resources necessary for many beneficial insects," says Goldman. "We're trying to determine whether habitat plantings [a mixture of clovers] will attract beneficial insects, such as syrphid flies, bigeyed bugs, and parasitic wasps, that could help control aphids and other pests."

Each week, members of the group sample the beneficial plantings with a suction sampler to find out what types of insects are attracted to the mixes. The group is also developing a sampling protocol for pests in the broccoli, and will release lacewings into some of the beneficial plots to analyze this natural enemy's impact on pest populations. The monitoring work will continue through the early fall, with initial results available by early 2002.

Organic Research Group Formed

With organic farming research gaining ground in the Monterey Bay region, Center director Carol Shennan and microbial ecologist Carolee Bull of the USDA–Agricultural Research Service in Salinas (Monterey County) have initiated an effort to improve communication and "cross-fertilization" amongst those involved in research that focuses on organic systems.

The Monterey Bay Region Organic Researchers group meets monthly to hear updates on projects, discuss collaborative efforts, and identify emerging research needs. Researchers interested in attending these meetings should contact Carol Shennan (cshennan@cats.ucsc.edu) or Carolee Bull (BactSalinas@aol.com).

Eric Brennan's recent appointment as Research Horticulturist with the USDA–Agricultural Research Service at the Salinas station will also enhance studies of organic systems in the region. Brennan will work on various aspects of organic vegetable production, including cover crops, soil fertility management, crop rotations, pest and disease management, and developing practices for sustainable crop production.

Symphylans

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the intractable nature of the pest and the problems it has created for many organic growers.

For example, in a discussion of plants that might be resistant to symphylan damage, one grower would report success with a particular crop, while another grower had experienced complete failure with the same crop. The same held true for such inputs as Sudan grass cover crops, shrimp shells, and compost, or practices such as repeated tillage: some growers had successfully eluded symphylan damage, while others using the same inputs or practices said they had no luck avoiding the pests.

"As we've discovered, timing of plantings plays a big role in whether a crop makes it or not," said Van Horn at the meeting. "This can confound any observation on a particular crop or treatment." Some common observations did emerge from the discussion: several growers noted problems when crops were direct seeded or transplanted soon after a cover crop was turned under, a time when symphylan activity may be at a peak. Others agreed that transplants stressed by cool growing conditions seemed more vulnerable to damage.

BASIC INFORMATION STILL NEEDED

Van Horn plans to continue trials at the UC Davis Student Farm, including deep soil drying with safflower and possibly summer flooding on fairly large plots. Leap will continue to monitor for the pest on the UCSC Farm, map symphylan infestations, and experiment with rotations, tillage, and other control strategies. He's currently interested in whether potatoes have some suppressive effect.

"I've noticed that following a crop of potatoes, the fields are free of symphylans, even in fields that were heavily infested when potatoes were planted. I want to continue to work with that idea. We're speculating that there's some alkaloid in the root or in the flesh—perhaps it affects symphylan reproduction. Right now, it's the most promising rotation we have," says Leap. Umble will pursue the potato rotation idea further in his graduate work at Oregon State University.

The research team realizes that a solution to the symphylan puzzle won't come quickly. "Due to the long, slow symphylan life cycle and some of the logistical challenges of control trials, it's been difficult for anyone to get quick answers from their symphylan experiments, whether they're professional researchers or growers," says Ambrosino. "That was one of the lessons from this trial—it can be tricky to account for the range of potentially confounding factors when studying this pest."

- Martha Brown, Mark Van Horn, Mario Ambrosino, Jim Leap

Growers and researchers with information on symphylans are encouraged to contact Jim Leap (831.459-3375, jimleap@cats.ucsc.edu), Mario Ambrosino (marioambrosino@yahoo.com) or Mark VanHorn (530.752.7645, mxvanhorn@ucdavis.edu). Complete results of the study are available through the Organic Farming Research Foundation, www.ofrf.org.

Apprenticeship Study

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ture enters the mainstream and becomes more regulated. And although apprenticeships offer beginners an appropriate level of training, Marshall has found that many aspiring farmers are frustrated when they try to make the transition to farming on their own, a move that is often limited by lack of access to land, capital, and equipment.

Despite these drawbacks, Marshall believes that apprentices play a key role in the spread of sustainable agriculture. "Apprenticeships not only provide an important mechanism for teaching small-scale, alternative techniques, they also tend to pass along a farmers' value systems," says Marshall. In many cases, these systems are community- and ecologically-oriented, and form the basis for strong regional social and material networks among farmers committed to sustainable food systems. An example of such a network is the Penobscot Bay region of Maine, where three well-established farms have spawned a community of 15 former apprentices who now farm in the area.

Marshall will spend the next year doing fieldwork with grower-apprentice communities in New England and Northern California, studying and documenting their networks of knowledge and social support.

Santa Cruz area

events

▸ **The World of Bats,** Saturday, August 4, 8 pm–10 pm at the UCSC Farm. Bat conservationist Morgan Venable will present a slide show talk and walk about bats. Learn how bats help control pests on the farm and in the garden. $5 for adults, kids 15 and under free, payable at the door. Call 831.459-3240 for more information or 831.459-4140 for directions.

▸ **The Art and Fun of Tea Blending,** Saturday, August 18, 1 pm–4 pm at the UCSC Farm. Join local herbalist and tea blender Julie Rothman for an herbal tea class. Julie will demonstrate the art of making medicinal and beverage teas and will lead an herb walk through the gardens. Participants will sample various teas and take home tea plant lists and recipes. $10 for Friends' members; $15 for non-members. Pre-registration required; call 831.459-3240 for more information or to register.

▸ **Preparing the Winter Garden,** Saturday, September 8, 12 noon–3 pm at UCSC Farm. Come learn how to prepare your garden beds for the winter season and get the most out of your fall-planted crops. Learn about cover cropping, best-performing vegetable varieties, and more. $5 for Friends' members; $10 for non-members, payable the day of the workshop. Call 831.459-3240 for more information.

▸ **Fall Plant Sale,** Friday, September 14, 12 noon–6 pm and Saturday, September 15, 10 am –2 pm, Barn Theater Parking Lot, UCSC. The region's best-suited varieties of organically grown winter vegetables and landscape plants will be available. Call 831.459-3240 for more information.

▸ **Dried Flower Wreath Making,** Saturday, September 22, 10 am–1 pm at the UCSC Farm. UCSC gardeners and staff from the Homeless Garden Project's Women's Organic Flower Enterprise will instruct you on the art of flower wreath making. All materials are provided and participants will leave with a wreath they've made. $25 for Friends' members; $30 for non-members. Pre-registration required. Call 831.459-3240 for more information or to register.

▸ **Traditional Grains and Tubers,** Saturday, October 6, 2 pm–6 pm at the UCSC Farm. Join garden manager Christof Bernau for a free talk and garden walk focusing on a selection of traditional grain and tuber crops from the Americas, Africa, and Asia. Learn how to grow and prepare grain and tuber crops that feed many of the world's people. Call 831.459-3240 for more information.

▸ **Friends Benefit Dinner at Blacks Beach Cafe,** Tuesday, November 13, 7 pm. Come enjoy a wonderful organic gourmet meal created by Blacks Beach Cafe chef Robert Morris and help support the Friends' mission. $75. For more information and to reserve your seats, call 831.459-3240.

▸ **The Soil Food Web, A "Wisdom at the End of a Hoe" Workshop,** October 22–24, at the UCSC Arboretum. Presented by Bioneers, this workshop covers all aspects of the soil food web with soil scientist Elaine Ingham, soil fertility innovator Bob Cannard, and Gabriel Howearth, director of Siempre Semillas. For information and registration details, see http://64.45.12.200/rdi/wisdom01_page.html.

California

▸ **Bioneers Conference,** October 19–21, Marin Center, San Rafael, California. This annual gathering of environmental visionaries offers practical solutions for pressing environmental crises. Plenary sessions, workshops, mixers, dances, and more. For information and registration details, call 877.246-6337 (toll free), email info@bioneers.org, or see www.bioneers.org.

International

▸ **First Worldwide Congress on Conservation Agriculture: A Worldwide Challenge,** October 1–5, Madrid, Spain. For information, contact the UN Food and Agriculture Organization by email at conservation.agriculture@ecaf.org

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