ORGANIC FARMING RESEARCH FOUNDATION

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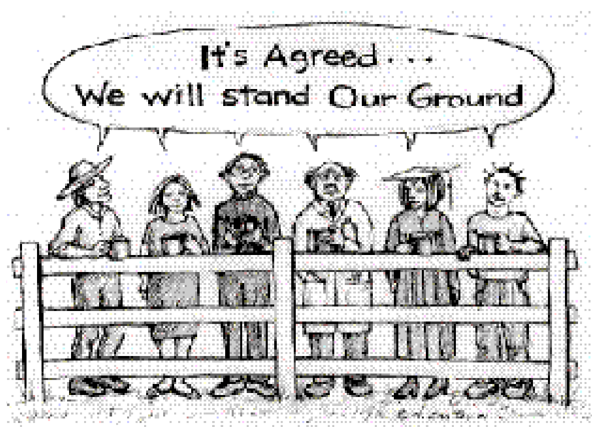
INFORMATION BULLETIN

An Experiment in Partnership: The Minnesota Institute for Sustainable Agriculture

Dana Jackson

The land grant colleges of agriculture in the United States have proudly led the country along the path to an industrial food and agriculture system, even though it has become increasingly destructive to the environment and rural communities. In the midst of farm foreclosures in the 1980s, family-sized farmers felt ill-served by the advice of these institutions, and people began to realize that behind the successes of high yielding crops and labor efficiency on the farm were failures: soil erosion, contaminated drinking water, streams filled with sediment, a decline in wildlife habitat and the loss of independent family farmers.

When farmers and environmentally concerned citizens asked agricultural researchers and college administrations to address these problems and lead farming to a more sustainable future, they were generally rebuffed. However, sometimes they found friendly faculty who weren't happy just doing research to improve the profits of agribusiness. And in some states, they convinced legislators and college administrations to open the door for small alternative agriculture programs.



Minnesota was one of those states; citizen efforts led to the establishment in 1992 of the Minnesota Institute for Sustainable Agriculture (MISA) which developed innovative educational and research programs that are widely recognized around the country. It heightened a discussion about sustainability in agriculture within the University of Minnesota and provided information to farmers that helped them become more economically viable while practicing good stewardship of the land. But after a successful eight years, MISA is in trouble; its creative leadership in sustainable agriculture may be crippled, because the key to MISA's success is also the key to its current conflict with the University administration—its structure and governance. MISA was established as a unique partnership between the College of Agriculture, Food and Environmental Sciences (COAFES) and the Sustainers' Coalition, a group of organizations advocating sustainable agriculture. This partnership has shared an unprecedented cooperative arrangement in MISA's management.

The Founding of MISA

In 1987, five community organizations joined forces to form the Sustainers' Coalition, for the purpose of overcoming the University of Minnesota's resistance to sustainable agriculture research and education. The coalition included the Organic Growers and Buyers Association, Minnesota Food Association, Joint Religious Legislative Coalition, Land Stewardship Project, and the Minnesota Project (today it also includes the Institute for Agriculture and Trade Policy and the Sustainable Farming Association of Minnesota).

"I don't think the problem at the University is so much active hostility to sustainable agriculture as it is a lack of information about what the critics of conventional agriculture are saying," journalist Paul Gruchow told Ken Taylor, a leader of the Sustainers' Coalition, after hearing Eugene Allen, then Dean of

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OFRF NEWS

2001 – An Organic Odyssey

Now is a time of transition in many areas of our world, and organic is certainly one. We are entering a new era in organic marketing with the USDA's recently released final Organic Rule. Overall the future looks promising for organic farmers and consumers, but serious threats remain in relation to GMO contamination and liability, costs to small farmers, and concentration in the growing organic industry.

OFRF is gearing up to face these challenges as we continue to pursue our purpose: the improvement and widespread adoption of organic farming practices. For us, it is also a time of transition from our first decade of work to our second. As we pass this milestone, the OFRF Board of Directors is undertaking a major strategic planning effort, with the goal of refining our vision and mission for the next five years. The **Jessie Smith Noyes Foundation** has generously contributed $7,500 in support of this important work to prepare OFRF for the future.

The **Strategic Planning Committee** leading this process includes three current board members, Vice President **Ron Rosmann**, Research & Education Committee Chair **Jerry DeWitt**, and **Marianne Simmons**; two former board members, SARE National Program Director **Jill Auburn**, and OFRF Founding President **Mark Nielson**; and two staffers, **Bob Scowcroft** and **Don Burgett**. Long-time nonprofit professional **Doug Ford** is helping to ensure the success of the group's work by advising on the process and facilitating communications. With luck and a lot of thoughtful work, the Committee will present a draft strategic plan to the Board at its Spring 2001 meeting.

More Staff, New Digs, and the Support to Make It Possible

To meet the growing demands on our programs, we have added a part-time Policy Assistant to our staff. (Former Program Assistant **Rebecca King** is filling this role for us until we hire a permanent staffer this March!) This position will help Policy Program Director **Mark Lipson** address policy issues in greater detail and broaden the reach of our policy analysis. We are also seeking an intern to round out the policy team. Other new intern positions are available in our development, information and administrative programs.

Of course, with the growing workload and staff to handle it, we have had to expand our office, too. As it turned out, we were packing up our things the day after the announcement of the final Organic Rule, and we moved down the hall into a space twice the size of our old one the following day. Amazingly, and with a great deal of credit to Program Associate **Melissa Matthewson**, we never missed a phone call (and there were plenty!), and we were settled into the new office before the holidays were over.

We would not be moving forward so positively without your support. Our network of organic farmers, consumers and businesses continues to grow and give generously to our work. We are particularly grateful to the **Clarence E. Heller Charitable Foundation** for their recent two-year grant of $150,000 for general program support. The Heller Foundation's trustees and staff are leading advocates of more sustainable approaches to our food and farming systems, and they have supported OFRF and many other worthy organizations over the years.

As we deposit your contributions coming in now in response to our year-end mailing, we are particularly thankful to all of you who have sent us donations of $10, $25 and $50. We work hard to earn your support, and we think of your gifts as we use the money day-to-day. Together with the support of those who have chosen to give $100, $500 and more, we have already received more than $30,000 from our year-end appeal.

We also greatly appreciate the companies who each have contributed $1,000 or more to our work since last summer:

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Working Assets

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Erica Walz
Editor/Typographer

WoodyDeryckx, Helen Atthowe, Cynthia Hizer
Editorial Advisors

Dianne Carter
Illustration

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OUR MISSION • To sponsor research related to organic farming practices • To disseminate research results to organic farmers and to growers interested in adopting organic production systems • To educate the public and decision-makers about organic farming issues

Notable Events!

OFRF Events Coordinator **Laura Ridenour** has had her plate full this fall, too—usually with delicious organic food! August brought a great thrill to our Northern California friends, as Grammy Award-winning singer-songwriter **Tracy Chapman** performed a concert to benefit OFRF and the **UCSC Center for Agroecology & Sustainable Food Systems' Farm & Garden Apprenticeship Program**. Tracy also stopped by our pre-concert dinner to thank everyone for supporting organic farming! She also took time on stage to tell the whole crowd about the importance of organic agriculture and describe how she had started gardening organically as a little girl. The dinner was an all-organic feast prepared by famed local chef **Jesse Cool** of **Flea Street Café**, making the evening delicious as well as memorable.

Following on the heels of the concert, OFRF held its **Eighth Annual Fall Organic Benefit Luncheon** at the **Lark Creek Inn** in Larkspur, CA. Sponsored again by **Whole Foods Market**, the meal was a culinary collaboration of five great chefs. It was wonderful to hear lead chef **John Mitchell** note how far we have come in the eight years since this annual event began. Finding the ingredients for a completely organic gourmet meal was very difficult in the beginning, but this year he said they had no problem tracking down everything they needed, from cooking oils, to spices, to organic chicken. The organic industry has come a long way, indeed!

In December, Executive Director Bob Scowcroft spoke at the **Tenth Annual Environmental Media Awards in Los Angeles**. Hosted by the Environmental Media Association (EMA), the event honored outstanding film and TV work focused on environmental issues. Organic food and farming was the theme of the evening, with the venue decorated in the style of a farmers' market, including stalls of produce all around the dining area. The 700 industry attendees were treated to an all-organic meal prepared by top Los Angeles chefs. Chef and long-time OFRF supporter **Donna Prizgintas** coordinated the meal, and her statement: "Eating is an environmental activity," became the underlying theme of the event.

OFRF Receives Gift of Prime Internet Real Estate!

In another first for us, Internet commerce company **WebMagic, Inc.** has donated an online domain name to OFRF. The unsolicited gift of Organically.com was valued at $20,000 by a domain name appraisal firm, and represents our first major virtual gift! We are glad that WebMagic CEO Greg McLemore identified us as a worthy recipient for the domain and thank him for the generous gift. OFRF does not currently plan to use the domain name itself (we like our ofrf.org), and we invite anyone interested in acquiring the domain to contact us (Don Burgett or Bob Scowcroft) at (831) 426-6606.

Looking ahead, Laura and the rest of the staff have their hands full. The **Inaugural Assembly of the Scientific Congress on Organic Agricultural Research** (SCOAR) will take place in January in Pacific Grove, CA, in conjunction with the 21st annual Ecological Farming Conference. Funds from the USDA's Initiative for Future Agriculture and Food Systems (IFAFS) are supporting SCOAR as part of the work of the **Organic Agriculture Consortium** of OFRF and Ohio State, Iowa State, North Carolina State and Tufts Universities.

Next up will be **Organic Day** at the annual **Natural Products Expo-West** in Anaheim in March. This year, the usual **OFRF Organic Benefit Luncheon** will move inside the main pavilion, where we expect to serve up to 500 people an all-organic gourmet lunch. This will be more than double the attendance of our previous Expo luncheons! Expo organizers **New Hope Natural Media** wanted to increase our visibility at the Expo and encourage more of the retailers attending Thursday workshops to experience what an organic meal can be. Chefs **Donna Prizgintas** and **Chris Blobaum** will preside over the meal again this year, so it is sure to be outstanding.

We hope you can join us for some of the festivities, and we wish you a relaxing winter and an early start to your season!

—Don Burgett

Continued from page 1

COAFES, admit that he was not familiar with Wendell Berry's writing. This motivated the Sustainers to propose a series of seminars in 1988 between university faculty and members of the Coalition, and the University agreed to participate. A joint task force continued the dialogue, and explored possibilities for initiating a program of research and education in sustainable agriculture. A lengthy process ensued until finally, in 1992, the first MISA Board of Directors was named, and by-laws were drawn up and approved by the University administration and legal advisors. Richard Jones, then COAFES Dean, committed $200,000 for the first year and $300,000 per year to support MISA efforts for the next four years.

One of a Kind

MISA is a unique entity; it's not a college "department," nor a sustainable agriculture "center," such as those at the Universities of Wisconsin, Nebraska, Washington or the University of California-Santa Cruz, nor a "program," like the one at the University of California-Davis. It wasn't established by state statute as was Iowa's Aldo Leopold Center. MISA is a joint venture, a partnership, hard won after four years of trust building, structured dialogue and negotiation between advocates for sustainable agriculture and family-sized farms and the COAFES faculty and administration. It is governed by a fifteen-member board of directors, seven of whom must be sustainable agriculture farmers. Nine members are nominated by the Sustainers, and six are nominated by the University.

All other university programs in sustainable agriculture that involve citizens place them on advisory committees, not on decision-making boards like MISA's. The past two deans of the COAFES struggled with this relationship because the University's hierarchal structure doesn't operate in terms of dialogues, collaborations or partnerships, especially with farmers or staff of non-profit organizations. However, though uncomfortable with MISA's independence, the deans came to realize the advantages of having good relationships with MISA's constituency and its friends in the state legislature.

MISA's Accomplishments

MISA has leveraged its yearly base budget from the College to bring over $8 million to sustainable agriculture endeavors in Minnesota over the past eight years. About one-fourth to one-third of the funds from the College were spent on a competitive grant program for multi-disciplinary research. MISA's Program Committee made grants to build research teams that included farmers, university researchers, non-profit organization staff and agency professionals. Recipients raised additional funds from private foundations, the USDA Sustainable Agriculture Research and Education program, and the Minnesota Legislative Commission on Minnesota Resources; thus additional dollars were funneled back into the University for research and outreach.

MISA's many other accomplishments include the establishment of a graduate minor in sustainable agriculture and a very unconventional endowed chair in agriculture systems, both guided by committees that include representatives of the community as well as faculty. The endowed chair program is called a "revolving bench" by its founders, because two or three people can "sit" in the chair at one time. Over a three year period the chair has been filled with eight individuals, including two farmers and two community organizers.

"Before MISA, the College wasn't even acknowledging such a thing as sustainable agriculture."

Special appropriations from the Minnesota Legislature also extended MISA's reach. In cooperation with the Minnesota Department of Agriculture, MISA created an information exchange that advises—and learns from—farmers and the general public. Organizations in the Sustainers' Coalition lobbied the legislature for funds to form five Regional Sustainable Development Partnerships that provide rural communities direct access to University resources to build their economies on sustainable principles. Farmers working with the Sustainers also convinced the Legislature to fund a new faculty position and facilities for an Alternative Swine Systems Program. MISA received the funds and established an Alternative Swine Systems Task Force that included farmers as well as faculty from the Animal Science Department. Today, swine research is going on in hoop house structures at the West Central Research Station in Morris, Minnesota.

The Conflict

MISA was accumulating successes and increasing its capacity to advance sustainable agriculture when President Mark Yudolf hired a new Dean for the College of Agriculture, Food and Environmental Sciences in 1999. Straight out of the pharmaceutical biotechnology industry, Dean Charles Muscoplat repeatedly declared that his goal for the College was to develop and patent a gene in soybeans that could cure cancer. MISA constituents could see that he was unfamiliar with the concepts of sustainable agricultural systems.

In January 2000, Dean Muscoplat announced that all the "centers" housed in the College would have to accept budget cuts and undergo a faculty review to determine if they should continue or be terminated. MISA, not a "center," had already undergone an outside review of its first five years, according to its by-laws, but Muscoplat ignored this process and its recommendations. Don Wyse, MISA's executive director, worked to build a good relationship between MISA and Dean Muscoplat, but the new dean didn't seem to understand what MISA meant by sustainable agriculture, nor the nature of community involvement in the Institute. Although he could successfully transition from the corporate boardroom to the hierarchy of university administration, he did not fathom how to work with a partnership that gave decision-making powers to small family farmers, non-profit organization staff and faculty members on the MISA board.

In April, 1999, Muscoplat forced the resignation of Don Wyse, "because of philosophical differences," without consulting the Board of Directors. Friends of MISA were outraged; more calls and letters of protest poured into the university administration than had ever been seen before. The MISA Board asked the Dean to meet with them, and he did, attended by two campus police officers who stood outside the door while the board chair, Sister Mary Tacheny, from the School Sisters of Notre Dame, facilitated the meeting. Dean Muscoplat talked unconvincingly about his commitment to sustainable agriculture, and it was clear that he expected the board to accept the situation and wait for a review by the College to learn MISA's future. He claimed that MISA's authority as laid out in the by-laws to hire and fire an executive director was invalid and refused to reinstate Don Wyse.

The Sustainers felt they were almost back to square one, but they sent representatives to meet with Dean Muscoplat and other administrators in May to start a dialogue, and agreed to continue meeting to gain a better understanding of each other's positions. Now, seven months later, they are still meeting. Muscoplat has insisted that MISA's unique structure "will not work," though it was approved by the University administration in 1991 and worked for eight years prior to his employment at the College. The MISA board refused to approve the hiring of a new executive director, asserting that they had not dismissed Don Wyse, but did accept the appointment of an "acting administrator," to assume some of Don's responsibilities. As of this writing, there appears to be a proposal on the table for a by-laws amendment setting up a joint oversight committee with equal representation from the University and the Board to handle personnel functions.

If negotiations on this proposal can produce a settlement, it would be a happy first step, but other problems remain. Last spring, MISA learned that its base funding from the University could be cut significantly or completely removed. Dean Muscoplat has offered to help raise grants and contributions for MISA, but the Sustainers insist that COAFES commit basic funds to MISA's budget on behalf of the public. Statements by Dean Muscoplat in reference to the management of MISA's grants program and the endowed chair program cause concern among Sustainers who fear he may attempt to override the committee process and gain control over how those funds are spent.

MISA Today

The MISA office is still open, the website (www.misa.umn.edu) is active, board meetings are held, students continue to hold their "What's up in Sustainable Agriculture" brown bag seminars, but according to Greg Reynolds, a MISA board member and organic vegetable farmer from Delano, Minnesota, "there is a feeling of being stuck." He thinks that the basic problem is that MISA's vision is not the Dean's vision for agriculture.

"Firing Don Wyse was not an accident,"Greg told me, "but a deliberate act based on where the College should go. The only reason the Dean has ever given is that he had a philosophical difference with Don." Now the University is dragging its feet in settling this, because "they don't know how to deal with community."

"You wouldn't recognize those research plots now."

Carmen Fernholz, an organic grain and livestock farmer from Montevideo, who chaired the MISA board from 1992 to 1998, is afraid that there is a deterioration of the friendly environment for sustainable agriculture that MISA created. "Before MISA, the College wasn't even acknowledging such a thing as sustainable agriculture. There were a few strong souls on the faculty, but they were afraid to step forward. In MISA's peak time, the College was getting new staff and researchers who wanted to make agriculture more sustainable."

This is not to say that COAFES became devoted to sustainable agriculture; faculty advocates for sustainable agriculture are still in the minority. But MISA did attract sustainability-minded students and faculty to campus. And new faculty does make a difference. Carmen and I recalled a MISA board visit in 1995 to the Lamberton Research and Outreach Station in southwest Minnesota, where the board was shown a field of soybeans dotted profusely with cockle burrs and told that it was an experiment in organic production. It was pitiful, a typical example of conventional researchers studying a field of soybeans with no chemical inputs, but not studying an organic production system.

"You wouldn't recognize those research plots now," Carmen told me. With the addition of two faculty members dedicated to doing effective research on organic farming, the station now has an entirely different research agenda. Lamberton researchers are looking at how to restore crop diversity to the region, and the rotations necessary to an organic system fit their research agenda well. Carmen, who serves on the Elwell Farm Ecology Board, a research focus of the Lamberton Station, credits the influence of Don Wyse and the friendly environment for organic agriculture that MISA created for the turnaround at the Lamberton station.

MISA Tomorrow?

What has made MISA such a vital force has been the involvement of a constituency in its conception, development and governance. MISA founders insisted that the organization exist outside the mold of traditional land grant college programs, and not be guided by conventional agriculture minds. Sustainers' Coalition members have vigilantly monitored its program grants, publications and the development of regional partnerships so that MISA reached out beyond the audiences land grant colleges have come to serve and connected with those the land grant colleges were established to serve.

MISA's founders thought they had built protection into the by-laws that would prevent its dismantling. But a new dean was hired who first disregarded the by-laws, then declared them unworkable, and he has been backed by the University President. However, MISA is backed by a tenacious grassroots constituency. In spite of the toll it is taking on individual organizations to have their executive directors spending so much time in negotiations with the University, the Sustainers are not giving up. This is how MISA was created. This is how sustainable agriculture advocates in Minnesota will keep it alive.

To follow events as they unfold, visit www.sustain.org/MISAfriends.

Dana Jackson is the associate director of Land Stewardship Project, an 18 year old Minnesota-based organization that fosters an ethic of stewardship for farmland and promotes sustainable agriculture and sustainable communities. Dana served on MISA's Board of Directors from 1994 through 1999 and is still a member of MISA's Endowed Chair Committee and the Graduate Minor Committee.

Policy Program Notes

by Mark Lipson, Policy Program Director

Another flash update on...

These Exciting Times in Organic Research Policy

New Organic Consortium

As we reported in the last issue of the *Information Bulletin*, OFRF's Scientific Congress on Organic Agricultural Research (SCOAR) has received funding from the USDA's Initiative for Future Agriculture and Food Systems (IFAFS) as part of a consortium with Ohio State, Iowa State, North Carolina State and Tufts Universities. This "Organic Agriculture Consortium" is another "first" in the progression of new institutional attention to the needs of organic growers.

The $1.8 million awarded for the multi-year Consortium is certainly the largest single grant award ever made for organic research and education. It's also the first time that multiple land-grant universities have collaborated on a set of organic projects, and it is the first significant federal grant money that OFRF has pursued for our own work. OFRF's portion of the Consortium proposal was funded at $220,000 over two years for activities of the SCOAR project. These funds will support OFRF staff time and pay for farmers to travel to SCOAR meetings.

Inaugural SCOAR Meeting

SCOAR is a nationwide effort to stimulate scientific dialogue about organic agriculture among working organic farmers, research scientists, and agriculture information professionals. Its mission is: *to plan and promote research and information exchange for understanding and improving organic agricultural systems*.

On January 23 and 24, OFRF will host the first national SCOAR meeting at the Asilomar conference center in Pacific Grove, CA. This meeting will be an opportunity for over 100 producers, researchers, and information-management professionals from around the country to come together and share their experiences about on-farm organic research. Meeting participants will refine SCOAR's objectives and begin developing a national agenda for organic farming research. A transcript of the meeting will be available. Check our website for more information at www.ofrf.org, where you can also find information about becoming a SCOAR participant.

USDA Highlights

Meanwhile, back in Washington, final USDA appropriations for the 2001 fiscal year emerged with a little bit of new money for organic research and education. $500,000 has been allocated for a new competitive grants program dedicated to "organic transition." OFRF has commented to USDA on how the program should be directed. The USDA-SARE program got its first real increase in years, with a boost of about $2 million dollars to a total of about $13 million. SARE is funding a growing number of organic projects, and this increase in funding should help continue that trend.

Of course the overall situation at USDA will be in turmoil as the new administration takes the reins. Ann Veneman, the new Secretary of Agriculture, has some familiarity with organic agriculture from her stint as the head of California's Department of Food and Agriculture. We believe that organic farming is basically a non-partisan phenomenon, and hope to convince Secretary Veneman that it is important to nurture its further growth.

Agricultural Biotechnology Program

In recent months, a major focus of our Policy Program has been agricultural biotechnology and genetic engineering. As a member of the USDA's Advisory Committee on Agricultural Biotechnology, I have been active in representing the questions and concerns of organic farmers regarding the use of genetic engineering in agriculture. We've partially succeeded in getting our concerns on the table and into the general debate, but that's about as far as it goes. In the context of the Starlink debacle, where GMO corn deemed unfit for human consumption found its way into numerous commercial food products, farmers generally are getting the short end of the stick and organic growers are certainly not an exception.

OFRF Board and staff are now finalizing an organizational policy statement on agricultural biotechnology, which will be available on our website shortly. In overview, OFRF feels that genetic engineering technologies may ultimately have useful potential, but we have grave objections to the ways in which it is being developed, employed, and regulated at present. We believe that conditions for the safe and effective use of organisms modified by genetic engineering (GMOs) for agricultural applications are not currently in place. This includes the inadequacy of scientific understanding about GMOs in the environment and the food supply, as well as the shortcomings of the U.S. government regulatory system for these products.

OFRF believes that the profitability of farming and food security will both improve without genetic engineering if farmers and researchers put much more effort toward developing ecologically sustainable systems. Therefore, the Organic Farming Research Foundation generally opposes the use of genetic engineering in agriculture at this time.

ACTION ALERT!

The USDA has released a request for public comments as a part of its biotechnology initiative. The request can be found in the Federal Register, November 30, 2000, p.71272-71273, and the deadline for comments is February 28, 2001. The request is on the subject of marketing of genetically engineered food products, as well as the related issues of product segregation and identity preservation. This is in advance of any rulemaking and offers an opportunity to let the USDA know what issues are of concern to the public and the agricultural industry. This is a very important occasion for the organic farming sector to voice its opinions about how the USDA should proceed with the regulation and marketing of GMOs in the foodchain. Please see the OFRF website at http://www.ofrf.org/policy/index.html for more information about this request for comments.

Technical Program Notes

by Jane Sooby, Technical Program Coordinator

Needle in a Haystack

Searching for organic farming research at land grants

Three years ago, OFRF Policy Program Director Mark Lipson published a groundbreaking study, *Searching for the O-Word*, which scoured USDA research projects for those relevant to organic producers. Of 34,000 projects, the study found only 34 that had "strong" relevance for organic producers, or 0.1% (one-tenth of one percent).

This past year, I've been doing a follow-up study, identifying specific organic research projects and information sources at land grant institutions across the country. I've considered calling it "Needle in a Haystack," since the information is so sparse and dispersed. *I have found that only 131out of 885,800 total research acres are certified organic and being used for organic farming research.* This works out to 0.01%, or one-hundredth of one percent, of the total. Another 206 organic research acres are not certified, and 239 acres are in transition to certified status.

There are notable organic research programs at the land grant level in Minnesota, Iowa, Ohio, North Carolina, and West Virginia. Many of these programs are taking a systems approach, involving growers at the decision making level and using interdisciplinary research teams. Here are some details:

University of Minnesota St. Paul, Minnesota

Eighty acres of the Elwell Agroecology Farm are certified organic. Elwell is part of the Southwest Research and Outreach Center in Lamberton (noted in our feature article). Organic rotation plots were established in 1990 and a comparison study has been done since 1989. Researchers Elizabeth Dyck and Paul Porter are also managing the Organic Conversion Project that works to connect farmers converting to organic with mentors and simultaneously collect data on the conversion process.

North Carolina State University Raleigh, North Carolina

The Organic Unit within the Center for Environmental Farming Systems (CEFS) had 80 acres certified prior to being flooded by two hurricanes in three years. The project has been moved to higher ground and organic certification is pending for 100 acres on a research station in Goldsboro. Numerous interdisciplinary research projects are being done, including a significant transition study that is comparing six organic transition strategies. Long-term cropping systems studies are also being established. According to researcher Nancy Creamer, plans are to conduct comparative systems research "for perpetuity." An advisory committee that includes farmers oversees the research. A 7-acre demonstration organic farm has been established at which an intensive summer internship program was held for the first time in the summer of 2000.

Though certified organic acreage represents only a tiny fragment of the total research area, the organic-dedicated programs that do exist are fascinating and inspiring.

Ohio State University Columbus, Ohio

A multi-disciplinary long-term study on the transition to organic was started in 2000. After the transition period, the study area will be devoted to purely organic research. Thirty-five acres of the 164-acre West Badger Farm in Wooster are designated transitional to organic in field crops. Five acres will be used for organic vegetable research at Fry Farm. Nine acres will be certified organic. Project coordinator Deb Stinner has planned trials with the market in mind. There were nine studies in the ground in 2000, the major effort being a large-scale transition study. An advisory group comprised of growers and researchers makes budgeting, research priority, and research design decisions.

Iowa State University Ames, Iowa

Kathleen Delate, assistant professor in organic agriculture/horticulture, holds the very first academic appointment in the U.S. specifically to study organic practices. Delate maintains designated organic research sites at 5 research farms and intends to certify all sites (one became certified organic in 2000). Delate has 13 trials currently, including a project comparing the agroecology and economics of organic and conventional corn, soybeans, oats, barley, alfalfa, red clover, green peppers, broccoli, and medicinal herb production. Farmers assist in setting research priorities through focus groups and annual meetings.

West Virginia University Morgantown, West Virginia

The 60-acre Horticulture Farm has the distinction of being the only research station in the United States being transitioned entirely to organic. An interdisciplinary transition study began in fall 1999, when the entire farm started to be managed organically. A major transition study is being done as well as work on apples, pears, grapes, and blueberries. According to director James Kotcon, the ultimate goal is to maintain the farm as an organic research farm. Advised by a committe of organic growers, researchers are comparing the organic transition in both a market garden and field crop/livestock farm. The crop/livestock farm will also compare presence and absence of animals in the system.

The full report covers organic farming research activities in all 50 states. ***State of the States: Organic Farming Systems Research at Land Grants 2000-2001***, is available for a requested donation of $5 or free through the OFRF website www.ofrf.org.

IN CONTEXT

Compost Teas: A Brave New World

In this issue of the *Information Bulletin* we present the results of two compost tea research projects. The first, by Richard Merrill, looks at designing and operating an aerated or "active" compost tea apparatus. The second, by Sylvia Welke, field tests a variety of compost tea extracts, produced by "passive" methods, which generate a less oxygenated tea mix. These reports help illustrate that there are many different opinions out there about compost teas: how they should be made, which varieties to produce for which crops and for various intended outcomes—such as disease suppression or a source of plant nutrients—and how effective teas are in the field.

To tea or not to tea

Anecdotal evidence suggests that not a lot of growers—organic or otherwise—are utilizing teas. Producing teas on a field scale—especially "aerated" teas—can require a significant initial investment (depending on how you go about it), but perhaps more important, a commitment to developing a reliable protocol and method of making observations. Key monitoring tools, such as pH and CO_2 meters and a thermometer can help, but a relationship with a good laboratory and a microbiologist might be needed to (begin to) make sense of the outcomes.

Nonetheless, compost teas are being explored enthusiastically by a number of farmers and researchers, who—you guessed it—have a variety of opinions about producing and using them. Carl Rosato, an orchardist in the Sierra foothills, is devoting significant time and resources to teas on his farm, and at this point is committed to aerated teas. (His early tea research was reported in *Information Bulletin* 1: Controlling Peach Brown Rot.) Yet he finds his research ideas and methods developing slowly as he figures things out along the way. For example, his trials attempting to control brown rot with teas were inconclusive, yet he feels he can "definitely" produce a nutritive effect in his peach orchards using a compost tea soil drench. He thinks he has successfully made peaches sweeter with a tea drench complemented with sulfur and potassium. While the additives may have produced the greater effect, he notes that he is also getting good K in the compost feedstock he uses.

Others who have experimented with teas have found their efficacy difficult to determine. Helen Atthowe, OFRF Board member, farmer and Extension Advisor in Montana, eagerly pursued tea research following publication of the first German tea studies (Weltzien et al., refer to project bibliographies in Research Reviews). Not having consistent luck with them, she focuses now on suppressive compost explorations. In reviewing content for this newsletter, she noted that the literature cited regarding disease suppressive effects of compost is controversial, and may be related to initial compost ingredients. The literature regarding disease suppressive effects of compost teas is even more controversial. Further, studies that document the nutritive effects of teas are not shown and to her knowledge have not been done sufficiently to allow prediction about what kinds of nutrients we can expect from compost teas made with different materials.

To air or not to air

A quiet "controversy" persists over whether compost teas should be produced "passively" (without active aeration), or "actively," a process which might include a bubbler, a vortex nozzle, or any recirculation method that moves the water through the compost feedstock. Others feel the aerated/non-aerated issue is overstated, and may not be as important as other factors.

Elaine Ingham, a tea researcher with Soil Foodweb, Inc. in Corvallis, Oregon, strongly supports the aerated approach, noting that passive systems can go anaerobic quickly and that anaerobic organisms are toxic to plant cells. At the same time, she notes that just because a system is "passive" does not mean that it *will* become anaerobic—it depends a lot on the feedstock, the environment and the brew time. However, she strongly suggests that anaerobic teas are not as helpful aerobic ones—that anaerobic by-products produce compounds that are toxic to plant cells, and these conditions should be avoided. She supports a recirculation or vortex system, because such active systems push the beneficial microbes out of the feedstock and into the tea substrate. Ingham believes this action is important to pull the organisms out of the solution, although not too forcefully or they will be macerated. Otherwise the tea will contain only the non-living nutrient and miss the desired bacteria and fungi.

However, a number of studies and researchers suggest that anaerobic teas may have greater disease suppressive capabilities—possibly due to the biocidal effects of the unpleasant by-products they create, or because the desired beneficial organisms *are* present in the extracts. Sylvia Welke investigated the potential for disease suppression of an" anaerobic" tea based on Will Brinton's (Woods End Laboratory, Mt. Vernon, ME) suggested protocol for making a tea without active aeration, other than occasional stirring.

Will Brinton finds the discussion of aerobic teas vs. anaerobic teas problematic. He believes that neither method represents a silver bullet; that nature is not that simplistic. Studies have shown that facultative anaerobes are the bacteria doing the work of disease suppression, yet by definition, they may live in aerobic or anaerobic conditions, and have the ability to survive in low-oxygen environments. Standing, unaerated solutions have been shown to have extremely high counts of facultative anaerobes.

Taking the plunge

Brinton suggests that for those who want to try teas for disease suppression, to first identify the disease you're trying to control and conduct a thorough review of the literature. Has the organism you're seeking to control ever been successfully controlled using teas, and if so, what was done? If you send a sample of your tea to a lab for analysis, look at bacteria counts and the mix of organisms, and check whether those organisms have been shown as effective against your disease. And realize, too, that weather and environmental conditions will affect the efficacy of a tea. A tea that performs well under one set of conditions may not be as effective when those conditions change.

Don't be afraid to experiment with compost teas. But rather than look for simple explanations, be open minded to the variety of possibilities, and as Brinton says, "review all of the literature and the contradictions, and embrace that."—*EW*

Apparatus Design and Experimental Protocol for Organic Compost Teas

Richard Merrill and John McKeon

Interest in organic teas for use in agriculture and horticulture has grown rapidly during the last decade. The literature and internet web sites are full of experiments, testimonials and observations which suggest that certain liquid extractions of manures or composts, at various stages of decay, can supply plants with at least four major benefits: a source of plant nutrients; a source of beneficial organic compounds, an ability to suppress certain plant diseases; and as a way to build soil structure when applied as a drench.

In preparing for this project we reviewed some of the pertinent research concerning organic teas, and noted that the results of studies on the effects of such teas, especially as a biocide, is quite mixed. We believe this is due to the variable nature of both the organic feed stock and the methods of extraction. We make some suggestions concerning a protocol for on-site research into the production and use of organic teas with suggestions for controlling feedstock and extractor variables in field experiments. Finally, we describe our experiences with a simply-made, aerobic organic-tea extractor prototype. Our results confirm those of others: so-called anaerobic tea systems—those in which organic stock is simply soaked in water—are actually aerobic for the first 48 hours or so of extraction. After that, they become anaerobic. In other words, aerated or aerobic systems simply extend the time of useful extraction by replacing or adding oxygen into a system that would otherwise go anaerobic. It should be the goal of all organic tea extraction methods to avoid anaerobic conditions.

Project leader:
Richard Merrill, Program Director, Dept. of Horticulture, Cabrillo Community College Soquel, California

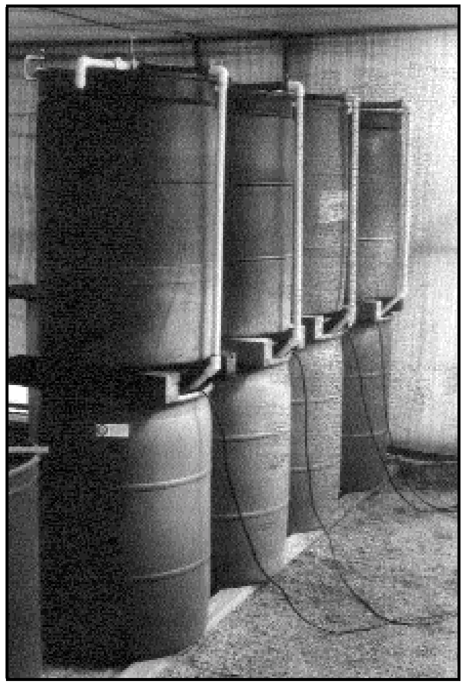
Student assistants:
John McKeon, David Seidman, Kay Hoberecht

Experimental design support & data analysis:
Marc Buchanan, Agricultural Consultant

Cooperating growers:
Route One Farms, Santa Cruz

OFRF support: $4,860

Project period: 1997-1998



The Cabrillo Organic Tea Project double-barrel active tea extractor units #1-4, set up in the greenhouse. The four passive extractors (#5-8) were single-barrel units (not shown).

Project Objectives

- To test the design and operation consistency of an organic tea apparatus in search of an inexpensive extractor design prototype that will produce expected microbial populations.
- To sample, test for, and document any short-term differences between aerobic and anaerobic teas in the Cabrillo Organic Tea Apparatus (COTA) experiment and the compost feedstock.
- To establish some experimental protocols for future projects that will further define what is being produced in aerobically-made organic teas.

Methods

Compost source. We located a consistent supply of near-finished compost made by Grover Environmental Products in Modesto, California, a commercial compost producer registered with the California Compost Quality Council. The compost is made from vegetable produce waste from supermarkets, city green waste collection programs and materials from their own landscaping business. Materials are screened, piled in rows and processed using a modified Lubke method. They have designed their own row-turning equipment that measures moisture content and adds water as needed while turning rows. Rows are monitored daily for oxygen, ammonia, pH, and temperature, which does not exceed 145 degrees F. Every 3000 yards of compost is checked for heavy metal content and ammonia content as regulated by the state waste management board.

Set-up. The experiment was performed in an empty greenhouse so that we could control the external temperature and environment for all of the individual tea apparatuses. Four *aerobic* tea apparatuses were built following the plans of "Model 3," a design that incorporated spray-head and screening improvements over earlier trial models. In addition, four *anaerobic* barrels were designed to be used alongside the aerobic apparatuses. These anaerobic barrels consisted of the same type of plastic, fifty-five gallon barrels used for the aerobic units. Shade cloth sacks were sewn to hold the same amount of compost as the aerobic apparatuses. These sacks were suspended in the middle of the barrels using a length of line and a metal bar.

Preparation. Two 55-gallon barrels were filled by taking shovels of compost from all sides of compost piles, and at different heights and depths. These barrels were then taken to the project site. All barrels were filled with 50 gallons of water run through a garden dechlorinator to reduce chlorine content. Five gallons of compost were added to every apparatus, in the feedstock container for the aerobic barrels (#1-4), and in shadecloth bags for the anaerobic barrels (#5-8).

Defining Organic Tea Extraction Systems

Organic tea systems have been described as either *anaerobic* or *aerobic* depending on the degree of aeration given to the system. This is somewhat misleading. The distinction is the degree of aeration given to the system in order to allow it to extract over a protracted time period. We prefer the terms ***passive*** (a contained or bagged slurry that is simply allowed to soak in water) and ***active*** or aerated (an organic tea system that receives a boost of oxygen with the use of mechanical mixing, packed columns or forced air.)

Passive tea extraction systems are those in which a feedstock is simply left to soak in water. After a few days, passive systems will become anaerobic and, as a result, begin to produce various organic acids such as butyric, proprionic and acetic plus the odors of reduced forms of nitrogen (NH_4) and sulfur (H_2S) which in turn will attract flies. There is some evidence that the by-products of anaerobic decay can actually harm plant roots (James Downer, pers. comm.).

The trouble with passive extraction methods is that they can go anaerobic very quickly. When you soak organic materials in water for more than a few days, aerobic microbes in the slurry pull all the oxygen out of the water. This turns over the production of the tea to oxygen-avoiding (anaerobic) microbes, which produce an inferior tea with fewer available nutrients and organic acids harmful to plant growth. Our research indicates that there is usually enough dissolved oxygen in clean water so that anaerobic microbes aren't dominant for at least 24-48 hours under most conditions. After that, the quality of the tea begins to deteriorate. All types of tea systems should be aerobic. The major variable is the length of time that aerobic extraction is allowed to take place.

There is evidence that adding oxygen to an organic tea slurry improves the quality of the extracted tea. This seems to be because aeration extends the extraction time, which allows the removal of beneficial organic compounds like vitamins, enzymes, organic chelators plus a bevy of beneficial microbes. *—RM & JM*

Baseline compost data. At the same time, samples of compost were collected from the feedstock containers of barrels #1-4. These were sent to BBC Labs in Tempe, Arizona for analysis to serve as a comparison to the tea samples collected later at 24- and 48-hour processing times.

Tea production and sampling. At 4:00 pm on June 21 the four aerobic barrels were turned on and the shadecloth bags of compost were put in the anaerobic barrels. Data collection began immediately. Every two hours, excluding the hours from 12 am to 8 am, we measured oxygen (O_2), pH, electrical conductivity (EC), and temperature. Oxygen measurements were taken with a portable O_2 meter to measure the differences in O_2 levels between the aerobic and anaerobic production methods. These measurements were taken within the barrels at a middle depth for the aerobic barrels and at a surface depth and bottom depth in the anaerobic barrels. Electrical conductivity, pH and temperature were taken with portable meters as well. Samples were extracted from each barrel and tested in a cup. These measurements were taken to establish any trends during production. At the 24-hour mark, tea samples were taken from all eight of the barrels and sent to BBC Labs for compost tea analysis.

Tea additive tests. After the 24-hour samples were taken, 32 oz of sulfured molasses and 32 oz of azomite rockpowder were added to aerobic barrels #1-4. These supplements were added as a food source for microbes that might exist in the tea to see if there would be any population increase in the groups tested for by BBC Labs in the 48-hour sample.

Anaerobic tank mixing. Also at the 24-hour mark, anaerobic barrels #5-8 were mixed vigorously for one minute and this was repeated every four hours up to the 48-hour mark. This was done to document any trends in the difference between the active and passive approaches to anaerobic tea production.

All measurements were continued until the 48-hour mark, at which point tea samples were taken from barrels #1-4 and sent to BBC Labs for compost tea analysis. At this point the physical experiment was completed.

Results

- There were minor differences in microbial populations as indicated by bioplate counts between the sub-samples of compost taken from the same batch.
- There was no significant difference in O_2 between passive and active treatments over the first 24-hour period.
- There was no significant difference in microbial populations as indicated by bio-plate counts between passive and active treatments after the first 24 hours, but there was a significant difference after the first 48 hours in active systems.

Discussion

Our experiments confirm those of others that so-called anaerobic tea systems—those in which organic stock is simply soaked in water—are actually aerobic for the first 48 hours or so of soaking. In other words, "aerobic" systems are merely extending the time of useful extraction by putting more oxygen into the system.

If suppressive microbes tend to be found more in older teas (several days) than younger ones (1-2 days), it is possible that the organic matter being extracted is, itself, undergoing decomposition in a complex aerobic/anaerobic environment within the slurry, i.e., maybe the extra time needed to extract microbes is really just more time to give the feedstock time enough to decompose to the appropriate microbial substrate.

Field test of the Cabrillo Organic Tea Apparatus

The COTA was field tested by farmers at Route One Farms, Santa Cruz, CA. Their critiques are as follows:

❖The capacity of the machine was not large enough for field use. Given this limitation they adopted it for use on greenhouse seedlings. However, they modified the bottom barrel by enlarging it to a container that can hold up to 250 gallons and are planning to use teas in the field at a 50% dilution.

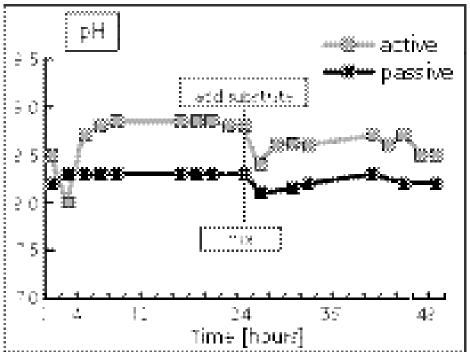


Fig. 1. pH flux during 42 hours in active and passive compost tea systems with substrate addition (sulfured molasses and azomite rock powder) at 24 hours.

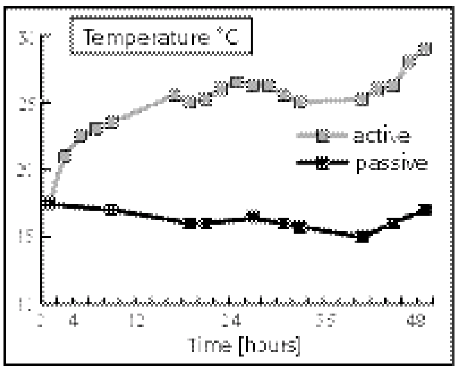


Fig. 2. Changes in liquid temperature during 48 hours in active and passive compost tea systems.

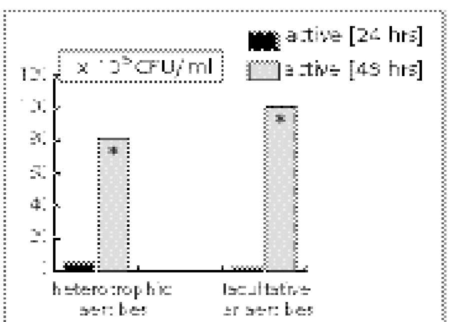


Fig. 3. Heterotrophic aerobic and facultative anaerobic bacteria in compost tea after 24 and 48 hours in active system with substrate addition at 24 hrs.
[* = differences significant at p < .01]

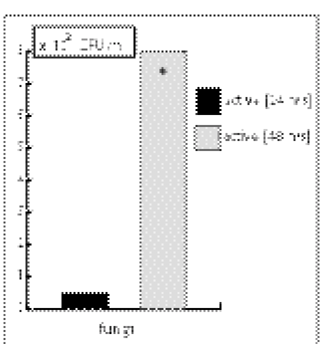


Fig. 4. Fungal counts in compost tea after 24 hours and 48 hours in active system with substrate addition at 24 hours. [* = differences significant at p < .01]

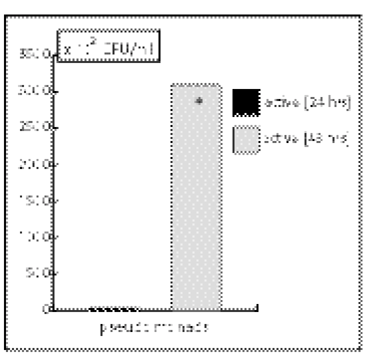


Fig. 5. Pseudomonad counts in compost tea after 24 hours and 48 hours in active system with substrate addition at 24 hours.
[* = differences significant at p < .01]

❖The top barrel is extremely heavy after producing tea due to saturated compost. Removing and replacing the compost takes more than one person.

❖The feedstock container was too difficult to use given its placement inside the top barrel. They replaced it with a plastic container the goes all the way to the top of the barrel and although still heavy, easier to deal with.

❖ Screening and sprayhead clogging is a problem with fine sized compost.

Suggestions for a field experiment protocol

Having reviewed over 100 papers on organic teas, we are unable to reach a conclusion as to the value or efficacy of organic teas. The problem, as we see it, has been a lack of standard protocol for organic tea experiments. A protocol is important because of three major sources of variation: 1) the organic feedstock, 2) the method of extraction, and 3) the time interval of extraction.

The most difficult variable to control is the feedstock, whether it is fresh manure or suppressive compost. A consistent source of feedstock should be found and sub-samples taken from *the same batch.* If possible, inorganic nutrient and bioassay tests should be done on pilot sub-samples to establish the degree of variation within the feedstock.

The method of extraction is a function of the type of extractor used, and the conditions under which the experiment takes place. Replications should be assigned to extractors of similar design and aeration units. Since multiple replications are so important to a well designed experiment, it is important to find a well functioning yet inexpensive extractor design such as the one described in this report. Experimenters should also control for the following environmental variables: 1) the temperature of extraction; 2) the amount of ambient light; 3) the chemical quality of the water used in extraction; and 4) the use of supplemental ingredients.

The temperature of extraction & ambient light. The organic tea apparatuses at Cabrillo College were maintained outside and under a shade structure. Tea production rates varied greatly with the swings in daily and seasonal temperatures. At Cabrillo College, ambient temperatures vary from daytime highs in the upper 70's (August-November) to nighttime lows in the lower 30's (December-February). Our observations indicate that below 45-50°F . extraction was noticeably slowed down. Most nutrients tend to be more soluble in warmer water, and because microbial respiration rates are proportional to ambient temperature, heating the slurry or keeping the extractors in heated spaces might have some merit in cool locations.

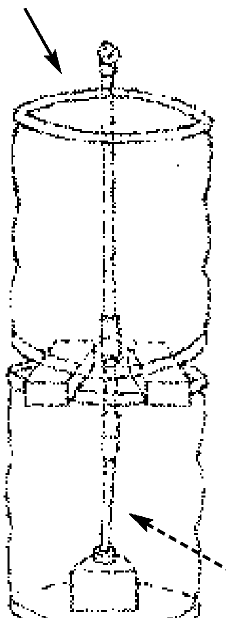
Chemical quality of the water. The chemical properties of the water being used can strongly affect the quality of tea produced. Acid and alkaline water with little buffering capacity can keep certain microbes from flourishing. Excess salts can do the same thing. When possible, try to use filtered, spring or rain water, which will produce a richer tea.

Supplements to feedstock. Several researchers and practitioners have recommended the addition of concentrated supplemental nutrients to increase microbial activity in organic teas. These include sugars, unsulfured molasses (at a rate of 1 tbsp of molasses per 5 gals of water), rock fertilizers, kelp and fish products and barley malt. We would only add the possibility of adding commercial microbial cultures to jump-start microbial activity in organic teas.

The time of extraction. The time of tea extraction strongly affects the quality and composition of organic teas. According to Amigo Cantisano[53] "Teas for nutrient and humic acid extraction are ready in 1-2 days...some disease suppression is noted from these young teas; more time is required for maximum disease suppressive teas."

An efficient organic tea experiment should focus on a minimum number of variables at a time because of the inherent variability of the testing situation.

Fig. 6. Double-barrel active tea extractor showing outline of 55-gallon plastic barrels, pump assembly and wooden spacers between upper and lower barrels.



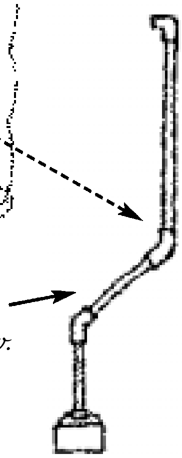


Fig. 7. Pump assembly, side view.

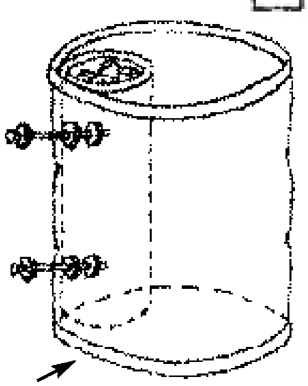


Fig. 8. Packed column filled with 4 inch PVC pieces, bolted inside of top barrel; a gravity-fed aeration system.

Figs. 6-10 (this and the following page): Details of active compost tea apparatus.

Design and Construction Details of the Cabrillo Organic Tea Apparatus

The overall design of the Cabrillo Organic Tea Apparatus is simple, inexpensive (total cost: $303), and uses readily available parts. What follows are step by step instructions for building the apparatus, completing assembly of six individual components, which make up the entire extractor unit.

These components are:

- The Containers
- The Packed Column
- The Pump Assembly
- The Spray Head
- The Feedstock Container
- Miscellaneous Parts

The order of assembly is important since completion of one component leads to the placement and sizing of the next. [*All required materials and number of units needed (#) are shown in boldface, followed by an estimated cost ($); required tools are shown as underlined.*]

The Containers (Fig. 6)

(2) 55 gallon plastic barrels (cost: $100). Cut the tops off both barrels: Drill with ½" bit a ½" hole on the top of each barrel on the inside of the lip. Insert the scroll saw and cut around the circumference of the barrel to remove the top.

Cut a hole in the bottom of the top barrel to-be: Draw a 10"x 7" diamond shape using a permanent marker. Using the scroll saw, follow your markings to remove the diamond.

(1) Automobile tire inner tube (cost $10). Use a utility knife to cut a piece of the inner tube (one layer thick) so that it extends 1" beyond the edges of the diamond. Measure and cut a slit lengthwise in the middle of the piece of inner tube 3½" long. Inside the barrel, sand the inside edges of the diamond as well as the edges of the inner tube with 80 grit sand paper. Apply waterproof silicone sealant to the sanded areas and glue the inner tube to the inside of the barrel. This creates a funnel which prevents the tea from leaking out the sides of the bottom of the barrel. It also reduces the splash and loss of tea as it falls between the barrels.

The Pump Assembly (Fig. 7)

(1) ¼ hp submersible pump w/ auto float switch ($80). Check the size of your submersible pump line out. Make sure you have the right fitting to adjust the pipe size to ½".

(1) 20' section of ½" PVC pipe ($12). Cut a 1'8" piece of the ½" PVC pipe. Glue the line out fitting to the pipe and attach it to the pump. Place the assembled pieces inside the bottom barrel. Cut a 1'10" piece of the ½" PVC pipe.

(8) 45 degree ½" PVC elbows ($7). Wet/dry PVC cement. Glue a ½" 45 degree PVC elbow at each end of the 1'10" pipe. Make the 45 degree angles opposite each other, one facing down to the pump and the other facing up towards the top barrel. Glue into place on the assembled pieces inside the barrel. Place **(2) 2' lengths of 4x4" lumber** ($5) spacers on the top of the bottom barrel. Place the top barrel on the spacers.

Adjust the pump assembly so that the top of it extends out the back of the bottom barrel. Measure the distance from the top of the pump assembly to the top of the top barrel and cut a piece of PVC pipe to size. Glue into pump assembly.

(9) 1/2" 90 degree PVC elbows ($7). Glue a 3" piece of ½" PVC pipe into a 90 degree elbow. Slip **(1) ½" ID (inside diameter) piece of clear poly hose** ($1) over the ½" PVC piece and secure with the second available ½" hose clamp. This will connect to the spray head and serve as a visible flow check. Glue a ½" 90-degree PVC elbow on the top end of the pump assembly.

The Packed Column (Fig. 8)

(1) 4" dia. PVC pipe, 2'6" long ($15). Place the PVC pipe inside the top barrel. Bring the top of the pipe 2" from the top of the barrel and hold it there. On the outside of the barrel, with a tape measure, measure down 5" from the top of the barrel. Take the drill with the ¼" bit and drill though the barrel and the pipe. Remove the pipe and measure down 2' from the first ¼" hole on the barrel. Drill a second hole though the barrel. Measure 2' down from the first hole on the pipe and drill a second ¼" hole.

Take a **5"x 5" piece of chicken wire** and cover the bottom end of the 4" pipe. Fold the chicken wire around the outside of the pipe and slide **(1) 4½" threaded hose clamp** ($3) over the wire. Secure the wire to the pipe by threading down the clamp. This serves to keep the 1" PVC pieces inside the packed column. **(1) 10' length of 1" PVC pipe** ($6) cut into 1" sections with PVC pipe cutters or hack saw. Attach the Packed Column to the inside of the barrel using **(2) ¼"x 2" carriage bolts, (4) ¼" washers** and **(2) ¼" wingnuts**. Fill the column with the PVC pieces to within 1" of the top.

The Spray Head (Fig. 9)

(3) ½" PVC tees ($3), **(3) ½" PVC slip-fit ball valves** ($18), **(1) ½" PVC cross** ($2), **(4) ½" PVC end caps** ($1). Individually assemble the top, connector, and bottom pieces of the spray head and then glue the three pieces together. The connector piece should be lined up directly underneath the line above it, so that it is running back towards the cross-piece. Attach the bottom piece to the connector piece so that the spray lines parallel the connector piece. Check the spray head assembly for fit in the top barrel. **(2) ½" hose clamps** ($3). Connect the spray head to the pump assembly and secure using a ½" hose clamp. Stabilize the spray head by placing a yardstick across the top of the barrel and under the top piece of the spray head.

The Feedstock Container (Fig. 10)

Cut a 4' diameter circle from **(1) 4' x 4' piece of shade cloth** ($4). Assemble feedstock container ring. Refer to diagram for feedstock container ring assembly, using the 1/2" PVC straight piece sections and 45- and 90-degree PVC elbows. Place shade cloth inside ring so that there is a 1" to 2" margin around the outside.

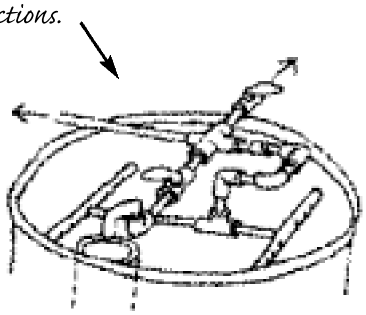
Use **zip-ties** (1 package $7) every 1½" to fasten the shade cloth around the ring. Use **(2) 10" S-hooks** ($2) (bought or easily made from 14-gauge wire) to hang inside the top barrel. Note: the inverted side of the ring should fit around the packed column.

Miscellaneous Parts

The Barrel Spacers. On the two 2' lengths of 4x4 lumber, measure in from each side 9". **(8) 2" C-clamps** ($3). Center two C-clamps at the 9" marks and nail into place. Leave a 1" gap between the C-clamps. These will serve to hold two screens in place. **(2) window screen kits** ($12).

The Barrel Spacer Screens. Assemble two 12"xl2" screens using a window screen kit or from existing materials. These serve to screen compost particles from the tea and keep compost from settling in the bottom barrel. With two screens, one can be cleaned easily.

Fig. 9. *Spray head assembly, showing top (above barrel), bottom (inside barrel) and connecting (middle) sections.*



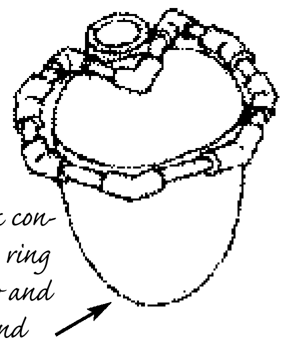


Fig. 10. *Feedstock container, with PVC ring made from elbow and straight pieces, and porous bag assembly from shadecloth.*

Benefits of organic teas: A review of the research literature

Teas Provide Inorganic Nutrients and Beneficial Organic Compounds

The types and amount of nutrients in an organic tea depend on the age and kind of material used. The nutrients from *fresh* manure teas tend to be soluble salts, especially macronutrient (N, P, K, Ca, Mg and S) plus micronutrients (e.g., Fe, Zn, Mn and Cu).

Nutrients from more decomposed feedstocks such as *young or unstable compost* contains some available nutrients not yet fixed in microbial biomass, but they also provide organic nutrients like sugars and amino acids, plus organic chelating agents (humic and fulvic acids) that carry extracted micronutrients (e.g, iron, zinc, manganese and copper) to plants. Since micronutrients are the building blocks of plant enzymes, vitamins and hormones, organic teas can also increase a plant's disease resistance, vigor and hardiness by providing both micronutrients and the organic chelating agents that make them available. Organic teas also contain long-chain carbon molecules which provide carbon and oxygen for soil microbes, including mycorrhiza. The mycorrhizal hyphae, in turn, greatly extend the root systems of plants, increasing their nutrient uptake, respiration, tolerance to weather extremes and possibly conferring some disease resistance.

Teas Suppress Certain Plant Diseases

It has been shown that certain soil microbes have the capacity to suppress many serious plant diseases[1,2]. The disease-suppressive characteristics of organic tea was reported as early as 1973 by Hunt et al[3].

Extractions from *well-aged* and *suppressive* composts have few soluble nutrients, but they do contain organic chelators and populations of various biofungicidal microbes. These teas have been shown to act as a natural fungicide, i.e., as an inoculum of microorganisms that can compete with and suppress some plant pathogens, especially foliar-fungal diseases.

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At the University of Bonn, Germany, Heinrich Weltzien pioneered research in "water extracts of compost." He showed[4] that organic tea can be used as a foliar spray to inhibit *Phytophthora* on tomatoes and potatoes. Weltzien also showed that the suppressive effect of organic teas are of a living microbial nature. Sterilized or micron filtered tea had little ability to impact pathogens[5]. He also documented that plants treated with tea appeared healthier and more vigorous than other plants.

Using organic teas or special compost extracts, other researchers and growers have reported modest to major control of several plant diseases with organic teas including: Apple Collar Rot[6], Apple Scab[7], *Botrytis* or Grey Mold[8,9], Downy Mildew[10], *Fusarium*[11], *Phytophthora*[12,13], Potato Blight[14], Powdery Mildew or *Erysiphe*[15], *Pythium*[14,16,17,18,19] and *Rhizoctonia*[19,20]. According to these authors, compost teas coat plant surfaces (foliar application) or roots (liquid drench application) with living microorganisms and provide food for beneficial microbes. This helps secure a diverse and healthy food web community where symbiotic bacteria and fungi help provide disease resistance.

In addition, several types of organic feedstocks have produced favorable suppressive results including composts [5,11,21,22,23,24,25,26,27], municipal and agricultural wastes[28] and various types of lignous materials such as wood wastes and peat moss[6,12,17,18,20,29,30,31,32,33,34,35,36,37,38].

The principle suppressive microbes in compost teas can suppress diseases in several ways[39]:

- They induce resistance against pathogens (pre and post-infection).
- They produce chemical inhibitors as reported for the suppression of *Phytophthora* root rot in media amended with hardwood bark[12,31].
- They inhibit pathogen spore germination.
- They antagonize and compete with pathogens through the antibiotic effects of parasitism, hyperparastism and nutrient competition. Some microbes, especially bacteria, produce antibiotics which cover the surface of the crop and thus prevent infection by the pathogen.
- They extend the root system of plants, and thereby improve nutrient uptake, plus increased food storage and soil respiration.

There is also growing evidence that chemicals called siderophores, pseudobactins and pseudomycins produced by the bacteria *Pseudomonas* spp. exert a powerful suppressive effect on other organisms[40]. Kai et al.[33] found that ten proteins from secondary metabolites of plant or microbial origin effectively suppressed certain pathogenic fungi. In some cases, cyanids and antibiotics interact with the host plant and create resistance to disease.

It's not always clear which of these effects is most important to a general impression of "disease-suppression" as noted in the literature. Furthermore, not all such experiments have been favorable. Using aerated Luebke compost tea, made in a lab extractor with a vortex nozzle for aeration, Wittig[41] reported that aerobic compost tea was not effective in controlling apple or pear scab, downy mildews, brown fruit rot or peach leaf curl. He generally rejected them as effective controls for "foliar diseases of fruit trees and grapes." Wittig goes on to note: "Considering that the microorganisms present in compost may be better adapted to a soil environment, perhaps there is greater potential for its use as a drench in controlling soil-borne pathogens."

In spite of the mixed results, there seems little doubt that certain beneficial microbes can be water-extracted from aerated organic slurries and applied to leaf surfaces (via foliar feeding) and/ or root systems (via drenching or fertigation). These "beneficial" microbes include mycoparasites[42], rhizosphere colonies[43], hyperparasitic fungi[40,44,45,46], epiphytic microbes[47,48] as well as specific bacteria such as *Pseudomonas*[49], *Azotobacter*[50], and certain fungi like *Trichoderma and Gliocladium*[51,52]. Apparently disease suppressive microbes that have been extracted from the compost are able to colonize the surface and roots of plants when applied properly. Organic teas simply concentrate these beneficial microbes and allow the grower to apply them in a convenient, concentrated form for nutrients, resistance and disease control[53]. In a real sense, organic teas are a concentrated liquid fertilizer and inoculum of beneficial microbes.

It is worth noting that between 50 and 80 percent of a plant's photosynthates (sugars, complex carbohydrates, amino acids and proteins) are translocated below ground into the root system of most plants (Elaine Ingham, pers. comm.). Of this amount, 40 to 60 percent are released by roots as exudates that supply food and create the conditions for colonization of soil microorganisms living in the rhizosphere (the microscopic habitat surrounding roots). These organisms, in turn, excrete, die, decay and are consumed by other organisms in the soil's food chain. Through this process of growth, death and decay, the waste and by-products of soil microbes become macro and micronutrients for plants. From these facts, one might hypothesize a profound reciprocal (symbiotic) relationship between plants and microbes as yet unexplained.

Teas Help Build Soil Structure

The microorganisms found in organic teas excrete organic gums and resins that, together with fungal hyphae, bind soil particles into structural aggregates, improving both soil structure and water-holding capacity. Thus, when organic teas are applied as a soil drench, they can promote good soil structure.—*RM & JM*

References

A key feature of this project report is an extensive bibliography of the research conducted on compost teas. A majority of these references are provided here; the full bibliography provided with this report (88 references, total) may be obtained by contacting OFRF or by visiting our website: www.ofrf.org.

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This complete project report (Project #97-40) is 47 pages, plus eight appendices. The main report and bibliography are available from OFRF by mail or by visiting our website (www.ofrf.org); *project appendices may be obtained by mail only and will be sent upon request.*

RESEARCH REVIEW

Effectiveness of Compost Tea Extracts as Disease Suppressants in Fresh Market Crops

Sylvia Welke

One of the major challenges facing organic producers is disease management. Losses in vegetable production due to disease can be significant and in some cases, can devastate entire crops. Cultural methods of disease control are commonly used on organic farms. The application of organic chemicals for disease control is often a last resort and regulated while biological control is still not readily available. The use of compost extracts presents a simple, inexpensive and potentially effective method to supplement on-farm disease management.

The effectiveness of using composts for disease control, particularly against fungal pathogens, has been studied extensively[1,2]. Composts of various kinds have been used to reduce the incidence of *Pythium* and *Rhizoctonia* in a variety of vegetables and fruits[3,4]. These results have led to further work using filtered extracts of composts. In some cases, the compost extracts were even more effective at controlling disease than conventional pesticides[5]. Stindt and Weltzien[6] at the University of Bonn achieved effective control of *Botrytis cinerea* in strawberries as well as blight in potatoes. Similarly, powdery mildew and root rot were significantly reduced in peas and beets in other trials in Germany[7]. The results of studies on compost extracts have been variable and seem to be crop and region specific, amongst other factors.

Project leader:
Sylvia Welke,
North Okanagan Organic Association

Co-investigator:
Lena Armstrong, field assistant.

Cooperating growers:
Hermann and Louise Bruns
Wildflight Farm, Mara, BC

Additional support:
North Okanagan Organic Association

OFRF support: $3,945

Project period: 1999

Therefore, a study was undertaken to look at the effectiveness of disease control with compost extracts on some cash crops in the Southern Interior of British Columbia.

Project Objectives

- To determine which compost extract is more effective in reducing disease in strawberries, lettuce, broccoli and leeks;
- To identify the point at which application of the compost extracts are more effective.

Experimental Methods

General description of study site

The trials took place at Wildflight Farm located in the floodplain of the Shuswap River near Mara in the North Okanagan region of British Columbia. The annual rainfall of the area is approximately 1,300 mm [51 in] with warm, humid summers. The plots were established on level or slightly undulating land with a soil of a clay loam texture. This particular farm provides produce for the fresh market and a CSA, and thus grows a wide variety of vegetables including brassicas, tomatoes, potatoes, salad greens, onions, garlic, leeks, strawberries, cucurbits, carrots and beets.

Crop planting and other details

Strawberries were established three years prior at recommended densities. Plots were superimposed onto the existing strawberry fields and were ribboned off. Regular cultivations were done to control weeds. No fertilizer or sprays were applied throughout the strawberry season. Similarly, compost extract treatments were superimposed onto existing leek fields. Here the spacing was six inches between plants and about three feet between rows. Leeks were cultivated for weeds several times prior to harvest. Lettuce (“Paris cos” variety) and broccoli (“Pakman” variety) were seeded into trays with the following soilless mix: 4:4:1 of chicken manure compost, peat and vermiculite, respectively. Some dolomitic lime was also added to adjust the pH to 7. Lettuce and broccoli seedlings were raised in the greenhouse until ready for transplanting. During this time, overhead watering was used and no extra fertilizer was added. Lettuce was planted out at 1 ft x 1 ft spacing while broccoli was planted at 1.5 ft x 3 ft spacing.

Compost extract preparation

Cattle compost from Greenleaf (Olds, Alberta) and chicken manure compost from a poultry farm in Armstrong, British Columbia, were used for the extractions. Both composts were actively turned for the first month and then only once a month for the next three months, then cured for another six months. A method of compost tea extraction proposed by researchers at the Wood’s Hole Laboratory was used[8]. This resulted in an 8:1 water-to-compost dilution. Water was added to the respective composts (cattle and chicken) and the mixture was stirred for about ten minutes every day of the week-long extraction period. The extract was filtered through several cheesecloths, stored outside away from sunlight until used on crops.

Application details

The compost extract was applied with a backpack sprayer that was rinsed thoroughly with water before and after each type of extract. Strawberries and leeks were already in the field, while lettuce and broccoli were raised from seed and so were sprayed in the greenhouse, and depending on the treatment, in the field as well. Crops were sprayed as long as weather allowed (i.e. extended wet periods). Sprays were applied at a rate that ensured coverage of all foliage. Approximate application rates are listed below:

❖ ***Strawberries***

• Sprayed twice a week at 1.3 litres/m^2 (0.03 gallons/ft^2)

❖ ***Lettuce***

• In the greenhouse, about 50 ml (2 oz) was applied to one seedling tray (200 plants) prior to setting the lettuce out.

• Initially in the field the same spraying regime as in the greenhouse was continued until the plants were larger.

• Sprayed twice a week at approximately 1 litre/m^2 (0.02 gallons/ ft^2).

❖ ***Broccoli***

• In the greenhouse, about 50 ml (2 oz) was applied to one seedling tray (90 plants) prior to setting the broccoli out.

• Sprayed twice a week at approximately 0.9 litres/m^2 (0.02 gallons/ft^2).

❖ ***Leeks***

• Sprayed twice a week at about 0.90 litres/m^2 (0.02 gallons/ft^2)

Plot layout and treatments

Strawberries, lettuce and broccoli trials were all laid out in a completely randomized design while the leek trial was a randomized complete block design. Each treatment was repeated four times within the experimental plot. The following treatments were either imposed on existing plants in the field (strawberries and leeks) or applied in the greenhouse:

Strawberries and leeks

a. cattle manure compost extract
b. chicken manure compost extract
c. water
d. control (no extract or water)

Lettuce and broccoli

a. cattle manure compost extract (applied in the greenhouse only)
b. cattle manure compost extract (applied in the greenhouse and in the field)
c. cattle manure compost extract (applied only in the field)
d. chicken manure compost extract (applied in the greenhouse only)
e. chicken manure compost extract (applied in the greenhouse and in the field)
f. chicken manure compost extract (applied only in the field)
g. water only (applied in the greenhouse and in the field)
h. control (nothing applied)

Measurements

Strawberries

The number and weight of ripe and uninfected, marketable strawberries were taken every two to three days for the length of the harvest (approximately one month, from June 18, 1999 to July 16, 1999). A scale of the incidence of *Botrytis cinerea* on the surface of the berries was used. This scale is similar to those used by other researchers investigating *B. cinerea* on strawberries[9,10]:

0 = no infection,
1 = 1-5% berry surface affected
2 = 6-15% berry surface affected
3 = 16-50% berry surface affected
4 = 51-95% berry surface affected

Lettuce

Lettuce was harvested when heads were of marketable size during the August 20 to September 3, 1999 period, generally twice a week. The weight before and after trimming infected leaves off the head was recorded. Both lettuce bottom rot *(Rhizoctonia solani)* and downy mildew *(Bremia lactucae)* were assessed together as total disease affecting the lettuce head. The following disease rating scale was used:

1 = plant infected, but affected leaves were removed with minimal trimming.
2 = moderate infection of wrapper leaves, but infection did not extend into the head (still marketable heads).
3 = extensive infection (little or no marketable head left after infected leaves are removed)[11].

Broccoli

Broccoli was harvested when heads were of marketable size between September 22, 1999 to October 15, 1999. Heads were weighed and the head diameter was measured. The incidence of head rot *(Rhizoctonia solani)* was measured using the following scale[12]:

0 = no disease
1 = 1% surface area affected,
2 = 10% of surface area affected,
3 = 30% of surface area affected
4 = 60% of surface area affected
5 = 100% of surface area affected

Leeks

Leeks were harvested from November 3-9, 1999. Weight after trimming diseased leaves was taken and disease *(Peronospora destructor)* incidence was assessed as present or not present.

Lab analyses

Samples of compost and compost extracts were sent to NorWest Labs in Edmonton and Lethbridge, Alberta, for nutrient and microbiological analyses. At harvest, samples of sprayed foliage from broccoli and leeks were sent to the lab as well.

Results are shown in Tables 1 and 2.

Data analyses

All data were analyzed for normality and heterogeneity of variance prior to an ANOVA. Strawberry and leek data were analyzed as a one-way ANOVA (type of compost) while lettuce and broccoli data was analyzed as a 2-way ANOVA (type of compost and time of application). Significantly different means were separated using Tukey's test. All statistical analyses were done using SAS.

Table 1. Chemical and biological characteristics of compost feedstock used for tea extracts.

Compost	pH	EC (mS/cm)	NH^4+/ NO^3- (%)	Total K (%)	Ca (%)	Na (%)	Total P (%)	Mg (%)	Total S (%)	Fecal coliforms (MPN/g)	Salmonella
Chicken manure compost	6.6	41.43	0.43	1.46	12.5	0.33	0.23	0.85	0.54	< 3	none
Cattle manure compost	7.0	14.15	< 0.02	0.88	0.82	0.12	0.53	0.31	0.18	930	none

Table 2. Chemical and biological characteristics of compost tea extracts.

Compost tea extract	pH	E.C. (dS/cm)	Nitrate (mg/L)	K	Ca (ppm)	Na	Mg (ppm)	SO_4	Fecal coliforms (CFU/100ml)	Salmonella
Chicken manure tea extract	7.33	2.47	154	409	61.3	83.2	117	72.6	80	none
Cattle manure tea extract	7.57	0.51	3.01	130	9.13	17.7	7.86	1.17	3500	none

Results

Compost and compost tea analysis

The analyses yielded few surprising results. Both cattle manure compost and its extract had higher fecal coliforn counts, yet these were still low enough to fall within acceptable limits and were not detected in the crops tested.

Strawberries

The number of berries harvested per harvest period varied between a low of 17 early in the season to 186 at peak harvest. There was a trend of greater berry yields with the application of cattle compost extract compared to the control and chicken compost extracts, although this difference was only significant at the 0.10 alpha level and only at certain harvest dates (Fig. 1). Applications of cattle compost extract and water yielded similar berry weights but were often higher than the control. Berries treated with extracts from chicken manure compost generally yielded less than all other treatments. The percentage of berries with no surface rot was not significantly different among treatments, although in the first half of the harvest, the control plots generally had fewer healthy berries (class=0) compared to sprayed plots. Berries infected with *Botrytis* in any of the other disease classes were similar with application of compost extracts, water or no application at all.

Lettuce

At every harvest, two to three lettuce heads were sampled. There was no consistent trend in either lettuce weight harvested (after trimming off diseased leaves) or in disease incidence with compost extract application. In fact, the control had higher average lettuce harvest weights compared to other treatments while plots sprayed with cattle compost extract had the lowest. (F=2.66, P=0.05) (Fig. 2). Greenhouse-only application of extracts produced heavier lettuce heads with lower disease incidence compared to application only in the field or both in the field and in the greenhouse (Fig. 3.). The type of compost extract and the time of application did not have an effect on any other variables measured for lettuce.

Broccoli

Broccoli heads were harvested when they were of marketable size; two to three heads early in the season and four to six heads during peak harvest time. The effect of compost extract type and application time was analyzed over the entire broccoli harvest period and was also separated into and analyzed by two harvest dates, early and late. No significant differences were found with respect to compost extract type at any time yet there were interactions between compost type and application time. The application of cattle compost extract generally increased the weight of marketable heads compared to other treatments and the control (Fig. 4). This was particularly true when cattle compost extract was applied in the field only (F=4.53, P=0.024).

Both the control and the application of water resulted in lower average broccoli head weights. Similar effects of the cattle compost was observed for broccoli head diameter (F=3.05, P=0.07). The percentage of head rot was not significantly different among treatments, however, broccoli in control plots had a lower average percentage of rot (Table 3).

There was no clear effect of time of compost extract application, yet applying the extracts only in the field or only in the greenhouse resulted in higher average head weight compared to application at both times (Table 3). In contrast, head diameter was generally higher with application at both times. A significantly lower percentage of head rot was observed when extracts and water were only applied in the greenhouse (F=3.76, P=0.05).

Leeks

The month before harvest and the harvest period of leek was distinctly wet. The extended periods of rain made extract application difficult and the

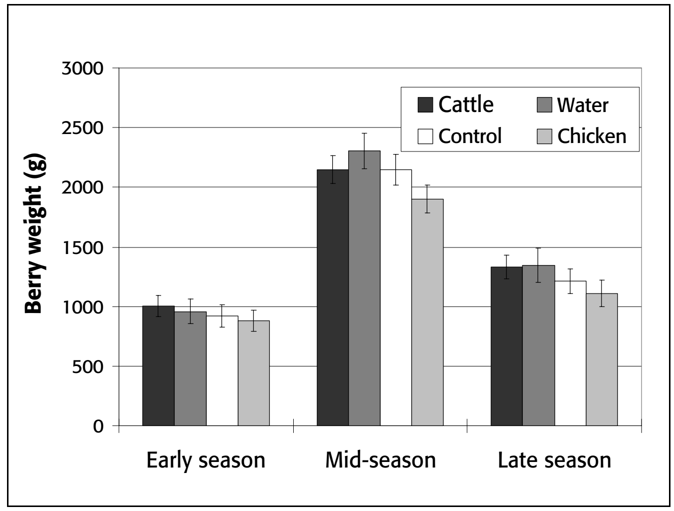

Fig. 1. Strawberry weight from plots sprayed with cattle and chicken compost extracts, water and no application of sprays over a 1 month harvest period. Mara, British Columbia. 1999.

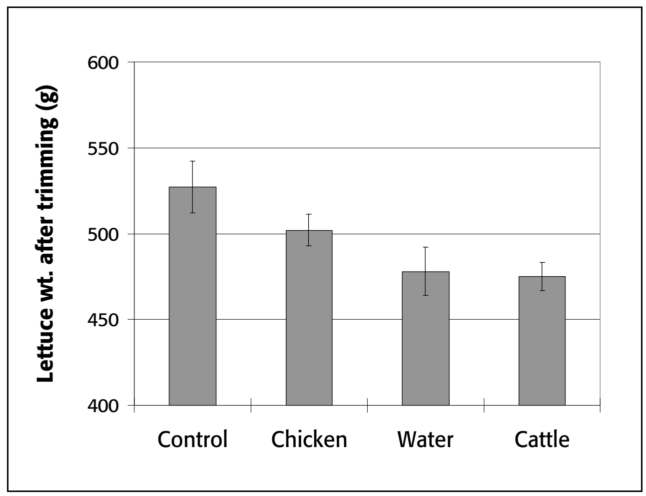

Fig. 2. Lettuce head weights with compost extract and water application compared to control plots. Mara, British Columbia. 1999.

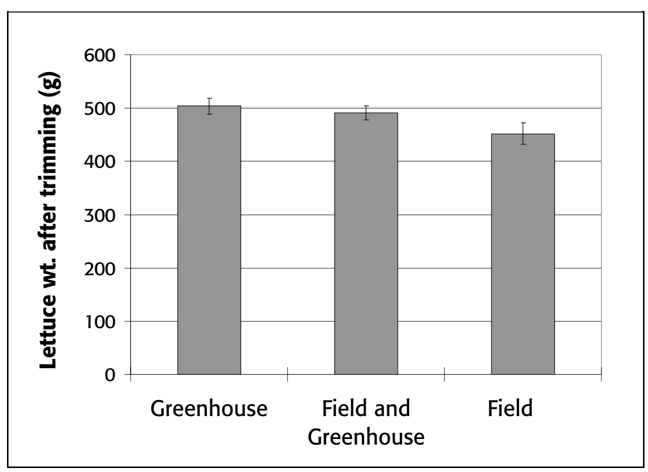

Fig. 3. Lettuce head weights at different times of compost extract application. Mara, British Columbia. 1999.

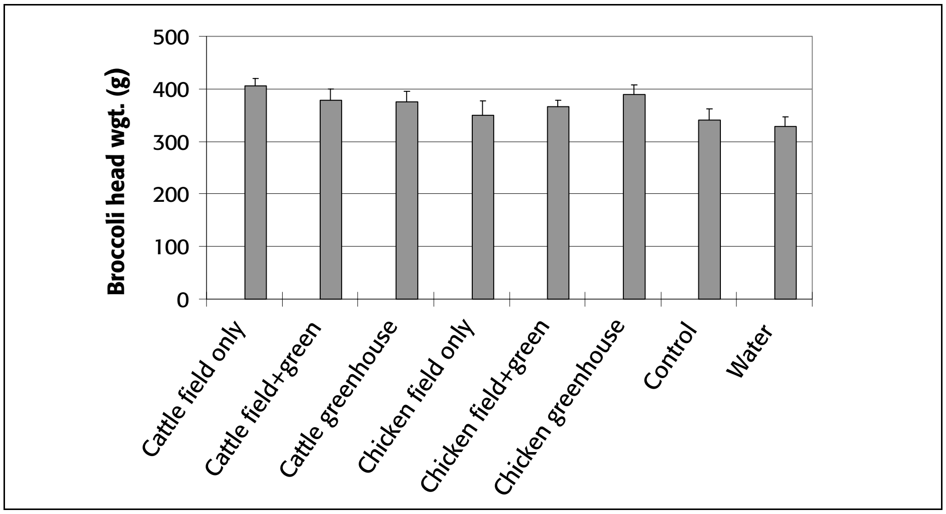

Fig. 4. Effect of compost tea extract application and application time on broccoli weight. Mara, BC. 1999.

crop was only sprayed when weather conditions allowed (8 times in October), rather than twice a week. Leeks were harvested over a period of a week (whenever there was a break in the rain). Approximately 30 leeks were harvested per plot. There were no significant differences in the various treatments in terms of leek weight after trimming diseased leaves. As seen with the other crops, the application of chicken compost extract generally resulted in lower leek weights (Fig. 5). No other trends were observed in the incidence of disease with the different treatments.

Table 3. Effect of compost tea applications on broccoli head rot.

Compost type	Head rot (%)
Control	1.1 (0.6)
Cattle	2.0 (0.8)
Chicken	2.6 (0.8)
Water	5.5 (3.7)

Microbiological analyses of plant leaves after compost extract application

Samples of broccoli and leek were sent away for microbiological analysis. No Salmonella was detected on any of these samples. Total and fecal coliforms were less than 3 MPN/g of broccoli and leek that received cattle compost extract while total and fecal coliforms were 3 and 43 MPN/g (Most Probable Number/gram) for broccoli and leek tissue sprayed with chicken compost extract, respectively.

Discussion

The effects of compost extract application were not consistent across all crops. Yet, some trends did emerge. Extracts from cattle manure compost were effective in increasing marketable number and weights of strawberries. The same extract also increased the weight of broccoli heads. Lettuce and leeks did not show any increased harvest weights or reduced disease incidence as a result of cattle compost extract application. Crops that received applications of chicken compost extracts had lower average harvest weights after diseased parts were removed, except for lettuce. It is possible that the chicken compost extract had some microorganisms associated with it or metabolites thereof that may have further contributed to disease progression or had some other negative effect on plant growth. It is also not clear why the cattle compost extract would have had a similar effect to water spray, unless after some storage time, the extract lost its 'potency' and had attributes more similar to the water treatment.

Table 4. Effect of application time on broccoli head weight, diameter and percentage of head rot.
(Standard error shown in parentheses.)

Application time	Broccoli head wt. (g)	Diameter (cm)	Percentage rot
Field only	390 (14)	15.7 (0.4)	3.6 (1)
Greenhouse only	383 (18)	15.7 (0.3)	0.6 (1)
Greenhouse and field	343 (14)	18.2 (2.8)	2.9 (1)

Disease incidence in strawberries and broccoli did not vary significantly among plots, yet compost applications often resulted in a greater average percentage of healthy crops compared to the control. This seems to indicate that there was some effect either related simply to the spraying of something liquid or to something associated with the extracts. Lettuce and leeks, however, did not show any clear response to compost extract application. Possibly, if compost extracts are effective as a result of an induced defense reaction of the plant as suggested by Samerski and Weltzien[13], lettuce and leeks may be crops that are not readily induced in this way. This study also lends support to the idea that different crops respond differently to extracts from a variety of sources (e.g. lettuce did not react to cattle extract as did the other crops).

The dilution of extracts in this study was 1:8 from the original compost; a recipe based on various research literature[8,14]. It is possible that this was too dilute for a consistent, significant effect. In fact, researchers have found that dilutions of extracts can reduce disease inhibition dramatically[9,14]. Compost extract incubation time also appears to be a variable in their effectiveness against disease. Urban and Trankner[15] found that 24 hour extracts from horse and cattle manure composts effectively controlled gray mold in beans. Others have only found disease suppression after an extraction period ranging from 7 to 14 days[9,16]. Some researchers suggest that compost extracts lose their efficacy if they are not used within about one week of preparation[17]. In this study, extracts were prepared in larger batches, extracted over a one week period and were used up to three weeks after preparation. It is possible that the mechanism responsible for inhibiting disease was much reduced as the compost extract 'aged'. This phenomenon seems to coincide with increased berry weights early on (when the extracts were freshly prepared) with cattle compost extract applica-

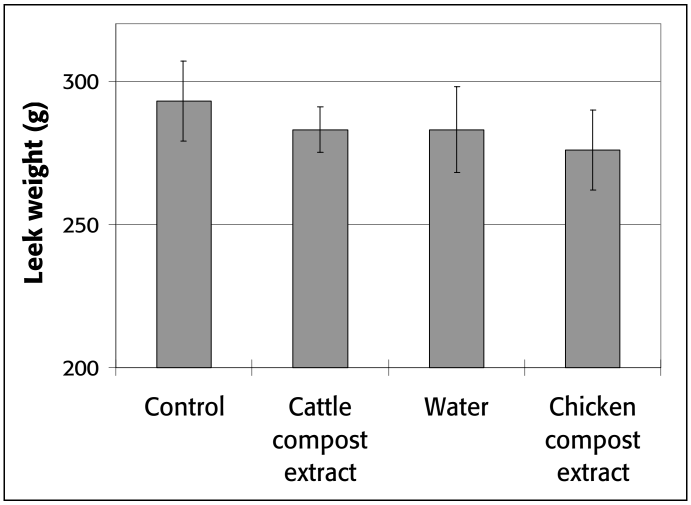

Fig. 5. Effect of applied compost tea extracts and water on leek weights compared to control plots. Mara, BC. 1999.

tion; this was not evident later on.

There appears to be some controversy about how extracts are prepared, anaerobically or aerobically. Cronin[14] and coworkers, for instance, found that anaerobically prepared extracts from spent mushroom substrate were much more effective at inhibiting apple scab than aerobically treated extracts. Weltzien[1] and Brinton[8] also promote the anaerobic method of compost extract preparation. These researchers suggest that the likely disease-suppressive effect is a result of a metabolite produced by anaerobic microorganisms in the extract[14]. In contrast, there is also evidence that indicates that aerobically produced compost extracts are much more effective[18]. Microbiological studies have also shown that aerobic microbes dominate compost[2]. The method used in this experiment was largely anaerobic with only occasional stirring during the extraction period. If, indeed, it is an aerobic microbial population that is responsible for disease suppression, then the extracts in this study would have been relatively ineffective.

Given that this growing season was unusually cool and wet, it is possible that populations of pathogens were favored and could easily out compete any beneficial organisms associated with the extracts. High pathogen populations could also be less impacted by inhibitory substances produced by organisms in the extracts.

The effectiveness of compost extracts appears to depend on many factors including method of preparation, extraction time, compost used and crop to which they are applied. Consistency and maturity of the compost to be extracted are yet more variables. Evaluation is necessary on specific crops and specific disease organisms over a period of several years to account for year to year variations in weather which can significantly influence disease dynamics. We recommend that at least another season is required to follow up on these initial results and to focus on strawberries and broccoli. A repeat of the initial experiment is necessary but we also suggest incorporating another extract dilution, an aerobically prepared extract and the use of only "fresh" compost extracts.

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Sylvia Welke's complete project report (Project #99-31) is 10 pages, including 8 figures. Copies may be obtained from OFRF or by visiting our website at www.ofrf.org.

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Impact of Disease Suppressive Composts on Organic Vegetable Quality, Composition and Yield

Anusuya Rangarajan

Numerous root rot diseases are widely distributed and cause severe yield losses on many vegetable crops grown in New York State and the northeast region of the US, including beans, table beets, cabbage, peas, sweet corn, lettuce, carrots, onions, tomato, potato, several cucurbits and others[1]. Control of these diseases has traditionally depended upon rotations and soil quality improvement strategies. One characteristic of compost which is receiving much attention is the observed suppression of soil-borne diseases in crops grown on compost-amended soils. Although organic systems have been shown to have some degree of suppressive soils, use of spring-applied highly suppressive compost may decrease the severity of root rot diseases, particularly during cooler, wet weather characteristic of the Northeast.

The primary mode of action of compost in disease suppression has been shown to be the enhanced microbial biomass and activity, which contributes to increased microbial antagonism to pathogens around plant roots. Disease suppressiveness of compost-amended soils may also be partially explained by enhanced nutrient supply and improved soil physical properties. Different compost types as well as different batches of one compost may vary in disease suppressiveness, and the suppressiveness of a batch may change over time [2,3,4]. The degree of curing or compost maturity has been shown to be important to maximize suppressive benefits in other systems[2,4,5]. Improperly or inadequately cured compost materials may lack disease suppressive qualities. Prior to promoting the use of any compost material based upon disease suppressive quality, more baseline information on the duration and nature of the suppressiveness is required for growers to make sound management decisions.

There are several biological and chemical indicators of compost maturity and suppressiveness[5,6,7], but these measurements require time and special equipment. A test has been developed to measure compost maturity within a short time frame (Woods End Research Laboratory, Maine)[8]. This test may also have some predictive value for ranking or comparing composts for disease suppressiveness, but this has not been evaluated. Such a tool may be very useful to growers for monitoring composts for optimal maturity to maximize most suppressiveness. Compost age and suppressiveness could be optimized to prevent N immobilization and to enhance likelihood of healthy, vigorous seedling production.

Organic systems, which already use regular inputs of green plant and animal manures, have been shown to have disease suppressive soils[5,11]. Adding highly suppressive compost may not further reduce disease incidence in these systems. Little information is available on the degree of suppressiveness of organically managed soils and there are no reports of changes in suppressiveness of these soils with addition of highly suppressive composts.

Principal investigator:
Anusuya Rangarajan, Asst. Professor, Cornell University, Ithaca, NY

Collaborators:
Will Brinton, PhD., Woods End Research Laboratory, Mt. Vernon, ME
Aaron Gabriel, Cornell Coop. Ext.-Washington Cty.; certified organic vegetable farmer
Lee Stivers, Cornell Coop. Ext.-Monroe Cty.
Brian Caldwell, Cornell Coop. Ext.-Tioga Cty.

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Project Objectives

- Analyze several animal manure-based, organic-approved compost products for suppression of important soil-borne pathogens of vegetable crops in the Northeast.
- Determine applicability of a farmer-based test kit for assessment of compost maturity to predict suppressiveness.
- Evaluate compost effects on plant stand and crop composition.
- Determine changes in microbial activity, disease suppressiveness and soil nitrate nitrogen of organically managed soils after addition of a compost.

Table 1. Compost tested in greenhouse and field experiments, 1997.

Compost	Description	pH	Moisture (%)	Organic Matter (%)	Total N (%)	Total C (%)	C:N ratio
A	farm made, mixed	4.80	70	81	2.8	39.5	14
B	dairy manure, commercial	7.82	6	14	0.6	8.6	14
C	poultry, no added carbon	7.37	6	65	6.1	30.0	5
D	poultry, added sawdust	8.77	4	78	2.0	28.7	14
E	dairy manure, commercial	7.82	30	36	1.5	11.8	14

Materials and Methods

Compost materials and testing. Five compost products were selected for field and greenhouse experiments based on collaborating organic grower' preferences. One compost was grower-made and the rest were certified and commercially available (Table 1). The grower compost was animal manure and food-waste based. Composts were analyzed for nutrient composition through the Cornell Nutrient Analysis Laboratories. Microbial activity was determined by measuring the rate of hydrolysis of fluorescein diacetate (FDA)[7], which has been correlated with compost disease suppressiveness[3,5]. Compost maturity was estimated using Wood's End Lab's "Solvita" Compost Maturity Test Kit, which esti-

Table 2. Interpretation guide provided with Solvita Compost Maturity Test Kit. (Information summarized from materials supplied by Wood's End Laboratory.)

Solvita Test Result	Approximate Stage of Composting Process
1	Fresh, raw compost; new mix; extremely high rate of decomposition; very odorous; high in volatile organic acids.
2	Very active decomposition, moderately fresh compost; very high respiration rate; needs intense aeration.
3	Active compost; young materials; high respiration rate; still needs intensive management.
4	Compost in medium active stage of decomposition; may be ready for curing.
5	Compost is moving past the active phase of decomposition; ready for curing, reduced need for intensive mgmt.
6	Aeration needs reduced; curing; significantly reduced management needed.
7	Well-matured, aged compost; cured; ready for most uses.
8	Highly matured compost; well aged; like soil; ready for most uses.

mates maturity based on respiration rate. Maturity is ranked from 1 (immature) to 8 (highly mature) (Table 2). Results from the FDA hydrolysis and the test kit were compared to determine whether the kit could suggest a suppressive compost.

Field experiments. Three organic farm, four conventional farm and two research station trials were conducted to explore the impact of composts on soil microbial activity and disease suppression.

Sites were selected based on historic problems with soil borne diseases, to examine compost effects on crop stand, tissue analysis and yield and soil nitrate levels. Compost application rates were based on grower practices. No attempt was made to control for differences in nitrogen contribution of products, since the primary interest was on effect of compost on soil microbial activity. However, soil nitrate nitrogen was also determined to assess potential differences between composted and non-composted treatments.

Two cooperating organic farms were located in the southern New York (Tompkins and Tioga Counties) for the following trials:

- **Farm A:** Grower-made compost 'A', (Table 1) was applied to one-half of the plots at a rate of 15 T/A. Four rows of spinach were seeded after one week, on June 15.
- **Farm B:** A commercial dairy manure compost 'B' (Table 1) was applied to one-half of the plots at a rate of 2.5 T/A. Four rows of beans were seeded five days later, on June 24.

Plots at each site measured 12'x 15' and four replicates of a composted and non-composted control were used. Stand counts and leaf tissue samples were taken from eight feet of the middle two rows in each plot of the bean trial on July 10 and from five feet of the middle two rows in the spinach trial on July 3. Leaf samples were dried and analyzed for total nitrogen and mineral composition (Cornell ICP Laboratory). Soils were sampled from all plots on July 16 and analyzed for nitrate levels and microbial activity.

The third grower trial took place at an organic farm in western New York:

- **Farm C:** Two commercial poultry compost products 'C', 'D' (Table 1), were applied at a rate of 2 T/A, one week before seeding. Beets were seeded one week later into these plots on June 2.

Stand counts and leaf tissue samples were taken July 8. Soils were sampled on three dates- June 2, July 7, and July 23, and analyzed for nitrate nitrogen concentrations. On June 2 and July 23, total microbial activity in the top 2 inches of soil was evaluated, using the same enzymatic assay applied to the composts.

A third poultry compost trial was established at the Cornell Vegetable Research Farm in Geneva, NY:

- **Farm D:** Poultry composts 'C' and 'D' were applied at 4 T/A and compared to a no compost control. These were the same composts used at the organic beet trial, but at twice the rate. Beets were seeded on June 12.

Soil and tissue samples were taken on July 23. At harvest (September 27), final plant stand, yield and incidence of root rot were recorded.

On two conventionally managed research farms, the poultry compost 'C' (Table 1) was examined for effects on soilborne disease and yield. This product had previously reduced levels of *Rhizoctonia* root rot on beets. To examine residual compost effects from previous years, a research site was identified that had received an application of this compost in 1996, at the Cornell Vegetable Research

Table 3. Plant stand and tissue analysis from plants grown on composted and non-composted plots. Farms A, B and C were organically managed and Farm D was a Cornell Research Farm.

Farm	Crop	Treatment[1]	Plant stand[2] (num/ft)	Tissue analysis (%)[3] N	P	K	CA	Mg	Na (ppm)	MN (ppm)
A	spinach	Compost A	2.9 a	3.31 a	0.54 a	7.33 a	1.25 a	0.79 b	306 a	70 a
		No compost	1.9 b	3.36 b	0.50 b	7.84 a	1.36 a	0.91 a	374 a	66 a
B	beans	Compost B	5.3 a	3.88 a	0.34 a	4.55 a	2.55 a	0.44 a	78 a	128 a
		No compost	3.9 b	3.74 a	0.33 a	4.22 a	2.62 a	0.46 a	72 a	127 a
C	beets	Compost C	9.25 a	3.46 a	0.53 a	8.93 a	1.27 a	1.53 a	5862 a	72 a
		Compost D	8.5 a	2.84 a	0.55 a	8.48 a	1.28 a	1.4 a	6222 a	74 a
		No compost	10.5 a	3.01 a	0.65 a	8.99 a	1.33 a	1.44 a	3724 b	72 a
D	beets	Compost C	13.1 b	4.32 a	0.43 a	5.05 b	1.79 a	1.1 a	9163 a	148 a
		Compost D	17.1 a	3.72 b	0.41 a	6.05 a	1.81 a	1.03 a	9094 a	136 a
		No Compost	16.1 ab	3.85 b	0.38 a	5.20 b	1.99 a	1.14 a	5363 b	149 a

[1] Spinach received 15 T/A compost and beans received 2.5 T/A. Beets on farm C received 2 T/A of each product and Farm D received 4 T/A of each products. Control (no compost) treatments received no supplemental N on organic farms. On farm D, control treatments received 120 lb/A N as ammonium nitrate.

[2] Numbers from same farm and in same column followed by the sam letter are not significantly different at the 5% level.

[3] Data for macronutrients is based upon a percent of dry matter or part per million for micronutrients. Analysis of other micronutrients indicated no significant differences among treatments.

Farm in Freeville, NY. In 1996, poultry compost 'C' had been applied to a 12-ft band (rate of 4 T/A) across the center of each plot, with control (non-composted) sections adjacent to either side of the band. This site was selected for the following trial:

- Compost 'C' was applied to one half of the original band, at a rate of 4 T/A and mixed into the top 2 inches of soil.

This design allowed replicated comparison of three treatments: a no compost control, 1996 compost application, and 1996+1997 compost applications.

Snap beans were direct-seeded on June 10, across the entire experiment. Soils were sampled mid season (July) to determine microbial activity and soil nitrate concentrations. Snap beans were harvested August 11, and above ground biomass and bean yield were recorded. Roots were evaluated for disease severity using a 1 to 9 (9=severe root rot) scale (Abawi, personal communication). Naturally occurring pathogen populations provided the disease pressure in this experiment, as in the on-farm trials.

Soil nitrate nitrogen and microbial activity analysis. On a soil sampling date, ten soil cores (8 inches deep) from each plot were taken. Additional cores of the top 2 inches were taken for microbial activity tests. Soil nitrate was extracted and analyzed using standard laboratory procedures and results were represented as concentration of nitrate nitrogen in dry soil.

The microbial activity of soil and compost was estimated by the rate of enzymatic hydrolysis of fluorescein diacetate (FDA) by soil microorganisms[7]. Soil or compost (.7 g fresh weight) was incubated in phosphate buffer for exactly 40 minutes. Enzymes present in the soil or compost cleave FDA to produce a yellow-green compound. The color intensity produced over the incubation period was compared to known concentrations of cleaved FDA to provide an estimate of the rate of microbial enzymatic activity. Results were presented as micrograms of FDA hydrolyzed per minute per gram dry weight of soil or compost ($ug\text{-}min^{-1}\text{-}g^{-1}$). Higher rates of microbial activity resulted in higher FDA hydrolysis values.

Greenhouse Disease Evaluations. Three commercially available compost products-two poultry manure based (C, D) and one dairy manure based (E) were screened for suppressiveness to *Pythium* and *Rhizoctonia* using a greenhouse disease bioassay. A rate equivalent to that used in field trials (4 T/A) was calculated to be 5% v/v compost:peat mix. Composts and the peat-based media were mixed thoroughly, and then subsamples were either autoclaved on three consecutive days (to kill media microorganisms) or held moist until beginning the bioassay. Sterilized composts allow isolation of compost nutrient or physical effects on plant growth and disease incidence. Both pathogens were grown on sterilized wheat kernels for 6 days, prior to commencing the trial. Just prior to seeding, the autoclaved and non-autoclaved soil media were inoculated with one of the pathogens, by grinding the infected wheat kernels in a food mill and dispersing evenly throughout the soil/compost mixes. Seeds of both cucumber and beets were sown into these mixes. Plant emergence, appearance and disease symptoms were recorded once per week.

At the end of the 4-week experiment, plant fresh and dry weights (above ground portion only) were measured. Soil nitrate-N, microbial activity, soluble salts, and pH were also recorded at the end of the trial. A second greenhouse experiment was conducted to evaluate the impact of two 'field-equivalent' rates of compost on beet germination and early growth. A soil mix (1:1 v/v peat:field soil) was amended with compost at two rates, equivalent to 2 or 4 T/A. No-compost mix was used for a control. One half of the pots were inoculated with *Rhizoctonia* as described above. Ten beet seeds were placed in each pot and plant stand was recorded every two to three days for four weeks.

Results and Discussion

Compost analyses. Compost analysis showed that the tested products varied in both maturity and stability. In commercial composts 'B' through 'E', the composting process was carefully monitored, and uniformity of the products over several batches was high.

The poultry compost 'C' had no carbon added during composting, as evidenced by the low C:N ratio and a strong ammonia smell to the product. However, the higher nutrient density of this compost (equivalent to a 3-4-5 N-P-K fertilizer) and observed disease suppression in the field made this product appealing to both organic and conventional vegetable growers and fostered support for this research effort.

Poultry compost 'D' did have added sawdust during production, no odor, and had been cured for 3 months.

Composts 'B' and 'E' were both dairy-manure based. Compost 'B' was purchased bagged product with little known about the production history or length of curing.

Compost 'E' was widely used by NY organic growers. Results from testing this product in greenhouse studies are presented.

Nitrogen contributions from composts were not controlled in these studies. When added to field trials, the total nitrogen supplied by the composts were as follows:

- Compost 'A' added at 15 T/A provided 840 lb N;
- Compost 'B' supplied at 2 T/A provided 24 lb N;
- Compost 'C' added at 2 or 4 T/A provided 244 or 488 lb N;
- Compost 'D' provided 80 or 160 lb N.

Not all of this N was available to the crop; estimates of N availability within the first year of compost application will vary by the compost feedstock and maturity, and range from 5 to 50%. At this high end, composts are still considered immature or unstable, and may be better described as 'partially stabilized manure.'

Seven compost products were analyzed for microbial activity, using the FDA hydrolysis method, and results ranged from 2 to 18 $ug\text{-}min^{-1}g^{-1}$ dry wt activity. The rate of FDA hydrolysis from composts would generally be expected to be higher than those found in soils. Research with peat-based potting mixes suggested a minimum FDA rate 3.2 $ug\text{-}min^{-1}g^{-1}$ dry wt for suppressiveness to *Pythium spp.*[10]. Based on this measure, all but three of these composts could be considered as potentially disease suppressive, provided this threshold would apply to straight compost as well. In potting mixes, the percentage of compost on a volume basis is generally less than 25%. Solvita test kit results for these composts ranged from 1 to 6. Based upon interpretation information provided with the kit (Table 2), none of the composts was considered 'finished'. Several were still very active and others were in the curing phase. In our studies, composts were grouped as either highly active (Solvita scores from 1 to 3) or approaching curing (score 5 to 6).

A comparison of results from microbial activity (FDA) and the Solvita Compost Maturity Test suggested that there may be potential to use the test kit to estimate suppressiveness (data not shown). However, results from these studies were clustered in two ranges of the Solvita test. Additional comparisons of composts of different maturity levels are required. These results were very preliminary and also dependent on the good correlation between microbial activity as indicated by FDA and actual disease suppression in bioassays. Once a compost product is characterized for effects on various soil borne diseases, however, this kit may be useful to track both maturity and potential disease suppressiveness.

Field Experiments.

Plant stand, disease incidence and tissue analysis. Late-season disease pressure was very low in the on-farm trials, despite selection of fields with historical soil-borne disease problems. Evaluating crop stands provided a measure of early season disease pressure as well as seed-bed soil quality for crop emergence. Compost applications significantly increased plant stands in the spinach and bean. on-farm trials (Table 3). Although a low rate (2.5 T/A) of dairy manure compost 'B' was applied, stands of beans were improved by 25%. A low rate of poultry composts 'C' and 'D' did not improve stands of organic beets. When poultry compost 'C' was applied at a higher rate (4 T/A) to conventionally grown beets, stands were reduced compared to other treatments, suggesting potential salt damage.

Only the conventional bean experiment supported previous observations of reduced disease pressure with compost application in the field. A high rate (4 T/A) of poultry compost 'C' applied to conventionally managed beans did not affect plant stand significantly. Previous applications of the same product one year earlier also did not affect stand. However, the incidence of root rot in this experiment was significantly reduced by 1997 spring compost applications (data not shown).

Mid-season tissue analysis of spinach from the organic farm 'A' did indicate some statistically significant differences among composted and non-composted plots, however these differences were minor (Table 3). There were no significant differences among treatments in the on-farm bean experiment. Beet tops were significantly higher in sodium in composted plots in both the on-farm and research station experiments. Beets respond positively to sodium applications, and historically sodium was applied to partially substitute for potassium fertilizers. Poultry composts contain higher sodium than other animal manure composts. At both the low (2 T/A) and high (4 T/A) rates, sodium concentration in beet leaves was increased.

Soil nitrate nitrogen and microbial activity levels. Compost additions significantly increased midseason soil nitrate nitrogen measurements only at farm C, in organic beets. In this case, addition of the high N poultry compost 'C 'contributed to higher mid-season soil nitrate N concentrations, up to ten times the levels of other treatments. Differences in soil nitrate N among the treatments on this farm continued to later in the season (data not shown). At the first sample date, there was no significant difference in soil nitrate N under the three treatments. By mid-season, soil nitrate levels under the control and compost 'D' treatments at this farm were low (3 to 5 lb/A) and may have become growth limiting. However, by the end of the season (soil sampling day 3), high levels of nitrate N were still detected under compost 'C', and could contribute to leaching losses of N from this treatment. The more stable poultry compost 'D' did not contribute to excess soil nitrate N.

Soil microbial activities at the midseason sampling date also were not affected by compost additions, except at farm A (Table 4). All composts had FDA values above a threshold of 3.2 $ug\text{-}min^{-1}\text{-}g^{-1}$ suggested for suppressiveness[10] and were applied and incorporated into the surface 3 inches of soil. On organic farm C, soil samples were also taken on June 2 and analyzed for microbial activity. At this earlier planting date, differences were detected in microbial activity among the three treatments, but these were not statistically significant at levels desirable for research. Plots with no compost averaged 1.47 $ug\text{-}min^{-1}\text{-}g^{-1}$, those with high N poultry compost 'C' averaged 1.95 $ug\text{-}min^{-1}\text{-}g^{-1}$ and those with poultry compost 'D' averaged 1.54 $ug\text{-}min^{-1}\text{-}g^{-1}$. Microbial activity of

Table 4. Soil nitrate nitrogen and microbial activity levels at midseason sampling of composted and non-composted fields at four farms. New York. 1997.

Farm	Crop	Treatment[1]	Soil NO_3-N[2] (lb/a)	FDA[3] (ug/min/g)
A	Spinach	Compost a	15 a[4]	1.05 a
		No compost	15 a	0.73 b
B	Beans	Compost b	42 a	1.12 a
		No compost	32 a	0.99 a
C	Beets	Compost c	31 a	0.84 a
		Compost d	3 b	0.88 a
		No compost	5 b	0.89 a
D	Beets	Compost c	42 a	0.54 a
		Compost d	28 a	0.57 a
		No compost	52 a	0.57 a

1 Spinach received 15 T/A compost; beans received2.5 T/A; beets on farm C received 2 T/A; beets on farm D received 4 T/A compost.

2 Farm A/spinach soil sampled 7/16/97; Farm B/bean soil sampled 7/23/97; Farm C beet soil sampled 7/23/97; Farm D beet soil sampled 7/23/97. Values for spinach and beans represent mean of four replicate samples, each comprised of eight cores taken to an 8 in. depth. Beet soil nitrate values from mean of three replicates.

3 FDA values from surface 2 inches of soil. Values represent mean of three or four replicates.

4 Numbers in same group and column followed by the same letter are not significantly different at the 5% level.

soils were lower at mid season sampling date (Table 4). The low rates of compost applied may have been insufficient to result in a measurable increase in microbial activity at a midseason test of these soils.

Measurements of microbial activity were higher at all organically managed on-farm trials than at conventionally managed farms. On conventionally managed beet farms with the same soil type and within two miles of organic farm C, soil microbial activities ranged from .43 to .45 ug-min^{-1}-g^{-1}as compared to .84 to .89 ug-min^{-1}-g^{-1} on organic farm C, on the same sampling date. This observation of higher soil microbial activity under organic management systems compared to conventional systems has been previously reported[11].

Crop yields. Crop yields were only recorded for the two beet and the conventional bean experiments.

Marketable yields of beets were significantly higher under the high N poultry compost 'C 'on both farms. Above ground biomass was also higher. Yields in the conventional trial were twice those on the organic farm, however, twice the amount of compost was used at that site. Yield results correlated with the high soil nitrate N associated with this compost 'C'. The poultry compost 'D' also enhanced yields over the control in the research station trial. In beans receiving compost 'C' in 1997, plot yield and individual plant bean yield was significantly increased and total plant weight increased over the control and plots which had received compost in 1996. Despite the potential nutrient carryover from compost applied in 1996, there was no observed yield effect.

Greenhouse Compost Trials. In the initial greenhouse experiment, attempts to establish a high population density of both *Pythium and Rhizoctonia* in the media tested in the greenhouse disease bioassay were unsuccessful. While there was some decreased growth of both beets and cucumbers in pathogen-inoculated soils, there was not the expected 50% reduction in plant number due to these damp-off diseases (data not shown). It is suspected that the wheat-cultured inoculum had too low a population density to adequately colonize the media within the short experimental duration.

However, the various compost treatments had significant effects on plant emergence rates and growth. Two of the tested composts, one poultry ('D') and the other dairy manure ('E') based, enhanced plant emergence rates and growth, particularly if microbial activity was intact (non-sterilized). Both beets and cucumbers had similar final stand counts, but significantly higher fresh and dry weight in non-autoclaved 'D' or 'E' compost based media compared to autoclaved media and the no-compost control. The effect of these two composts was particularly pronounced for cucumbers. The similar plant stands and fresh/dry weights among the autoclaved medias and the control indicated that release of phytotoxic compounds as a result of autoclaving was minimal. Soluble salt levels and nitrate and ammonium-N concentrations did not vary among autoclaved and non-autoclaved mixes of these two composts, and the no-compost control (data not shown).

Those treatments containing poultry compost 'C' were phytotoxic to beet and cucumber growth, resulting in slower emergence rates, and lower stand counts, plant fresh and dry weights than other treatments. Sterilizing the media had no effect on crop response, unlike those observed for the other two composts. The poultry compost 'C' mixes had higher soluble salts and pH compared to other treatments, which contributed to poor plant growth in these treatments.

Because of the observed reductions in *Rhizoctonia* root rot observed in the bean experiment and previous beet research, an additional greenhouse experiment was conducted to explored the effect of the high N poultry compost 'C' on beet emergence and disease resistance to *Rhizoctonia.* This poultry compost provided no reduction in disease incidence in these greenhouse studies. Greater disease losses were observed in compost amended treatments than in non-compost amended treatments. Over the 4 week study, total stand of beets was reduced by 25% in the control, non-compost treatments, as compared to 66% in the treatments receiving the lowest rate of compost. The higher level of compost (equivalent to 4 T/A field rates) reduced germination and plant stands over the experiment. Thus, it appears that this poultry compost product increased beet yield in field trials through a nutrient and not a disease suppressive effect.

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Anusuya Rangarajan's complete project report (Project #97-09) is 29 pages, including 8 tables and 3 figures. Copies may be obtained from OFRF or by visiting our website at www.ofrf.org.

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RESEARCH REVIEW

Efficient Use of Organic Nitrogen Fertilizers

Mark Gaskell

Organic growers generally use cover crops in conjunction with diverse types of organic fertilizer materials for fertility management. While cover crops are an economical source of organic nitrogen and provide additional potential benefits for succeeding crops, time or market constraints and the need to intensively farm high value land may limit the use of cover crops and increase the need to utilize organic fertilizer sources of plant nutrients.

Compost is often the most economical source of pre-plant applied nitrogen, but various factors may limit application of compost as a sole source of nitrogen, and other organic fertilizer sources may be more convenient for side-dress or fertigation. Several types of commercially available nitrogen fertilizer materials are approved for organic certification but little information exists on their optimal management. Little data is available comparing organic fertilizer materials, different modes of application, and economical use for diverse organic vegetable crops.

Costs per unit nitrogen of organic fertilizer materials can vary widely; from approximately $1 per pound of nitrogen for compost to $51 per pound of nitrogen for some liquid organic fertilizers. Greater than 50 fold differences in price per unit nitrogen are quoted for different organic fertilizer materials from commercial supply sources.

Principal investigator:
Mark Gaskell, Farm Advisor, UC-Cooperative Extension, Santa Maria, CA

Collaborators:
Helmut Klauer, General Manager, Nojoqui Farm, Buellton, CA

James Witty and Derek Markolf: laboratory soil extractions, field sampling

OFRF support: $4,840

Additional support: laboratory facilities provided by CalPoly Soils Department

Project period: 1998-1999

Project Objective

■ To develop data on soil nitrogen dynamics and bell pepper yield in response to the application of different types of commercially available organic nitrogen fertilizers.

We conducted the trials on bell peppers, a long-term annual vegetable crop requiring repeated fertilizer application. We compared different rates of pre-plant incorporated application combined with varying additional amounts of side banded, incorporated applications. We measured weekly soil nitrate nitrogen (SNN), plant tissue nitrogen, and bell pepper fruit yield associated with the different types of organic fertilizers at different application rates.

Table 1. Organic fertilizer materials, manufacturer, advertised analysis, and estimated cost per unit nitrogen.

Material	Manufacturer/ Source	Advertised Analysis (% N-P-K)	Cost ($/lb N)
Compost	New Era	(2-1-3)	1.00
Pelleted chicken	Integro	(3.5-1-7)	6.50
Fish meal	Peaceful Valley	(10-6-2)	5.50
Liquid fish	EcoNutrient	(3.4-2-0.5)	6.00
Phytamin 800 (liquid soybean meal formula)*	California Organic/ Peaceful Valley	(7-0-0)	7.50
Feather meal	California Organic	(7-1-7)	5.50
Seabird guano	Verditech	(11-8-2)	6.25

*Phytamin 800 ingredients have changed since this project took place.

Materials and methods

We evaluated seven different organic nitrogen fertilizers during the summer of 1998 on transplanted bell peppers. The trials were conducted at Nojoqui Farm in Santa Barbara Co. near Buellton, CA. The materials evaluated are summarized in Table l.

Each material was applied at rates equivalent to 60, 120 and 180 lbs of N (as commercial product) per acre. Treatments were replicated four times. Field plots consisted of three 40" beds, 20 feet long. Treatments were applied to all three beds in a plot but SNN and yield samples were taken from the center beds only, and thus were buffered from neighboring treatments. All treatments were applied by hand and subsequently incorporated with a cultivator. Pre-plant applications were applied as broadcast applications which were subsequently incorporated and side-dress applications were applied in 6" wide bands 2" - 4" to the side of plant rows and incorporated with cultivating shoes. All plots were sprinkler irrigated.

The materials were applied as:

- **60 lb total N treatment:** 30 lb N pre-transplant (PRE) and 30 lb N at 20 days post transplant (POST);
- **120 total lb N treatment:** 60 lb N PRE and 30 lb N at 20 days POST and 30 lb N at 40 days POST;
- **180 total lb N treatment:** 60 lb N PRE, 30 lb N at 20 days POST, 45 lb N at 40 days POST, and 45 lb N at 70 days POST.

The PRE treatments were applied May 1; side-dress one was applied June 1, side-dress two on June 20 and side-dress three on July 20, 1998. Bell peppers were transplanted on May 14 and the initial SNN sampling was made at transplanting.

To measure SNN, trowel samples were taken down the row and mixed into a small bucket from which the composite sample in each plot was drawn. Samples were transported to the laboratory where they were extracted using 2N KCL according to standard procedures. The KCL extracts were sent to the Division of Agriculture and Natural Resources (DANR) laboratory at the University of California-Davis for nitrate nitrogen determinations.

Results

We measured weekly soil nitrate nitrogen (SNN) over 14 weeks POST, leaf tissue N at week 14, and fresh bell pepper fruit yield for all treatments. Overall, there was frequently a statistically significant increase in SNN with increasing N application rates with each material during a given week. Weekly SNN varied from lows of 4 PPM in the 0 N treated plots to over 80 PPM in feather meal treated plots at the 180 N rate. Highest SNN was often observed in plots treated with feather meal, seabird guano, Phytamin 800, liquid fish, and feather meal at the 180 N rate. Peaks in SNN lagged fertilizer applications by three to four weeks.

Plant tissue N also increased with increasing N application rates, but these increases were only statistically significant with feather meal and seabird guano (data not shown). Total pepper yield increased with increasing N rate with all materials. The different types of materials, while not markedly affecting total pepper yield, did affect early yield and size. *Early yield* and *percent extra large peppers* were the yield traits that varied most among the different fertilizer materials. Highest early yield and largest sizes were observed in feather meal treated plots at the high (180 lb N) rate. The higher early yields and the larger peppers tended to come from those materials such as feather meal, seabird guano, Phytamin, liquid fish,

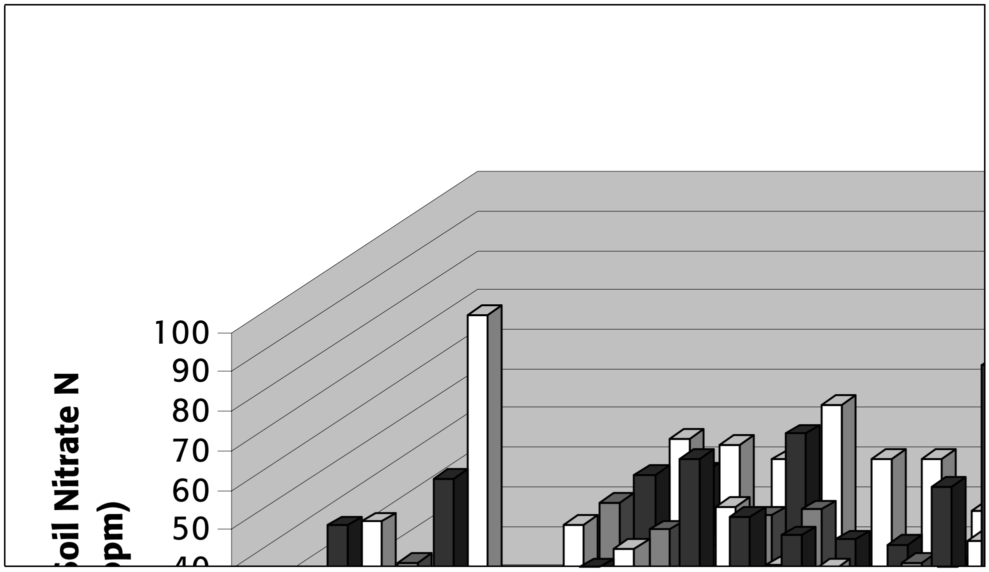

Fig. 1. Weekly residual soil N03-N following application of different organic soil amendments, at 180 lb N application rate. Buellton, CA. 1998.

and fish meal, that had shown higher SNN many weeks. Compost and pelleted chicken manure consistently showed the lowest SNN levels at all levels of applied N. Compost and pelleted chicken manure also produced fewer peppers than the other materials even at the highest N rates.

Weekly SNN, tissue N and yield were all analyzed using analysis of variance (ANOVA) and simple linear regression analyses. The SNN values are generally quite variable in field soils and four replications are the minimum necessary to get reasonably consistent results. The weekly SNN frequently showed statistically significant regression lines with increasing applied N in each treatment. The relationship between SNN and applied N are never extremely close however, as evidenced by correlation coefficients ranging up to 65-70%. The correlation coefficients of SNN on N rate are not always statistically significant across weeks although the means tend to follow similar patterns. The SNN levels from the individual treatments could be distinguished with 95% confidence some weeks but confidence intervals (95%) around the regression lines often overlap due to the high variability. The total harvested yield is not significantly different (P>0.05) among the fertilizer materials. Differences in extra large pepper yield (Table 2) and early pepper yield are more useful for identifying the more promising fertilizer materials.

Table 2. Statistical mean separation of extra large grades of bell peppers fertilized with 180 lb N per acre of the different fertilizer materials.

Material	X-Large pepper yield (lbs / plot)
Feather meal	23.7 a
Phytamin 800	17.1 ab
Liquid fish	16.8 bc
Fish meal	16.7 bc
Seabird guano	16.1 bc
Compost	14.9 bc
Pelleted chicken manure	11.3 bc

Values followed by the same letter are not significantly different (95% confidence) using Fisher's LSD.

Discussion and Conclusions

Figures relating SNN to optimum crop productivity quoted in the scientific literature typically range from 20 to 40 PPM nitrate nitrogen, but little specific data is available for bell peppers or for weekly SNN variability. Results from these trials show higher SNN was associated with higher N application rates with each of the fertilizer materials but even at the highest rates, SNN values do not consistently remain in the range of 20-40 PPM. This may mean that N application rates higher than 180 lbs N per acre are necessary for optimum yield. Higher N rates would be suggested by the fact that highest yields occurred in these trials at the highest N application rates although differences were not always statistically significant. The weekly SNN varied markedly among the materials, and in the consistency of their response (statistical significance). Treatments that frequently showed higher SNN, such as feather meal and seabird guano, also were the only materials to show statistically significant tissue N associated with applied N. Only feather meal stands out in terms of bell pepper yield and then only related to larger pepper sizes and higher early yield. Yields of extra large and early peppers can be important because these typically carry a sales price premium.

The lack of consistent statistically significant (P< 0.05) differences among treatments is not unusual with a variable such as SNN in field soils. However, the relationships and trends are consistent among materials and rates across weeks and this adds to the value of the data. More additional study is certainly needed. Because SNN and yield are highest at the highest application rate it would be valuable to evaluate even higher rates of applied N. It would also be valuable to evaluate the patterns associated with application of these materials during cooler cropping periods.

An economic evaluation of the different materials was conducted at the highest N rate. This evaluation compares gross dollar value of peppers produced (beyond the zero plot yields) per dollar of fertilizer applied. It uses average figures for the different treatments and assumes 50 cents a pound for peppers for the total marketable yield and 75 cents per pound for the early yield plots. These figures were consistent with Nojoqui Farm's prices during the 1998 pepper sales season. These economic analyses are summarized in Figure 2. Compost treated plots at 180 lb N produced highest gross economic return per fertilizer dollar, because the compost had such a dramatic cost advantage over the other materials. The lower productivity of the compost overall was overwhelmed in the economic analysis by the dramatic cost advantage for compost. In this economic analysis we assumed that compost was 2% N (as advertised), 25% moisture, and cost $40 per ton applied. The compost is variable however, and cost per unit value of N for compost may vary. The economic comparison may be dramatically affected by cost and composition of the materials. Further study is needed with different types of management of compost as a fertilizer material. It is unclear whether it may be possible to manage compost material in such a way so as to attain the levels of SNN apparently necessary for optimum bell pepper yield and size.

The variability in composition of organic fertilizer materials is a serious problem limiting their efficient use, but of course growers cannot be expected to analyze every material coming on to the farm. Ideally the data presented here and these types of trials will provide an additional tool for growers to more effectively choose between and utilize these materials. We are only beginning to get reliable scientific data to guide efficient and effective use of these and other important organic fertilizer materials.

There is an important role for green manure crops to fill depending upon the cropping intensity of a given farm operation. And economics will only be one of many key factors considered in developing fertilization and soil building strategies.

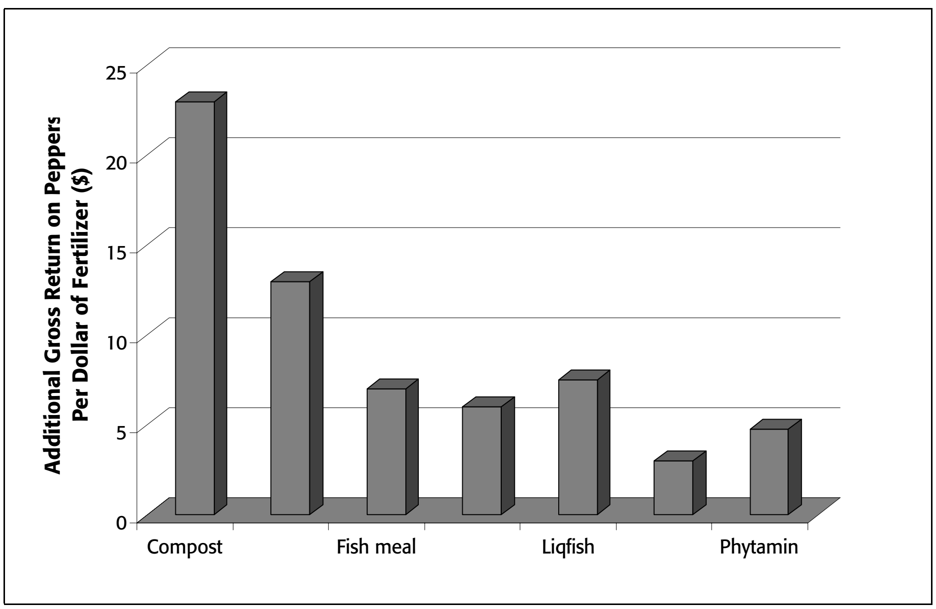

Fig. 2. Additional return on early harvested (first and second pick) bell peppers following application of varying types of organic fertilizers at 180 lb N per acre. Assume $0.75 per lb peppers. Buellton, CA. 1998.

There are other potential problems associated with the long-term, heavy use of compost as would be necessary in an intensive organic production environment. Clearly many other factors need to be considered in the development of a comprehensive strategy for optimum nitrogen management in an organic production environment.

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The full report for this project (Project #98-04) is 16 pages and includes 17 figures and two tables. The report is available by mail from OFRF or by visiting our website at www.ofrf.org. OFRF renewed funding for this project in 2000; further project results will be reported in a future edition of the Information Bulletin.

Testing Alternative Parasiticides for Organic Lamb Production

Janet Allen

Dragon Mountain Farm has been growing and selling certified organic lamb in the commercial marketplace since 1993. We've had keen interest from retailers and wholesalers for our product and have consistently under-supplied the market. We have been troubled by an increasing problem with internal parasites that we have not been able to control through grazing management alone. The management standards of the Certified Organic Association of British Columbia allow us to worm our ewes with conventional products up to the third trimester of gestation. However, this does little to alleviate the worm problem in the offspring, as the worm load in the ewes is always highest during lambing and lactation. Grazing management is the most important tool in controlling internal parasites, and much worldwide research has been done on this. To date, we have not found a practical and effective grazing rotation pattern that will alleviate this problem. Just as our well-managed organic garden will sometimes need to be sprayed with Bt, we are looking for an effective worming method to complement other management strategies.

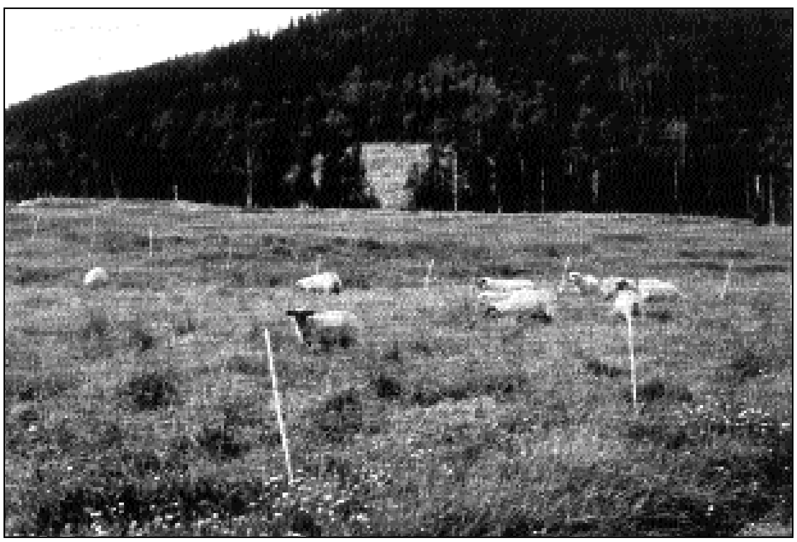
Principal investigators:
Janet Allen, Murray Boal, Paddy Doherty, Dragon Mountain Farm, Quesnel, British Columbia

OFRF support: $3,284.00

Project period: 1999

Objective

- To evaluate the anthelmintic (worming) properties of four different substances that have been suggested to us through articles or by other producers. By monitoring fecal samples and recording rates of gain in the test animals, we wanted to see if any effect could be found.



Sheep and lambs on pasture at Dragon Mountain Farm.

Methods

On July 24, 1998, we weaned lambs, which ranged in age from three to four months of age, from our ewes. About ten days later, we selected 15 test lambs from this group. Post-weaning is when the lambs seem to be most susceptible to worm infestation or at least when the effects are most noticeable, probably due to the stress of weaning. We chose from the less thrifty lambs in the flock with weights ranging from 56 to 66 pounds. These lambs were randomly divided into five groups as follows:

Group 1 - Control: Three lambs receiving no treatment at all.

Group 2 - Herbal: Three lambs receiving a commercially prepared herbal wormer from Hoeggers Supply. This contains wormwood, gentian, fennel, psyllium, and quassia. It was fed as per manufacturer's instruction at a rate of 1½ teaspoons morning and night for three consecutive days. When mixed with grain, it was readily consumed by the lambs.

Group 3 - Garlic: Three lambs receiving three crushed garlic cloves each that were administered with a bolus gun to ensure that it was consumed.

Group 4 - Diatomaceous Earth (DE): Three lambs receiving DE at the recommended rate of 2 percent by weight of feed ration. They were fed this daily throughout the trial with rolled barley.

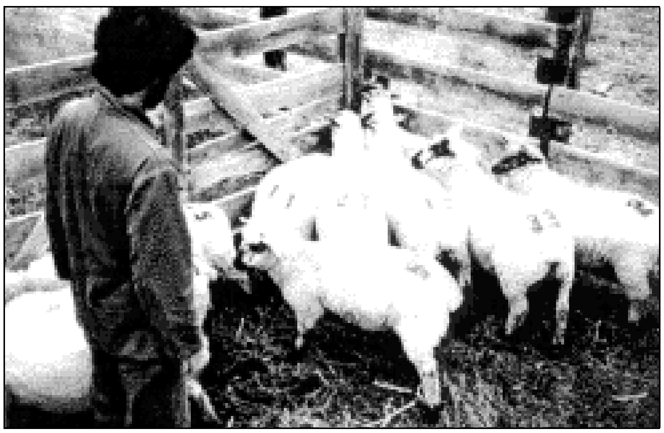
Group 5 - Pyrethrum: Three lambs receiving a drench containing pyrethrum. The recommended rate was 3.5 mg/kg of body weight of 0.8 percent pyrethrum. This concentration of pyrethrum was not available, so we calculated the rate using Trounce insecticide, which contains 0.2 percent pyrethrum, to obtain the same dosage. These lambs received one initial dose and two subsequent doses.

The sample size made it practical for us to test several agents. We were looking for strong indicators to point towards further investigative possibilities.

The lambs in four of the treatments were pastured together on second-crop grass, clover, and alfalfa pasture. The DE group (Group 4) was kept alongside, but separated by electric fence to enable administration of the daily dose of DE and grain. The other groups also received the same one half pound of barley per day to keep the rations even. Each lamb was painted to identify its group and given an individual number. Each lamb was weighed and had a sample taken before the first treatment and was weighed and sampled four more times throughout the test period, which ended on September 21, 1998. The lambs were moved every week to clean pasture to avoid recontamination.

On August 11, one of the DE lambs

appeared very ill with diarrhea. He had maggots in his taggy wool, so he was sheared and externally treated with fly spray. We added another lamb to Group 4 at this point in case the sick one didn't recover. The sick lamb recovered quickly, so we then put him back in the test. From this point, we carried four lambs in Group 4. Initially we thought the diatomaceous earth was responsible for his illness as the product seemed dusty and unappetizing; however, there was no reccurrence or incidence in any other lambs, and they consumed the grain mix readily.



On August 23 and September 7, the herbal mixture, the garlic, and the pyrethrum were re-administered to the target groups. The DE, of course, was ongoing.

Data Analysis

For this trial of several organic ovine anthelmintics, the fecal flotation diagnostic test was used. Fecal samples were mixed with Fecasol, a commercial brand of flotation solution with a specific gravity of 1.2. Containers used were the Fecalyzer brand of diagnostic systems. Eggs were floated for 10 minutes; this time allowed a sufficient number of eggs to rise to the surface while reducing the amount of deterioration observed.

Observations were carried out using a standard light microscope. Slides were scanned first with the 4x objective for *Trichostrongyloidea* (Nematocera) eggs The objective was then switched to 10x for scanning of *Moniezia* (Tapeworm) eggs and roundworm eggs, *Haemonchus*, *Ostertagia* and smaller *Trichostrongylus* species were counted as roundworms. The number of roundworms visible in several microscopic fields was recorded, and if sufficient numbers were present, they were recorded as "numerous." At the beginning of the trial, the number of visible roundworm eggs needed to record a "numerous" result was 20 - 30 eggs. As the trial progressed, and the roundworm density increased, the number needed to record a "numerous" went up to 30-50, or even higher! After roundworms, the objective was switched to 40x for a quick scan to determine presence of *Eimeria* species.

Identification of parasite eggs was made using W.J. Foreyt's *Veterinary Parasitology Reference Manual, Third Edition.*

Limitations of Diagnostic Methods

The fecal flotation tests were used to determine presence or absence of parasite infestation of lambs tested. Due to the fluctuating amount of feces available (not all samples had a full quotient; for example, some had scant diarrhea), several samples would still test positive for infestation, but when placed on a graph, would show a lower egg count. One scant sample was further diluted by accidental spillage and refilling, yet still showed parasite presence (September 21).

Observations

All groups showed presence of roundworms at the beginning of the trial. All groups also showed a higher level of roundworm presence at the end of the trial. The only samples showing extremely low levels of infestation were the three random flock samples tested on September 14 (these had been dewormed with Ivomec, a commercial anthelmintic).

Figure 1 shows worm counts for roundworms. These are average counts for the lambs in each group. In doing the count, 25 in one slide was considered very numerous; it's evident we are dealing with a significant infestation. Overall, no pattern or improvement can be seen in any one of the samples from the different testings. In fact, the Control group, Group 1, received no treatment at all for worms and ended up with the lowest count overall for this particular type of parasite. It should be noted, however, that even this rate is an unacceptable level of infestation.

Rate of Gain

Actual weight gain averaged for each group is plotted in Figure 2. These lambs were all gaining at a slower rate than the expected rate of gain for a lamb with no infestation (lamb treated with Ivomec). The test groups show the same curve as the control group. After September, the high worm counts took their toll as the lambs actually began to lose weight. It should be noted that drought conditions at this point were a contributing factor as pasture quality dropped as well. Also note that the October 6 weight was recorded two weeks after these lambs all went off test and were treated with a commercial wormer.

Group 1 - Control: This group performed as well as or better than the groups receiving alternative wormers.

Group 2 - Herbal: This group receiving the herbal preparation showed no improvement throughout the study. While much anecdotal evidence exists about its effectiveness, we have not seen any measurable data to contradict the findings in our study.

Group 3- Garlic: This group initially had the best rate of gain from the five groups. Perhaps garlic stimulates the appetite, but it showed no effect on fecal worm counts or overall performance.

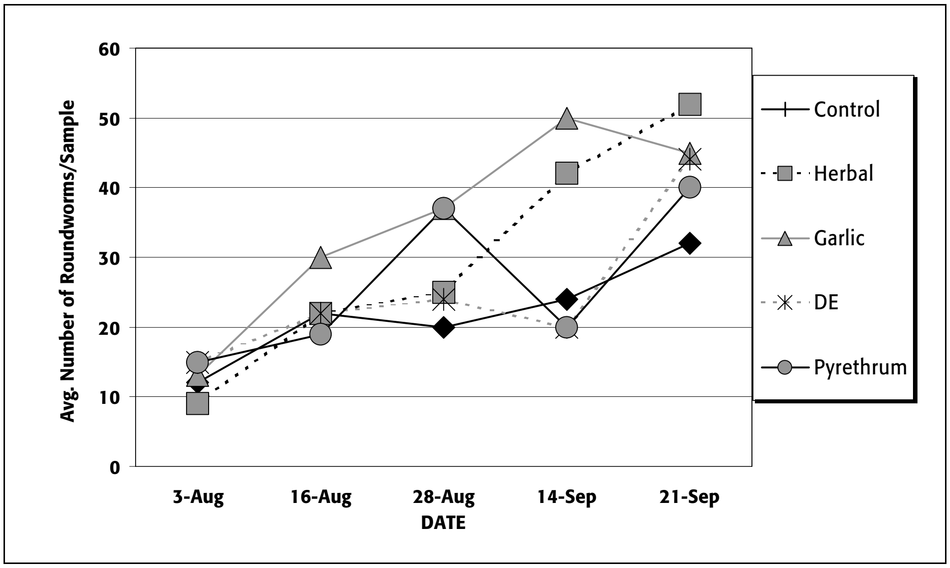


Fig. 1. Rate of roundworm infestation in lambs treated with alternative anthelmintics. Quesnel, BC, 1999.

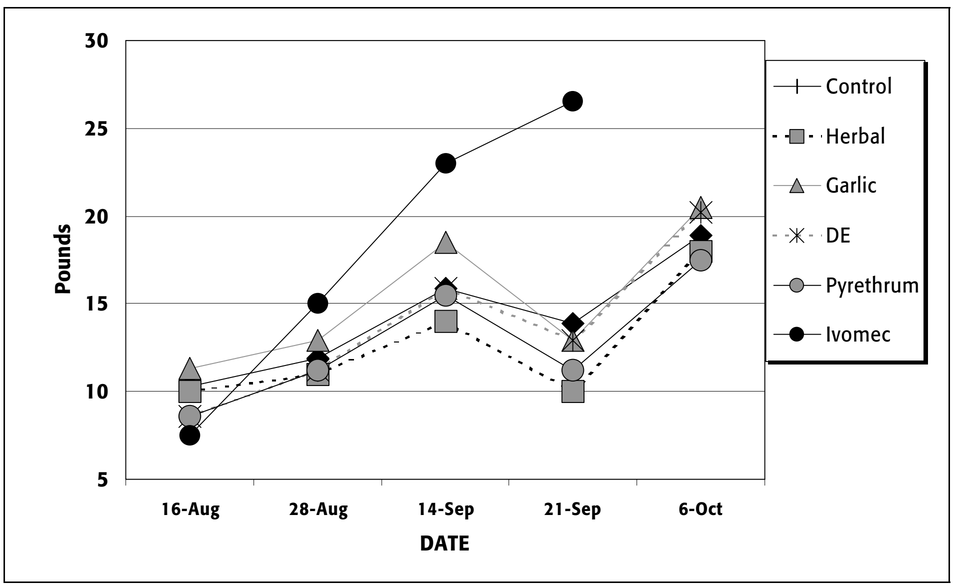


Fig. 2. Rate of weight gain in lambs treated with alternative anthelmintics; alternative treatment and control lambs received conventional wormer on September 21. Quesnel, BC, 1999.

Group 4 - Diatomaceous Earth: This group receiving. DE showed no improvement throughout the study. DE is the most commonly touted natural wormer and is often advertised as a natural worm control agent. Our findings support those of previous studies in that no effectiveness could be measured.

Group 5 - Pyrethrum: We feel our findings are the least conclusive here. While no effectiveness was demonstrated in our study, we feel pyrethrum should be re-trialed with a purer product, perhaps at a stronger rate. Our dosage was basically an educated guess; and while no positive results were seen, it perhaps was not fully explored. Working closely with a veterinarian to determine the proper product and dosage should be pursued before this product is ruled out.

Overall, these lambs were subject to a heavy parasite challenge; and while it would perhaps be unrealistic to expect these alternative wormers to eradicate the problems, if they were at all effective, some positive dip in count numbers or improvement in rate of gain should have been observed.

We pastured these lambs together so that they were subjected to the same conditions. As these lambs were moved to fresh pasture regularly, we don't think that cross-reinfection was a significant problem. If there were any effectiveness at all in these alternative wormers, it should have been demonstrated by either rate of gain or fecal egg counts.

Conclusion

Our study failed to show any effectiveness in any of the tested alternative wormers. At this point, none of them show any usefulness as part of a management strategy in dealing with internal parasites in sheep. As these substances are commonly recommended among organic livestock producers, it is disappointing that no anthelmintic properties could be demonstrated.

However, our study has been extremely useful to us. We feel that it stresses the need to systematically assess the usefulness of any alternative wormer. If there are substances out there that could be part of a livestock management plan for dealing with internal parasites, we need to measure their effectiveness objectively.

In Britain, where much of the organic management research has been done on sheep, commercial wormers are still allowed, where necessary, in the organic standards. While we research and test certifiable, safe, effective alternatives, we feel the British model is a sensible approach.

We are extremely interested in communicating with any producers or researchers who are keen to pursue this line of inquiry.

This project report (Project # 98-03) has been presented in its entirety. Project investigators may be reached at Dragon Mountain Farm, Box 31, Bastin RR #7, Quesnel, BC, Canada V2J 5E5.

Grants Awarded

OFRF awards grants for organic farming research and education projects two times per year. Grant application deadlines are January 15 and July 15. Projects may be farmer initiated, and/or should involve farmers in project design and execution and take place on organic farms, whenever possible. OFRF considers funding requests within the range of $1,000 to $10,000.

We marked our ten-year anniversary this fall by awarding a record level of research funds. Over $82,000 in competitive grants was funded this fall, bringing the year's total to $150,500 in grants made.

To obtain our **Procedures for Grant Applications**, please contact OFRF at: tel. 831-426-6606, or visit our website at www.ofrf.org.

Fall 2000 Grants:

Organic apple crop thinning strategies.
Curt Rom, University of Arkansas, Fayetteville, AR $7,442

Evaluating corn varieties for organic crop production.
Phil Rzewnicki, Ohio State University, Columbus, OH $8,280

Integrated caterpillar control in organic sweet corn (Year 2).
Ruth Hazzard, University of Massachusetts, Amherst, MA $9,285

Use of *Metarhizium anisopliae* (Agassiz strain) as a microbial control for wireworms.
Todd Kabaluk, Pacific Agri-Food Research Centre, Agassiz, B.C., Canada $5,805

Effects of organic alternatives for weed control and ground cover management on tree fruit growth, development, and productivity.
Steve Ela, Silver Spruce Orchards, Hotchkiss, CO $7,680

Evaluation of kaolin-based particle film coatings on insect, disease, and heat stress suppression in apples (Year 2).
Andrew Thomas, University of Missouri, Mount Vernon, MO $4,171

Increasing organic farmer access to relevant and practical research-based information.
George Kuepper, Appropriate Technology Transfer to Rural Areas (ATTRA), Fayetteville, AR $4,500

Long-term organic farming impacts on soil fertility.
Jessica Davis, Colorado State University, Ft. Collins, CO $5,548

Bat houses for integrated pest management.
Mark Kiser, Bat Conservation International, Austin, TX $5,800

Improving the quality of organic herb production and marketing.
Kathleen Delate, Iowa State University, Ames, IA $5,500

Biological control of *Delia* sp. in cole crops with rove beetles, *Aleochara* sp. (Year 2).
Renée Prasad & Deborah Henderson, E.S. Cropconsult, Vancouver, B.C., Canada $5,600

Green manure and weed mat impacts on soil biota and tree growth in organic peach orchards.
Rick Zimmerman, Rogers Mesa Research Center, Hotchkiss, CO $4,000

Comparing antibiotic susceptibility patterns for *Staphylococcus aureus* in organic and traditional dairy herds.
Ynte Schukken and Linda Garrison, Cornell University, Ithaca, NY $8,500

Effectiveness of compost extracts as disease suppressants in fresh market crops (Year 2).
Sylvia Welke, Wild Flight Farm, Mara, B.C., Canada $2,900

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