Spring 1990 - Vol. 1, No. 2

In This Issue:

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Welcome to the second issue of COMPONENTS, the technical newsletter of the UC Sustainable Agriculture Research and Education Program. Our aim with this new publication is to present a range of current research and information on topics relevant to sustainable agriculture in California. The first several issues of COMPONENTS will be published on a trial basis. We would like your feedback about its relevance and importance. To facilitate your response, we have enclosed a brief survey which we encourage you to fill out and return.

We recognize that there are many approaches to improving California farming systems and that what we present in COMPONENTS is not necessarily the complete picture for a particular topic or issue. You may find some articles or comments to be controversial. We do, however, want COMPONENTS to be an open forum. Let us know what you think and please pass on to us any information or research you feel would be appropriate to the newsletter. Sources of information for COMPONENTS will be journals, books, reports, and material presented at meetings, conferences, and workshops. On a quarterly basis, COMPONENTS will deliver information that covers the entire range of disciplines related to sustainable agriculture.

The technical summaries and notes will be aimed at farm advisors, specialists and faculty. However, we also expect that the information presented in COMPONENTS may be of use to other organizations and consultants. We will continue publishing our quarterly newsletter Sustainable Agriculture News for a more general audience.

-Bill Liebhardt, Program Director

Land in the balance--Williamson Act costs, benefits, and options.

Carter, H.O, A.D. Sokolow, et al

UC Agricultural Issues Center and California Department of Conservation. 1989

A team of researchers led by Harold 0. Carter, director of the University of California Agricultural Issues Center (UC/MC), recently completed a study of California's major program for the protection of agricultural land: the Land Conservation Act of 1965, often called the Williamson Act, which lowers property taxes to owners of land who contract to keep it agricultural. According to a synopsis of the study reported in a recent newsletter of the UC/AIC, "the Williamson Act has been more effective in limiting leapfrog development in areas removed from existing urbanization than in protecting farmlands located at the fringes of growing cities...Limiting the property tax burden in contracted parcels has helped to stabilize farm income, especially for owners of grazing land." The 19-page Executive Summary report is available free from The California Department of Conservation, Office of Land Conservation, 1516 9th St., Room 400, Sacramento, CA 95814. The complete report is available in two parts from the same address: Part 1 (200 pages, $2.50) deals with "subventions," the payments made by the state to local governments to partially replace the property taxes lost from land enrolled in the program, landowner benefits, administration of the program by county governments, and perceptions of effectiveness of the program. Part 2 (54 pages, $1.50) is a short history of the Williamson Act. Parts 1 and 2 together cost $3.50.

(JSA.101) *Contributed by Jill Auburn*

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California agriculture and groundwater quality.

Ingels, Chuck

Article written for COMPONENTS. 1990

The impact of agriculture on groundwater quality has become a key environmental and health concern, both in California and nationwide. Groundwater serves as the primary source of domestic water for nearly 90 percent of the rural population of the U.S., and for about 50 percent of the total population (Power, 1989). In California, 70 percent of cities of 10,000 or more people rely on groundwater as one source of drinking water (CDFA, 1990). The most important UC Sustainable Agriculture Research & Education Program concerns related to groundwater quality are contamination by nitrate and pesticides. The following is a summary of the primary health effects and causes of groundwater contamination by nitrate and pesticides, and possible solutions to the problem.

Nitrate. The principal health effect of high nitrate drinking water is the potential for the infant disease, methemoglobinemia (blue baby syndrome). The U.S. Environmental Protection Agency has set the maximum contaminant level (MCL) of nitrate in drinking water at 45 mg/L (10 mg(L as nitrate nitrogen); no cases of this disease have been reported in the U.S. when water contained less than this amount. High nitrates may also increase cancer through reduction to nitrite in the stomach and reaction with amines to form nitrosamines, which are carcinogenic to nearly all mammals.

Water that contains 45 mg/L nitrate has 27 pounds of N per acre foot (CDFA, 1989). As of October 1988, about ten percent of the California wells tested contained more than this amount (CSWRCB, 1988). Most of the wells analyzed, however, were deeper municipal wells. The generally shallower individual domestic wells often contain higher nitrate levels. For instance, about 60 percent of the wells tested in the Hilmar area of Merced County and about 75 percent of the private wells in Sutter County exceeded the MCL. Furthermore, one-third of the wells in the Sacramento Valley are undergoing significant increases in nitrate concentrations (CSWRCB, 1988).

While nitrates in soils and groundwater can originate from natural sources (geologic deposits and atmospheric deposition), human-related sources, such as septic tank leakage and agriculture, account for most of the excessive levels. Agricultural activities contribute to nitrate leaching from point sources, such as fertilizer production and storage facilities and intensive animal husbandry operations, and from non-point sources through normal use of manure or N fertilizers.

Nitrogen from commercial fertilizers and manure has the potential to be transformed into nitrate, which is soluble and moves with water through the soil profile. The amount of nitrate leached is therefore directly related to the percolation volume, so both N management and water management are essential in reducing nitrate leaching (Univ. of Calif., 1980). Though water management is difficult in areas with significant rain-fall or where excess water must be applied to flush soluble salts beyond the root zone, the following management practices are recommended to reduce nitrate contamination:

- Adjust the amount and timing of fertilizer applications to match N needs of plants.
- Regulate N fertilization practices so that little nitrate is present when leaching is likely to occur (reduced rates, split applications, delayed applications, use of nitrification inhibitors, slow-release forms).
- Apply the minimum amount of water that is consistent with efficient crop production.
- When preirrigating, apply only as much water as needed to fill the soil profile, based on the soil water holding capacity and the amount of water already in the soil.
- Know the nitrate level of the irrigation water and adjust fertilization practices accordingly.
- Rotate crops requiring high N with those requiring low N or those which can utilize residual N from previous plantings.

Farmers can also reduce residual soil N by growing winter cover crops which take up N during the wet season when leaching is likely, or by using composted manure and crop residues. The composting process creates a stable, slow release N form, although N is lost to the air as ammonia during the process. Cover crops and compost add organic matter, which can improve the water holding capacity of soils, thereby reducing leaching.

Pesticides. Potential health problems associated with pesticides in drinking water may include cancer, immune system disorders, birth defects, and male sterility. The tolerance levels which are set for a particular pesticide take into account these health effects as well as the high sampling variability within any given aquifer and the degree of uncertainty regarding the health effects of mixtures of chemicals. Nation-wide, about 50 pesticides have been found in groundwater and thousands of wells have been closed as a result of contamination by one or more of these chemicals. Many of these closures are a result of point-source contamination. The impact of normal, legal agricultural use of a pesticide on a particular aquifer is much more difficult to determine. In California, eight pesticides have been found in groundwater due to normal agricultural use: aldicarb, atrazine, bentazon, bromacil, diuron, prometon, simazine (CDFA, 1990).

Movement of pesticides to groundwater is governed by several factors, including soil and pesticide properties, interaction processes occurring during transport, and by the amount and timing of irrigation and rainfall after pesticide application. Soil properties involve two pathways of contamination: 1) direct streaming, where materials flow quickly from surface to ground-water through a "pipeline', such as cracked or dry wells and soil macropores, and 2) leaching, where pesticides follow the normal routes of water through the soil. Regarding direct streaming, guidelines have been established which specify methods of sealing dry wells (CDFA, 1990). Macropores are small pores in the soil created by root channels, earthworms, drying, and other factors. There is much debate over their role in moving pesticides downward with water. The hypothesis that macropores enhance the downward movement of pesticides is supported by the fact that greater leaching is usually seen under nontillage than under tillage, where channels in the upper soil layers are destroyed (Hall, 1989).

As with nitrates, water management is a critical factor in reducing pesticide leaching. A new University of California (1989) publication offers some excellent guidelines for improving irrigation efficiency, thus reducing the amount of deep percolating water. Furthermore, retaining pesticides in the upper soil layers, where microbial activity is highest, will enhance the degradation of some pesticides. While it is advisable to use pesticide materials which do not leach, sometimes essentially "immobile" pesticides with very long half lives and very low solubility are still found in groundwater. The reasons for such movement include high application rates and increased half lives below the root zone.

In an effort to address the potential for pesticide contamination of California groundwater, a program has been set up based on the Pesticide Contamination Prevention Act of 1985 (AB 2021) and a plan by the California Department of Food and Agriculture (CDFA, 1990). The program establishes Pesticide Management Zones (PMZs) when a specific pesticide has been detected in groundwater or soil in the zone due to legal agricultural use. A restricted materials permit will be required for the use of certain pesticides within PMZs. Currently, the use of atrazine is regulated in 62 PMZs in four counties. In the near future, aldicarb, bromacil, diuron, prometon and simazine will likely be regulated in 221 PMZs in six additional counties if proposed regulations are adopted.

Conclusions. Because there is often a significant lag between the time agrichemicals are applied and when they are detected in deep aquifers, the magnitude of the groundwater contamination problem may not be fully realized for 30 to 40 years (Fleming, 1987). One solution to reduce pesticide contamination is for farmers to begin cutting back or eliminating the use of those which are known leachers. To do so may require farmers to bear additional costs associated with reducing pesticide usage, researchers to develop viable alternatives, and/or the public to begin to bear the true costs of food production. Reducing nitrate leaching presents a different challenge; farmers cannot simply stop using N fertilizers. All N sources, conventional and organic, can cause nitrate pollution. Clearly, stricter management of inputs will be required before regulations force a change.

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(CAI.028)

Utilization of cotton gin wastes: Technology demonstration and safety testing of composting, and evaluation of alternate utilization strategies.

Seiber, James N., Robert C. Curley, David J. Hills, Offa D. McCutcheon, George Miller, G. Stuart Pettygrove and Wray L. Winterlin

Final Report Submitted to the California Solid Waste Management Board. October, 1982

How feasible is it for the approximately 220,000 tons of cotton gin waste produced each year in California to be used as a soil amendment? This 1982 study by seven University of California researchers answers the question with relevant information for farmers interested in alternative soil management strategies. Three avenues for disposal of cotton gin waste are considered: incineration and/or gasification of gin waste to produce useable energy; feeding of gin waste to cattle; and, composting of gin waste in order to create an acceptable soil amendment. The last alternative, composting, is the primary focus of this report and combines the results of several research projects:

1. Optimum procedures for composting.

2. The nutrient value and benefits of composted gin waste when applied to selected crops at varying rates.

3. The effect of composting on the fate of the common defoliants, persistent pesticides, common weed seeds and Verticillium disease organisms.

Optimum composting procedures. Screening of gin waste may be a desirable first step for the composting process. Screening removes extraneous soil material and produces a better substrate for microorganism activity enhancing organic matter breakdown. Three different experiments evaluated both screened and whole gin waste for optimal composting conditions.

Laboratory trials showed that the optimum water content for composting of whole gin waste is approximately 60 percent; the frequency of mixing should be around seven days.

Windrow field trials (pilot scale) showed that the time required for composting is seven weeks. During that time, temperatures in the compost pile reached a maximum of near 170 F. Close to the center of the pile temperatures were in excess of 140 F for up to five weeks. These field trials also indicated that aerobic conditions were better than anaerobic for complete composting of the gin waste. Generally, the N, P, K plant nutrients were concentrated in the composting process as indicated in the following table for whole gin waste:

Results from a full scale composting trial confirmed that preliminary information gleaned from the laboratory and pilot scale projects could be duplicated in a commercial operation. Final nitrogen, phosphorus and potassium concentrations in a 300 ton compost pile averaged 1.98, 0.28, and 2.45 percent total solids, respectively.

Windrow	Nitrogen	Phosphorus	Potassium
		--% of total solids--	
Aerobic			
initial	1.18	0.24	3.33
final	2.14	0.37	2.90
Anaerobic			
initial	1.25	0.17	3.25
final	2.40	0.34	4.03

Potential of composted gin waste as a fertilizer source for selected crops. Four greenhouse/laboratory experiments and four field experiments evaluated the nitrogen availability of composted cotton gin waste as well as its effect on plant growth and development in sorghum, cotton, soybean, wheat and tomatoes. Conclusions can be summarized in four main areas:

- Effects on germination. At low rates applied in the field with minimal soil mixing, gin waste (composted or noncomposted) will not reduce germination. In this study, a reduction in germination occurred at rates of five tons for composted, and 20 tons for noncomposted

- Effects on plant growth. Again, at lower rates of application (up to eight tons/acre for both composted and non- composted waste) no deleterious effects were observed in either the seedling stage or at harvest. Higher rates of application may significantly reduce yield particularly as a result of delayed or inhibited seedling emergence.

- Availability of nitrogen in gin waste. The concentration of nitrogen in composted gin waste is generally between 2.0 and 2.5 percent. Only a portion of this, however, is in a plant-available form. Its release rate depends on several environmental factors such as temperature and moisture, but is estimated to be at most 30 percent during the first season after application.

- Physical improvement of the soil. No measurements were taken on soil physical improvement. Based on numerous studies of other organic matter sources, however, plus anecdotal information from California growers who use cotton gin waste as a soil amendment, the authors conclude that cotton gin waste can be used economically to amend problem soils.

- Soluble salts in gin waste. During the composting process, the salt content of gin waste concentrates from approximately 1.5 to 3.0 percent, slightly less than the salt concentrations found in California livestock manure. One experiment indicated salt levels of gin waste could be a problem when applied to soils already close to salt tolerance limits.

Effect of composting on chemical residue. Toxicological data on the fate of several defoliants and pesticides are summarized in the following table:

Residues of five chemicals during composting of whole cotton gin waste (ppm on dry weight basis).

Treatment Pesticide	Days		
	0	26	51
Noncomposted (whole waste)			
Omite	3.26	3.32	2.58
DEF	1.02	1.29	1.07
Supracide	1.72	2.3	1.82
Paraquat	17.9	21.0	11.6
Aerobic Compost (whole waste)			
Omite	3.41	1.74	0.19
DEF	1.36	1.96	1.26
Supracide	1.91	0.07	0.04
Paraquat	17.7	24.4	22.2
NonComposted (fine fraction")			
Omite	3.46	4.57	3.78
DEF	1.32	1.42	1.37
Supracide	2.12	2.43	1.81
Paraquat	28.9	25.2	22.9
Aerobic Compost (fine fraction)			
Omite	4.07	3.87	1.62
DEF	1.39	2.12	2.25
Supracide	2.02	0.08	0.09
Paraquat	32.6	29.02	15.8

These data can be summarized in two main points: 1) Chemical residues are more concentrated in the fine fraction of cotton gin waste than in the coarse starting material; and, 2) the behavior of chemical residues depends on the chemical in question as well as the composting conditions.

When composted gin waste was applied to soil, the resulting concentrations of all chemicals evaluated were less than 0.5 ppm (maximum values observed for DEF) and generally less than 0.1 ppm, just after incorporation. Researchers concluded that possibly the greatest danger comes from the exposure of workers to chemical residues in airborne dust near gin waste screening operations. Workers should wear protective face masks at a minimum in order to prevent inhalation of harmful levels of dust.

Effect of composting on weed seeds and disease inoculum. Composting destroyed virtually all seeds evaluated (cotton, pigweed, watergrass, and Bermuda grass) through a combination of moisture-initiated germination followed by heat destruction of the cotyledon or plummule. The only disease organism evaluated in this study was *Verticillium dahliae*. High temperatures during composting eliminated propagules of this organism.

The information from these experiments plus analyses of the feeding value and thermochemical potential of cotton gin waste led the study group to recommend the utilization strategy for gin waste shown in Figure 1.

The exact pathway for any given batch of gin waste would depend upon local economic factors (mainly demand and operational costs) and the composition of the starting material.

(DEC.087) *Contributed by Dave Chaney*

Spring 1990(v1n2)

Thoughts on drought-proofing your farm; a biodynamic approach.

Goldstein, Walter

Michael Fields Agricultural Institute Bulletin No.1, 16 pp. 1989

The current water shortage in California challenges farmers and researchers to develop strategies for dealing with potential drought conditions. In the past, very little emphasis has been placed on this area of research. This article gives a perspective from the northern Great Plains, and may stimulate some thought and discussion to address the California situation.

Primary considerations in drought-proofing a farm on the northern Great Plains are: 1) improving soil structure through integrated use of grasses, 2) integrating animals with grain-farming operations, 3) effective management of yellow sweetclover (*Melilotus officinalis* Lamarck), 4) stubble mulching to improve infiltration of water, and 5) timing tillage to have maximum positive impact on soil improvement. Also mentioned are the use of alternative legumes and biodynamic preparations, and weed control.

It is desirable to have soil that is crumbly and loose, composed of crumbs 1-10 mm in width which maintain their structure after wetting. This sort of soil usually has large air spaces or pores, and such a soil is good at absorbing and retaining rain water. Grasses enhance soil structure better than do other plants, through their production of masses of fine roots, stimulation of soil microorganisms that exude gums which aggregate soil particles, and direct root action in binding soil crumbs. Perennial warm-season prairie grasses such as big bluestem, little bluestem, and buffalo grass are especially good at improving soil structure, and are much better than brome, alfalfa, or grain crops. The annual grain crops, for example, produce only 11-16 percent as much root biomass as do the prairie grasses. The residual effect of improved infiltration from a warm-season perennial sod can endure six years after the sod is plowed. In addition to improved water relations, other beneficial effects from improved structure include enhanced biological activity and easier root growth.

Yellow sweetclover is useful when grown in combination with a brome grass or a winter-hardy orchard grass like cv 'Pierre'. This is better than a solid stand of yellow sweetclover for both soil improvement and grazing. Such a mixture could be grazed or stubble mulched by undercutting the plants and leaving the residue on the surface. This approach to tillage leads to better water infiltration and efficiency of nitrogen use in the following grain crops than does plowing.

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(CCZ.240) *Contributed by Robert Bugg*

Analyzing competition between a living mulch and a vegetable crop in an interplanting system.

Wiles, L. f., R.D. Williams, G.D. Crabtree and £R. Radosevich

J. American Hort. Society 114(6): 1029-1034. 1989

In a replacement series experiment, pak choi (*Brassica oleracea* L. var. *capitata*, Brassicaceae, cv 'Sakata #7') was seeded amid strips of perennial ryegrass (*Lolium perenne* L., Poaceae, cv 'Manhattan II'). Pak choi was seeded, at several densities, in rows 90 cm apart, amid 30-cm, grass-free strips. The intervening 60-cm strips were devoted to perennial ryegrass, again seeded at several densities. There was no variation in the distance between rows of pak choi and the perennial ryegrass. Mowing and herbicide (fluazifop) were used to suppress the living mulch. Results showed significant effects due to densities of ryegrass on mean plant weight of pak choi, but there was no significant regression. Therefore, managing density of perennial ryegrass does not appear to be a viable tactic for reducing competition. Mowing or herbicide led to improved yields of pak choi. Selection of a mulch with less-invasive root growth might be a useful approach.

Strips of perennial ryegrass can facilitate harvest of interplanted pak choi during cool, wet weather. The perennial ryegrass can help reduce soil compaction caused by traffic through muddy fields. The living mulch might also reduce weed infestations, soil erosion, and fertilizer needs, and enhance soil organic matter, water infiltration, and retention of nutrients and moisture. A possible problem is interference by the perennial ryegrass with the economic crop.

For copies of this article write to: Department of Horticulture, Oregon State University, Corvallis, OR 97331

(CCZ.269) *Contributed by Robert Bugg*

Struktur, mikrobieller Stoffwechsel und potentiell mineralisierbare Stickstoffvorraete in oekologisch und kontventionell bewirtachafteten Tonboeden. (Structure, microbial metabolism and potentially mineralizable nitrogen pools in organically and conventionally farmed clay soils).

Niederbudde, E.A. and H. Flessa

J. Agron. Crop Sci. 162:333-341 1989

One organically cultivated clay soil (unplowed, but rotovator tilled from 0 to 10 cm in depth) was compared to one conventionally tilled clay soil (tilled from 0-22 cm). A pasture topsoil was used as a reference.

Saturated hydraulic conductivity was high in the organically farmed and pasture soils. The conventionally farmed soil had a lower pore continuity and conductivity, particularly in the upper 10 cm of the profile.

Aggregate stability was highest in the pasture soil, followed by the 10-20 cm stratum of the conventionally tilled soil. Aggregate stability was lowest in the fine-textured organically farmed soil.

Dehydrogenase activities and mineralizable nitrogen contents were similar in the pasture and organically- farmed soils, and lower in the conventionally farmed soil. Higher dehydrogenase activities and mineralizable nitrogen are indicators of enhanced microbial activity. Soil respiration was highest in the conventionally farmed soil, apparently because undecomposed crop residues were present.

For copies of this article (in German) write to: Institut fur Bodenkunde der Technischen Universitat Munchen, 8050 Freising-Weihenstephan, Federal Republic of Germany

(CCZ.281) *Contributed by Robert Bugg*

Bodenzoologische Untersuchungen an oekologisch und konventionell bewirtschafteten Weinbergen. (Investigations on the soil fauna of ecofarmed and conventionally farmed vineyards).

Luftenegger, G. and W Foissner

Landwirtschaftliche Forschung 42: 105-113. 1989

This trial was conducted in two Austrian wine-grape vineyards (cv 'Veltliner grun'), one in Mailberg, and one in Brundlmayer in Langenlois. In the Mailberg vineyard, planting was in 1969, and the research began in 1979. Plots were 10.5 x 35 m, each containing 30 vines. Distance between plots was 14 m. There were four replications of each of five treatments:

A. Minimal management. A green-manure crop of cereal rye every other alley. Minimal input for plant protection.

B. Conventional management (100-150 kg/ha of N, 50 kg/ha of P, 100 kg/ha of K). Green manure as for management regime A. Application of plant protection substances 10 times per season.

C. Biodynamic management, based on Rudolph Steiner's recommendations. Organic fertilizers were compost (animal manure + stone meal + preparation: 2,000 kg/ha/year). A legume-rich green manure was used. Plant protection was by wettable sulfur and plant extracts.

D. Organic-biological management, based on the recommendations of H. Muller (fresh stable manure application of 2,000 kg/ha/year, and in 1980 and 1981 dried chicken manure 800 kg/ha/year). Otherwise managed the same as treatment C.

E. Semi-biological management. Mineral fertilizers included 140 kg/ha/year of N, but no P or K, organic fertilization was by compost (80 percent cattle manure and 20 percent maize straw, 2,000 kg/ha). Green manure was chopped several times annually. Synthetic pesticides were avoided in plant protection.

The Brundlmayer vineyard was divided into two portions which were assigned different management regimes. 1) Ecological management. Organic fertilization was by "trester" (residues of fruit, grapeskins or husks) and turnip wastes (about 15,000 kg/ha in all during the 2nd and 3rd year); green manure was grown in alternate alleys (nothing seeded, only volunteer vegetation); plant protection by wettable sulfur and Bordeaux mixture. 2) Conventional management, as with treatment (B) in the Mailberg vineyard.

Statistical comparisons were not made between the Mailberg and Brundlmayer sites. In general, treatments with at least aspects of ecological farming showed richer soil life than did either the minimal management or the conventional management regimes as shown in the following table:

Management	Density of Soil Organisms		
Regime	T. Amoebae	nematodes	Earthworms
A	med	low	low
B	low	low	low
C	low	high	high
D	med	med	high
E	high	high	low

Data on testate amoebae were used to construct dendograms using procedures developed by Renkonen, Bray and Curtis, and Jaccard. These were used to assess similarities in the communities of testate amoebae among the various treatments and the two locales. All three approaches indicated distinct differences between conventional and ecological farming regimes. Abundance, biomass, numbers of species, and diversity were consistently higher in the latter.

It is remarkable that soil animal numbers were similar in both unfertilized plots and those receiving conventional N-P-K fertilization. Ecological farming shows the capacity for increasing the abundance and diversity of soil animals.

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(CCZ.282) *Contributed by Robert Bugg*

Spring 1990(v1n2)

Plant pathology and sustainable agriculture.

Bugg, Robert L.

Article written for COMPONENTS. 1990

Sustainable agriculture comprises a number of practices which can have important ramifications for management of plant pathogens. In this article, I briefly review the possible implications of vegetational diversification in space and time, cover cropping, surface management of crop residues, addition of soil organic matter, use of vesicular-arbuscular mycorrhizae, enhanced densities of soil mesofauna, and reduction of agrichemical inputs. I will emphasize recent or underexposed papers.

Diversity in Space. Vegetational diversity in space can lead to increased problems with plant pathogens that are dispersed by wind or transmitted by insects, and which feature alternate hosts. Examples given by Flint and Roberts (1989) include transmission of Pierce's disease bacteria to grapes from wild plants by two species of leafhopper, the green and the blue-green sharpshooter. On the other hand, Traenkner and Weltzien (1989) indicated that mixed plantings of wheat and rye reduced incidence of the foliar pathogens *Rhynchosporium secalis* on rye and *Puccinia recondita* on wheat. There was, however, some increase of Septoria nodorum. A multiline is a mixture of strains of a single crop which differ from one another only at a few genetic loci. Such mixtures can reduce outbreaks of pathogens and prevent the development of pathogen strains that could circumvent single-gene resistance (Cook and Baker, 1983).

Diversity in Time. Vegetational diversity in time is achieved by crop rotation. The successive planting of taxonomically unrelated crops has long been recognized as an approach for reducing inoculum of host-specific pathogens, or those which lack resistant dormant stages. Plant pathological benefits of this tactic may frequently be poorly documented and be merged with other benefits as a so-called "rotation effect."

Cover Crops. Use of cover crops in rotation can influence soil-borne diseases, and the effects may vary profoundly depending on which cover crop is used. For example, Sonoda (1978) showed that mycelia of *Sclerotium rolfsii* Sacc. lysed and died on the surface of soil to which had been added residues of alfalfa, (Medicago sativa L.), *Crotalaria spectabilis* Roth, or white sweetclover, (Melilotus alba Desr.). Negative impact on the fungus increased with increasing amounts of plant material incorporated. None of these three prospective cover crops supported reproduction by the fungus. Other plant species, such as the tropical forage legumes *Desmodium intortum* (Mill.) Urb., *Macroptilium atropurpureum* (DC) Urb., *Stylosanthes guianensis Swt*., and *Vigna luteola* (Jacq.) Benth., and the grass *Digitaria decumbens* Stent had lesser effects on the fungus. Antagonistic fungi, e.g. *Trichoderma* spp., may have been involved in the present study. Alternatively, preformed inhibitory compounds may have been present in the crops employed.

Rothrock and Hargrove (1987) showed that cool season cover crops varied in their influence on densities of propagules of *Pythium* spp. Propagule densities were greater for hairy vetch than for crimson clover; in turn, densities for crimson clover were greater than those for rye which was indistinguishable from the control (no cover crop).

There is some evidence that understory weeds can promote bacteria that cause russeting of apple, and that different weeds and cover crops can harbor different levels of these bacteria. Chickweed (*Stellaria media*) appears to be a particularly potent source (S. Lindow, pers. comm.).

Surface Management of Crop Residues. Surface management of crop residues can be helpful in enhancing activity of surface- feeding earthworms, and improving soil structure and infiltration of water. No-till management has been contrasted with conventional tillage in its effects on plant pathogens. No-till can lead to build-up of certain plant pathogens, but such a build-up can often be circumvented through crop rotation, occasional use of tillage, and the strategic application of certain fertilizers (Boosalis et al., 1986). Special direct seeding equipment that separates winter wheat seedlings and residues of prior crops can help avoid contact toxicity by acetic and butyric acid, or colonization of wheat roots by growth inhibiting pseudomonad bacteria, according to Elliott and Papendick (1986). Other researchers doubt that these mechanisms are involved in the observed pathology (R. J. Cook, pers. comm.).

Addition of Organic Matter to Soil. Effects of organic soil amendments on plant pathogens were recently reviewed by Linderman (1989). Based on that account, decomposing organic soil amendments can produce volatile compounds that stimulate germination of *Sclerotium rolfsii*, which can either colonize hosts immediately, or after first colonizing residues and ramifying out from these. This could lead to increased incidence of disease where amendments have been added. On the other hand, there are numerous examples of organic amendments stimulating germination by propagules of pathogens, which then die in the absence of hosts. Or, amendments may be colonized by various microbes which interfere with pathogens.

Linderman indicates that the ability of a soil to suppress a particular disease is linked to the breakdown of organic matter. In the early stages of decomposition, plant residues may produce aromatic acids or other toxic chemicals which predispose crop roots to attack by pathogens; as decomposition progresses, organic matter may increase or decrease plant disease, depending on whether the specific pathogen can colonize the substrate, or whether antagonistic (beneficial) organisms can do so. The implication of this discovery is that the degree of pathogen suppression may vary throughout a soil profile depending on the stage of residue decomposition at various levels. The most disease-suppressive stratum for phytopthora root rot, for example, is the humus layer at the surface, where decomposition is maximal. Where the profile has been reconstructed for avocado orchards, the results show improved disease suppression and profuse root development in the organic layer.

Precise effects by a given amendment on mycorrhizal and pathogenic fungi may vary among soils. That is, microbial responses are still too unpredictable to make incorporation of organic amendments a reliable remedy. Improved purification of specific humic fractions should permit better clarification of their roles in the dynamics of plant disease.

Another review (Chung et al., 1988) confirms that addition of organic matter to soil can have varying effects on the severity of plant disease (e.g., bare patch of wheat caused by *Rhizoctonia solani*), depending on the extent of decomposition of the amendments. The more extensive the decomposition, the less the development of the pathogen.

Compost added to non-sterilized soil has been shown to protect carnations from the fungus *Fusarium oxysporum* (Filippi and Pera, 1989). Steam-sterilized poplar bark compost was better at suppressing the pathogen than was non-sterilized compost. This apparently occurred because the microflora of the compost were killed by steaming, and provided a food base to beneficial soil microorganisms which quickly colonized and subsequently inhibited the pathogen. The compost microflora itself was thought to have no significant effect on the pathogen, which could account for the less efficient suppression of the pathogen with the non- sterilized compost. In the latter case, the compost microflora would survive for a time after incorporation into the soil, so colonization by the antagonistic microflora would not take place as rapidly.

Vesicular-Arbuscular Mycorrhizal Fungi. Vesicular--arbuscular mycorrhizae (VAM) can be important in enabling efficient uptake of phosphorus by crop plants, and may also help reduce the incidence of soil-borne disease, according to Caron (1989). For example, *Glomus intraradices* Schenck and Smith may reduce the incidence of *Fusarium oxysporum* Schlecht. on tomato. Other researchers question the latter assertion (R.M. Davis, pers. comm.). Possible mechanisms include production of inhibitory chemicals by the mycorrhizal fungus. By improving nutrient availability to crop plants, VAM may to some extent mask the impact of soil borne root pathogens. On the other hand, the effect of foliar pathogens may actually be increased (Cook and Baker, 1983). There is evidence that certain rotational and interplanting techniques can improve the infection of crop plants with VAM fungi (R. Knoll, pers. comm.).

Soil Mesofaunae and Decomposers. Certain springtails (Collembola) are fungal feeders, and are believed important in nutrient cycling. Some springtails (e.g., *Folsomia candida*) have been shown to feed on hyphae and spores of mycorrhizal fungi (Moore et al. 1985), and may reduce infection by, and effectiveness of; VAM symbionts of crop plants (Warnock et al. 1982). On the other hand, the collembolans *Proisotoma minuta* and *Onychiurus encarpatus* are known to feed on spores of fungal pathogens. Grazing experiments conducted in petri dishes by
Curl et al. (1988) showed that springtails permitted no growth by *Rhizoctonia solani Fusarium oxysporum, Macrophomina phasolina*, and *Verticillium dahlia*. By contrast, the soil pathogen *Sclerotium rolfsii* and the biological control agent *Trichoderma harzianum* were inhibited only slightly.

Reduction of Agrichemical Inputs. In Dutch production of winter wheat, a comparison of "conventional", "integrated", and biodynamic farming systems suggested advantages to the latter, and that reduced application of nitrate fertilizer appeared likely to aid control of yellow rust (causal organism *Puccinia striiformis*), mildew (*Erysiphe graminis*), and snow mold (*Gerlachia nivalis*) (Daamen et al. 1989). Several other pathogens were not affected. There is also evidence that addition of specific nutrients may at times alleviate problems with plant pathogens (Englehard, 1989)

Conclusion. What may not be clear from this brief review is that interactions among the phenomena recounted may be expected. This is highlighted here in the effects of organic soil amendments on pathogenic and mycorrhizal fungi, and in the interactions of VAM fungi, Collembola, and soil-borne fungal pathogens. Collembola may attack both classes of fungi, and the consequences for crop plants are not clear, *a priori*. Organic matter can affect availability of soil nutrients, which in turn can influence susceptibility of plants to pathogens. Clearly, there is opportunity for elegant and imaginative experimentation.

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Dietary guidelines for sustainability.

Gussow, Joan Dye and Katherine L. Clancy

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Consumers today need to make educated food choices that reflect not only their concerns about nutrition and health, but also which contribute to the protection of our natural resources. The content of nutrition education should therefore be broadened to include both medical knowledge and information from disciplines such as economics, agriculture and environmental science. "Sustainable diets" is suggested as an appropriate term for describing a food pattern which considers the energy and environmental resource costs of food choices.

The widely accepted Dietary Guidelines are used as the framework for suggesting more sustainable food selections. These Guidelines are: 1) Eat a variety of foods; 2) Maintain ideal weight; 3) Avoid too much fat, saturated fat and cholesterol; 4) Eat food with adequate starch and fiber; 5) Avoid too much sugar; 6) Avoid too much sodium and 7) Drink alcoholic beverages only in moderation. Each guideline is discussed with an emphasis on incorporating issues such as biological diversity, energy and environmental consequences of particular food choices. Health and environmental effects on American consumers as well as those in poorer countries are also considered.

For example, concerning the guideline on eating a variety of foods, the authors call our attention to the risks of allowing the world's population to become dependent on a small number of profitable crop species. Nutritionists should therefore "help consumers learn to create a demand for a wider variety of whole foods instead of a succession of food novelties whose claim to diversity is based on processing techniques and artificial colors and flavors." A sustainable diet would include a variety of foods which are seasonal, preferably local, with attention given to the costs in natural and human resources.

Interpreting the guideline about eating foods with adequate starch and fiber, the authors note that fruits and vegetables are major sources of dietary fiber; however, "all...are not created equal where environmental impact is concerned." Producers' access to cheap energy and subsidized water has concentrated the production of fruits and vegetables in a few regions. This produce must then be transported over long distances. The result is a greatly reduced role for locally-grown commodities, despite their more favorable energy cost. A sustainable diet would include a greater proportion of fruits and vegetables that are produced and marketed locally.

It is hoped that these guidelines can be used by nutritionists to teach consumers about health AND the sustainability of the food system. Not all sources of nutrients within such a framework will be viewed as desirable. "Sustainable diets" would encourage consumers to think about how and where their food is grown, not solely about its nutrient content. Finally, "nutritionists who become concerned about how the food they recommend has been produced will become natural allies of those who wish to grow and process food in a manner consistent with the long-term stability of the food system."

(GWF.O01) *Contributed by Gail Feenstra*

Marketing organic produce in certified farmers' markets.

Vaupel, Suzanne

Organic Market News and Information Service (OMNIS), Colfax, CA. 1990

A mail survey was sent to the market managers of all 110 Certified Farmers' Markets in California in 1989, asking about the produce that was sold at the market in August, 1988. Managers were questioned about the amount of sales in one of three categories: certified organic, noncertified organic, or "unsprayed" (including the similar terms "no pesticides" or "no sprays"). Replies were received from 62 markets (56 percent), representing a crosssection of large and small markets throughout the state.

Over half of the markets reported they had farmers selling certified organic produce, totaling less than 10 percent of market sales on average. Most reported that certified organic produce was sold at a premium price, and a majority of managers reported a shortage of certified organic produce. Noncertified produce was reported sold at about two-thirds of the markets, and unsprayed produce was reported sold at more than three-fourths of the markets. These two categories were both usually (although not always) sold at prices comparable to conventional produce, and were not reported in short supply at most markets.

Thirty-five markets have designated rules for the sale of organic produce. Twenty-five said they had rules for non-certified organic, and eleven reported rules for unsprayed produce. Rules for each category are summarized in an appendix to this report.

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