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Welcome to the first issue of **COMPONENTS**, the technical newsletter of the UC Sustainable Agriculture Research and Education Program. The aim of 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.

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 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. This first issue has a strong emphasis on soil management and cover crops. Future issues will cover the entire range of disciplines related to sustainable agriculture.

The technical summaries and notes will be aimed at farm advisors, specialists and faculty. 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

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Using crop diversity to manage pest problems: Some California examples.

Flint, Mary Louise and Philip A. Roberts

Amer. J. Alt. Agric. 3(4):163-167. 1989

Crop diversity is a general term referring to the number of species of plants grown over time and space. Several related terms are crop rotation (diversity over time) and intercropping, multiple cropping and companion planting (all examples of diversity within a field). The benefits of increasing crop diversity on farms can be generalized to include enhanced soil fertility, spreading of economic risk, and improved pest control (the focus of this paper). The purpose of this review article is "to present some examples of the types of changes in cropping patterns that have led to improved pest control in California on medium to large scale farms" on a case by case basis.

Crop rotation. Though crop rotation is used in California for soil improvements, water conservation and weed control, there are relatively few examples of rotations that are practiced specifically for control of insects, diseases and/or nematodes. The feasibility of the rotation to control a pest depends upon the biology of the organism in conjunction with agronomic and economic considerations. Biological considerations:

- the pest inoculum must reside within the field
- the pest cannot be mobile enough to move into the field from other areas
- the pest must have a narrow host range
- the pest must not be capable of surviving in the absence of the crop host

Some agronomic and economic considerations would be:

- the profitability of alternative crops
- the cost of other pest control options
- the complementarity of production practices for the crops grown

Two well-documented instances of effective pest control through rotations are with nematodes in sugar-beets and cotton. The sugarbeet cyst nematode (*Heterodera schachtii*) can be effectively controlled by a three to seven year break of non-host crops between sugarbeet crops. Root knot nematodes (*Meloidogyne spp*.) have a wider host range than the cyst nematodes but can be effectively controlled using resistant varieties in rotation with other susceptible crops.

Managing adjacent lands. Pierce's disease of grapes and sugarbeet yellows are two examples of how adjacent lands can negatively impact a developing crop. Pierce's disease is a bacterial disease transmitted from weedy and natural vegetation to grape vines primarily by two leafhopper species, the green and blue-green sharpshooter (*Draeculocephala minerva* and *Graphocephala atropunctata.*) Control of this disease can be accomplished by vegetation management on weedy lands adjacent to vineyards or by growing grape species more tolerant of the disease near areas where the unwanted vegetation cannot be controlled.

Sugarbeet yellows viruses are transmitted by aphids. Crop damage is particularly acute at the seedling stage and may be effectively controlled by establishing newly planted fields a distance of at least 5 miles from older plantings. The spread of sugarbeet yellows in California has also been curtailed through the designation of beet growing districts that specifically eliminate spring plantings from areas where sugarbeets had overwintered.

Border harvesting of alfalfa is an example of how adjacent lands can have a positive influence on crop growth and development. Lygus bug (*Lygus hesperus*) favors the lush, nutritious growth of alfalfa over cotton. By staggering the harvest schedule of fields adjacent to cotton or by alternately harvesting a strip of alfalfa along the borders of each check in the alfalfa field, lygus populations can be kept from moving into cotton. The continuous presence of unharvested alfalfa also provides a habitat for other important beneficial insects such as spiders, wasps, ladybeetles and lacewings.

Intercropping. Two examples of intercropping as a pest management alternative on moderate to large scale farms are cited. 1) Capitalizing on the known preference of lygus for alfalfa over cotton, some California growers plant alternating strips of alfalfa in cotton fields every 300 to 500 feet. 2) Seeding oats with alfalfa is a viable option for weed control in seedling alfalfa. Oats suppress weeds during stand establishment and are then harvested along with the first cutting of alfalfa. The remaining oat stubble continues to reduce weed growth until the alfalfa is large enough to out-compete weeds on its own.

Strong economic incentives and/or the removal of a pesticide as a management option will probably be the most effective motivating factors for growers to increase the diversity of crops in their production systems.

(DBC.082) *Contributed by Dave Chaney*

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Biological control of arthropod pests: Traditional and emerging technologies.

Hoy, Marjorie A.

Amer. J. Alt. Agric. 3(2,3):63-68. 1988

A recent issue of the American Journal of Alternative Agriculture highlighted a series of papers presented at a March 1988 symposium on biological pest control. This particular article discusses biocontrol of arthropod pests from the standpoint of both historical successes and future opportunities. In general, biological control programs may be classified according to three basic approaches: classical, augmentation, or conservation.

Classical biological control involves the importation and establishment of exotic natural enemies (parasites, predators, or pathogens) into new environments. "Classical biological control has been actively practiced for about 100 years in the United States. Worldwide, approximately 2,300 introductions directed against insect pests have provided complete biological control in about 100 cases. Substantial control was provided in an additional 140 cases." In spite of these successes, there are still enormous research needs and opportunities m this area if sufficient resources were made available.

Augmentation efforts are focused at increasing existing populations (or the beneficial effects) of natural enemies that act against pests. Specific techniques of augmentation include periodic releases of natural enemies, and manipulation of the environment. This approach has been particularly useful in glasshouse commodities.

"Conservation involves protecting and maintaining natural enemy populations. Conservation is crucial if both native and exotic natural enemies are to be maintained in agricultural ecosystems. Most commonly, conservation involves modifying pesticide application practices so that they occur only when the pest population exceeds specified levels."

Some opportunity exists for improving the effectiveness of natural enemies through genetic manipulation. However, there are several key questions to be considered: (1) What factors limit the efficacy of the natural enemy? (2) Does sufficient genetic variability exist for artificial selection? (3) Is the improved natural enemy effective in the field? (4) Will the benefits achieved justify the cost of the project?

The author argues for greater effort and support in all areas of biological control including the traditional avenues of classical, augmentation, and conservation.

"In addition, research efforts should be continued to combine and develop new and innovative approaches to biological control, including the genetic manipulation of natural enemies, the manipulation of natural enemy behavior through semiochemicals [chemicals that can modify the behavior of natural enemies], and the development of improved artificial diets and improved rearing methods so that mass production for augmentative releases becomes economical."

(DEC.083) *Contributed by Dave Chaney*

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The magnitude of the resistance problem.

Georghiou, George P.

Pesticide Resistance: Strategies and Tactics for Management, National Academy Press. Washington D.C. 1986

This chapter of a National Academy of Science (Board on Agriculture) publication documents the extent of resistance to pesticides for insects, diseases, weeds, nematodes, and rodents. Observations within natural ecosystems show that the gene pool of most of our pest species already contains the genes that enable pests to break down or circumvent the toxic effects of many of the pesticides developed over the past 40-50 years. Increasing the dosage and/or frequency of application, and changing to new pesticides when older ones fail to control pests, only compounds the problem further and has resulted in the sharp increase in cases of resistance experienced over the last three decades.

As Figure 1 shows, the number of known cases of resistance to pesticides is greatest for arthropod pests, followed by plant pathogens, weeds, and nematodes:

--Resistance to one or more insecticides has been reported in at least 447 species of insects and mites. Of these 447, 59 percent are of agricultural significance, 38 percent have medical importance, and 3 percent are beneficial parasites or predators. Classes of chemicals for which resistant species have been found cover the whole range: cyclodienes, organophosphates, carbamates, and pyrethroids.

--At least 100 species of plant pathogens have been found to have resistance to such chemicals as benomyl, thiophanate, and streptomycin. During the first four years of the current decade, cases of resistance have also been reported for dicarboximides, dichloroanilines, acylalanines, and ergosterol biosynthesis inhibitors.

--Some 41 species of weeds have developed resistance to the triazine herbicides and at least seven weeds are known to be resistant to other herbicides including phenoxys, trifluralin, paraquat, and ureas.

--Only two species of nematodes have developed resistance to pesticides. In addition, five species of rodents (not shown in Figure 1) have developed some rodenticide resistance.

The costs to society of the growing problem of resistance to pesticides is difficult to measure, but several factors must be taken into account: 1) The broadspectrum effect of many pesticides alters not only the genetic make- up of target pest species, but also may result in unintentional selection in other non-target organisms; 2) Increasing dosages or rates of application, or changes to more effective chemicals can only mean a significant increase in the direct costs of pest control to the farmer and society; 3) The length of time and amount of money necessary to develop new, more effective pesticides will probably result in a more narrow selection of chemical means of pest control for the farmer. An important part of the solution to the pesticide resistance problem will very likely include an emphasis on non-chemical, ecologically based methods of pest control.

(DEC.080) *Contributed by Dave Chaney*

Comparison of soil properties as influenced by organic and conventional farming systems.

Reganold, John P.

Amer. J. Alt. Agric. 3(4):144-155. 1989

This paper summarizes data from several studies on two adjacent farms in the Palouse region of eastern Washington. Environmentally, the two farms were identical. Management practices, however, changed about 1950. One farm (320 hectares) was farmed organically, while the other (525 hectares) was farmed conventionally. The organic farm has received very few pesticide applications and relied mainly on green manure crops and crop rotations for plant nutrients. The conventional farm began receiving recommended rates of fertilizers and pesticides in 1948 and the early 1950's, respectively. The farms were evaluated for soil biological, chemical, and physical characteristics. Differences in erosion from water and tillage were also analyzed.

A comparison of several key soil quality traits is shown in Table 1. Organic matter was identified as an important component of soil quality because of its positive effect on granulation, water storage capacity, water infiltration, nutrient supply and the activity of beneficial microorganisms. Polysaccharides contribute to soil aggregate stability. The higher CEC and pH of the organically farmed soil are indicative of better inherent fertility and a stronger buffering capacity from organic matter. The differences in topsoil characteristics between the two farms was attributed to significantly greater erosion on the conventionally-farmed soil between 1948 and 1985. "The difference in erosion rates between farms was most probably due to their different crop rotation systems; i.e., only the organic farm included a green manure crop in its rotation, and it had different tillage practices." The number of plowing operations was roughly the same for both farms. On the organic farm, however, half of the plowing was done when turning in the green manure crop; the remainder of plowing occurred in the fall to turn in wheat stubble. All plowing operations on the conventional farm were done in fall when turning in wheat stubble. "These studies indicate that, in the long-term, the organic farming system was more effective than the conventional farming system in maintaining the tilth and productivity of the Naff soil and in reducing its loss to erosion.

Table 1

Soil Property	Organic Farm	Conventional Farm
Organic Matter:0-15 cm (%)	1.9*	1.5
Polysacch. Content (mg/ml)	1.13	1.00
CEC:0-10 cm (cmol/kg)	17.3	15.6
pH:0-15 cm (cmol/kg)	6.9*	5.7
Total N:0-15 cm (mg/kg)	1179*	1066
Mineral N:0-15 cm (mg/kg)	11.5	28.5**

Total P:0-15 cm (mg/kg)	598	600
Extractable K (cmol/kg)	1.2**	0.7
*, ** Statistically significant at the 0.05 and 0.01 levels, respectively.		

(DEC.081) *Contributed by Dave Chaney*

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The environmental effects of conventional and organic/biological farming systems. II. Soil ecology, soil fertility and nutrient cycles.

Arden-Clarke, C. and R.D. Hodges

Biol. Agric. & Hort. 5:223-287. 1988

This extensive review article (211 references) examines the inputs characteristic of conventional and organic/biological farming systems. Part I of this paper specifically addressed the impact of conventional agriculture on soil erosion in Britain. Part II focuses on the physical, chemical and biological impacts that various inputs have on the ecology and fertility of agricultural soils. In addition, nutrient cycles within conventional and organic farming systems are discussed.

A superficial evaluation of organic and inorganic fertilizers might easily lead a farmer to conclude that inorganic fertilizers are the nutrient source of choice. Not only are they cheap, clean, and easy to handle, but you can also be more sure of their specific nutrient analysis and they are associated with higher, more predictable yields than organic fertilizers. In contrast, organic fertilizers are bulky, less easy to handle, highly variable in their nutrient analysis and may have an objectionable odor. A more detailed assessment, however, will show that there is more to these materials than meets the eye.

Some potential negative impacts of inorganic fertilizers are: 1) Deterioration of soil structure through loss of organic matter; 2) Large fluctuations in soil pH; 3) Crop damage and reduction in beneficial soil microbes due to high concentrations of soluble salts; 4) Reduction in populations of soil fauna, especially earthworms. Organic fertilization practices, on the other hand, enhance soil structure and improve populations of beneficial soil fauna. They are less disruptive of soil chemistry than inorganic fertilizers and in some cases inhibit the activity of microbial pathogens. Indirect impacts of inorganic fertilizers (related mainly to soil organic matter levels and deteriorating soil structure) include crop rooting problems and a reduction in the water retention capacity of the soil. Organic fertilizers generally facilitate crop rooting, improve soil water holding capacity and result in a better balance and cycling of nutrients through the soil profile. The slower nutrient release rate of organic fertilizer materials is largely responsible for the efficiency of nutrient cycling in organic systems. In some instances, however, it can limit nutrient availability at crucial periods in crop development.

Maximizing nutrient cycling takes more careful management but can conserve non-renewable energy and mineral resources. Though seriously limited by "infrastructural and technical considerations," im-proving the nutrient balance between humans and agriculture is particularly important for developing sustainable and resource efficient methods of main-taining the soil's productive capacity.

(DEC.021) *Contributed by Dave Chaney*

Cover crop manipulation in northern California orchards and vineyards: effects on arthropod communities.

Altieri, Miguel A. and Linda L. Schmidt

Biol. Agric. & Hort. 3:1-24. 1985

Different floor management practices in orchards and vineyards have previously been shown to have substantial effects on plant growth, soil characteristics, and insect pests and diseases. Results of numerous studies indicate that predator and parasite activity is usually greater, and pest populations and damage are often reduced when cover crops are present than when clean cultivation is practiced. In this series of experiments, comparisons were made of pest and beneficial arthropod populations in several organic apple orchards and an organic vineyard in which treatments of cover crops vs. clean cultivation and different cover crop species were used. While none of the treatments in these experiments were replicated, clear trends were nevertheless apparent among the orchards. The authors used "biological knowledge and intuition" to evaluate whether observed differences were due to the effects of cover crop diversification.

The first study was conducted on two adjacent dry farmed apple orchards in Sebastopol. One orchard was disked twice a year to remove ground vegetation and the other contained grasses and sowed bell beans and was mowed once in June. The important differences between these treatments were that substantially more male codling moths and leafhoppers were caught in the disked orchard in one of the two years, and codling moth damage was lower and predation pressure was higher in the cover cropped orchard.

In another study, half of a two-hectare apple orchard at UC Santa Cruz was planted to bell beans and lana vetch, while the other half was repeatedly cultivated throughout one season. More than twice as many male codling moths were caught in the disked section than in the cover crop section. Leafhopper densities and twig infestations were also greater in the disked section, and higher densities of Lygus species were caught in trees of the cover cropped section. Apple scab was more severe in the cover cropped section, which was believed to have been caused by higher humidity.

Six types of cover crops were evaluated for growth, biomass production and phenology in a newly planted apple orchard in Courtland. The six covers were rye, tetraploid rye, ladino clover, 'Salina' strawberry clover, 'Mt. Barker' subclover and resident vegetation. The two rye varieties proved to be the tallest cover crops and exhibited the highest seasonal biomass production. Ladino and 'Salina' strawberry clovers bloomed through early fall, while the other cover crops died by early summer. 'Mt. Barker' subclover and resident vegetation contained the highest levels of aphids and the two rye varieties had more leafhoppers. Ladino and 'Salina' strawberry clovers supported by far the most predators and parasites.

In the final experiment, half of a small Martinez vineyard was undersown with a bell bean cover crop, and half was kept free of vegetation. Few differences were observed in aphid and leafhopper populations, except on a few sampling dates when populations in the disked section were greater. Parasites were more abundant in the cover cropped section, especially after midJune.

The authors recognize that separating the effects of cover crops on arthropods from other sources of variation, such as soil and microclimatic differences, are not possible in these unreplicated experiments. However, some trends were observed among the studies and several conclusions were drawn: 1) Cover cropped orchards and vineyards in general had less colonization and infestation of pests, more soil dwelling predators, and higher removal rates of artificially placed prey than those which were free of vegetation; 2) An abundance of prey on the cover crops (aphids and leafhoppers, etc.) drew varying numbers of predators, although this did not always result in higher predator levels on the trees; 3) Legume cover crops with extended bloom supported the largest reservoir of natural enemies.

(CAI.OO1) *Contributed by Chuck Ingels*

Orchard floor mulching trials in the U.S.A.

Lanini, W. Thomas, John M. Shribbs and Clyde E. Elmore

LeFruit Belge, 3rd quarter, pp.228-249. 1988

This article presents an extensive review of literature and current research activities related to living and nonliving orchard floor mulches. Living mulches are cover crops or sod covers and nonliving mulches include dead organic materials such as rice hulls, small grain straw, chopped wood products, leaves, etc, and synthetic materials such as black plastic. Mulches can be disadvantageous in that they can compete with trees for water and nutrients, modify the microclimate, or harbor pests. However, the benefits of mulches, including reduced erosion, increased water penetration and improved soil characteristics, can far outweigh the disadvantages.

Numerous experiments cited in the article show that mulches help prevent erosion on sloping orchards. Other research has shown that sod mulches increased porosity, organic matter content, and aggregation of surface soils. The binding together of soil aggregates, which is of prime importance in improving soil structure and water penetration, was shown to be improved by the release of nitrogen and other organic compounds from decaying vegetation.

From evaluation of numerous experiments, the following floor management systems are ranked on the basis of availability of soil moisture (from most to least): organic mulch, bare soil, minimal cultivation, grass sod, legume sward, continuous cultivation. In separate studies, water infiltration has been found to increase when various grass covers are used as compared to clean cultivated orchards. In another study, however, infiltration was greater when a manure mulch was used than under a living mulch. In any case, "mulches increase infiltration by reducing dispersing action of large water drops from rain or sprinklers striking the ground, thus preventing surface sealing." The carbon/nitrogen ratio of mulch materials has also been found to improve infiltration; i.e. the higher the ratio, the greater the improvement.

While several researchers have monitored soil and plant tissue nutrient levels associated with different mulching regimes, leaf nutrient concentrations are considered better indicators of plant nutrition. In general, leaf nitrogen, phosphorus and potassium levels have been shown to be reduced when living mulches are used. Leaf nutrient levels in orchards with nonliving organic mulches usually increased after the first year. Trials have indicated that living and decomposing materials with high carbon/nitrogen ratios tie up soil nitrogen, so the authors recommend applying additional nitrogen fertilizers to sustain both the mulch and the trees.

Mulches act as insulators by reducing the extremes of soil heating and cooling. Cool season air temperatures decrease when mulches are present, increasing the danger of frost damage. In one study, however, a living mulch in a peach orchard delayed the warming of the soil in the early spring so that the trees blossomed later, thus reducing the chances of damage due to late frosts. Summer mulches have been observed to create cooler soil and air temperatures than bare soils, which can preserve fruit quality. Mulches have also been shown to reduce the loss of humus and nitrogen as a result of less sunlight reaching the soil.

Living mulches can have a profound effect on beneficial and pest organisms in the orchard, according to the article. The blossoms of some weed species can compete with tree blossoms for bee visits. Certain diseases have also been found to be associated with various mulches. Vertebrate pests can potentially increase when mulches are used. Research indicates that pest insects appear to be preferentially attracted to broadleaf plants, so it is recommended to carefully evaluate these plants before use as orchard mulches. Ground covers in general help reduce dust in orchards. Less dust will reduce populations of harmful mites by enhancing populations of beneficial insects. In one study, parasites of codling moth in apple orchards increased when ground covers of various weeds were used.

In terms of weeds, a hay mulch used in combination with simazine was very effective in weed control; the researchers proposed that the mulch also reduced simazine residues and soil leaching. Thick mulches can reduce weed populations by shading the ground, thus inhibiting weed seed germination, and by the sheer weight of the mulch, which suppresses weed growth.

Numerous experiments cited in this article indicate that living mulches may compete with trees, although strip spraying in the tree row often reduces this negative impact of the ground cover. The growth of young trees appears to be inhibited by living mulches due to competition for moisture and nutrients. Mature tree growth, on the other hand, appears to be enhanced by vegetative cover because they are more competitive for light, they have more extensive root Systems, and because erosion is reduced and soil organic matter increases with time. Decomposing mulches, however, increase tree growth more rapidly than do living mulches. Allelopathy of certain plants has been shown to inhibit weed growth, but may also suppress tree growth.

More and more growers are adjusting their orchard floor management practices to modify soil fertility, modify orchard microclimates, improve soil and water conditions, increase equipment traction during wet weather, and modify pest complexes. While no standards exist for mulch use in orchards, continued research efforts should resolve many of the limitations and unanswered questions in the practice of mulching.

(CAI.002) *Contributed by Chuck Ingels*

New plow saves soil, harnesses microbe power.

Kaniuka, R.

Agric. Res. 36(2): 12-13. 1988

Several University of Nebraska researchers have developed a modified sweep plow that loosens soil and increases water holding capacity while undercutting and killing a cover crop, but leaving residues on the surface. Earlier versions of the sweep plow caused sheer planes, which reduced infiltration of water and interfered with root penetration. A key feature of the current version is the presence of 6-inch-long steel shanks that break up soil in the sheer zone, and keep the soil porous.

(RLB.OO1) *Contributed by Robert Bugg*

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Ichneumonidae (Hymenoptera) using extrafloral nectar of faba bean (Vicia faba L., Fabaceae) in Massachusetts.

Bugg R.L., R. T. Ellis and R.W. Carlson

Biol. Agric. & Hort. 6: 107-114 1989

Extrafloral nectaries of faba bean (also called fava bean, bell bean, or horse bean) occur on the stipules. These nectaries appear as dark spots, from early vegetative growth through late pod filling, and are attractive to various insects, including the adults of ichneumonid wasps, which attack and parasitize other insects, including many pests. From mid-September through late October in coastal Massachusetts, sixty specimens of Ichneumonidae (Hymenoptera), representing 20 species and four subfamilies, were observed feeding at the extrafloral (stipular) nectaries of faba bean (cv 'Ipro'). Of the ichneumonids collected, three were known parasites of lepidopterous pests of agriculture, two of forest Lepidoptera, and three of both agricultural and forest Lepidoptera.

(RLB.002) *Contributed by Robert Bugg*

Lupin as a biological plough: evidence for and effects on wheat growth and yield.

Henderson, C.W.L.

Austral. J. Ex[. Agric. 29: 99-102. 1989

Effects of sowing density of blue lupin (*Lupinus angustifolius* L. cv 'Illyarrie') on a following wheat crop (*Triticum aestivum* L. cv 'Gutha') were investigated on a compacted, earthy sand soil. Lupin population densities ranged from 25 to 200 plants per sq. m. High-density plantings of lupin were better able to alleviate compaction, although total lupin biomass declined as density increased. Peak biomass production was about 260 g/sq. m; as density increased, biomass declined about 25%. The reduced compaction was apparently due to the increased numbers of taproots penetrating the compacted soil. The contribution to improved wheat yield was estimated to be about 100 kg/ha. In comparison to improvements due to nitrogen fixation and breakage of disease cycles, this contribution is minor, but could be important on compacted sandplain soils. Other benefits of high stand densities include reduced erosion, less crop disease, better weed control and more efficient harvesting.

(RLB.005) *Contributed by Robert Bugg*

Subterranean clover cover crop used to increase rice yield.

Dabney, S.M., G.A. Breitenbeck, J.L. Griffin and B.J. Hoff

Agron. J. 81:483-487. 1989

Subterranean clover (*Trifolium subterraneum* L., cv 'Woogenellup') was used as a cover crop preceding rice (*Oryza sativa* L., cv 'Labelle'), under two clover regimes (clover vs. fallow), two tillage regimes (rototilling vs. no tillage), and four levels of nitrogen fertilizer addition (as urea): 0, 56, 112, and 168 kg/ha. Under the notillage regime, clover was suppressed by herbicide. The subterranean clover contained from 70-110 kg/ha of nitrogen prior to rice planting, and increased rice yields by about 10% across both tillage and all nitrogen regimes. Nitrogen content was higher in rice following subterranean clover than following fallow, but the clover did not reduce the amount of nitrogen required to generate maximum rice yields. Tillage increased nitrogen assimilation by rice only after fallow; clover did so only following no-till management. Maximum yields of rice under no-till management were greater than or equal to those obtained with tillage. No-till management resulted in better reestablishment of subterranean clover stands than did spring tillage.

(RLB.008) *Contributed by Robert Bugg*

Water Infiltration problems and management in orchards.

Prichard, Terry

Presentation at 12th Annual Field Day, May 2, 1989, Nickels Soil laboratory, Arbuckle, California. 1989

UC water management specialist Terry Prichard summarized the problem of poor water infiltration and orchard management practices to help overcome this in a presentation to growers at the Nickels Soil Laboratory in Arbuckle.

Twenty-three percent of California's irrigated cropland suffers an annual loss of $500 per acre or more due to poor water infiltration. The problem is widespread in the Sacramento and San Joaquin valleys, on both coarse and fine-textured soils.

Soil conditions that cause poor infiltration include surface crusting (either "depositional" crusting due to particle orientation, or "structural" crusting from clay swelling) and problems throughout the soil body, such as when the soil has a high salt content. Water that is low in total salts (less than 75 ppm) or high in sodium will infiltrate poorly. Tillage and heavy equipment that lead to soil compaction or the formation of a plow pan can also inhibit water infiltration. Many management practices can improve water infiltration. Reduced tillage, lighter equipment, larger wheels, and fewer trips can prevent further soil compaction. Crop residue management, including winter annual cover crops, can improve infiltration. Perennial cover crops are likely to increase water use, however. Chemical amendments such as gypsum can help, if indicated by soil and water analysis. If low-salt water is the source of the problem, blending water from a source with higher total dissolved solids (TDS) may help. Irrigation management is important: maximize winter storage by filling the soil profile early, don't wait until too late to start irrigating in the spring, and maximize the distribution uniformity of your irrigation system.

(JSA.003) *Contributed by Jill Auburn*

Nutrient cycling.

Liebhardt, Bill and Dave Chaney

Presentation at Fertilizer Use and Management in the Tahoe Basin. A workshop held 27 April, 1989. North Tahoe Conference Center. 1989

Fertilizer management in the Tahoe Basin was the focus of a one- day workshop held April 27 at King's Beach, California. The meeting was sponsored jointly by the Nevada Tahoe Conservation District and the Tahoe Resource Conservation District with the assistance of the USDA Soil Conservation Service and the University of Nevada Cooperative Extension. Presentations were aimed at golf course managers, landscapers, and ski slope managers in the Lake Tahoe area, and addressed the impact of nutrient management on the lake's water quality. Throughout the day, speakers emphasized the need for good erosion control through proper irrigation and vegetation management; and the importance of fine tuning fertilizer applications in conjunction with irrigation. The workshop began with this presentation on nutrient cycling. It set the stage for other talks including fertilizer programs for turf and ornamentals, and fertilizer management on critical areas.

Numerous studies of Lake Tahoe since 1959, but particularly those of the Lake Tahoe Interagency Monitoring Program since 1978 have documented an increasing nutrient load to the lake. The impact of this nutrient load is increasing algal growth and, ultimately, a loss in water clarity in a lake renown for its crystal clear water. Since sewage from the Tahoe Basin is now transported elsewhere, added nutrients originate mainly from non-point sources such as disturbed soils (construction and industry), enhanced runoff over impervious surfaces (roads, pavements), air pollution, destruction of natural vegetation and wetlands, and fertilizer applications.

Construction and Industry. Extensive shoreline development has been closely correlated with increasing rates of algal growth in Lake Tahoe. Home, recreational, and industrial development have all led to increased nutrient and sediment loading to both streams and groundwater that ultimately affect the lake. Watersheds of the Tahoe basin are the most important source of nutrients responsible for algal growth (N and P). Nutrient yields from these water-sheds are directly related to the extent of soil disturbance in those watersheds.

Enhanced Runoff. Many important nutrients in the form of ammonia and nitrate settle from the air into the basin. Those nutrient chemicals that fall on the surrounding watersheds (rather than on the lake itself) in the undisturbed ecosystem, are available for use by the wide variety of plant communities in the region. The disruption of the uptake of nutrients by these natural plant and soil communities allows the accelerated release of nutrients that were already part of the watershed soil through natural means. In recent years, Tahoe algae have become more sensitive to additions of phosphorus and trace metals in conjunction with nitrates as growth-stimulating substances. Phosphorus in particular is strongly associated with the sediments transported by stream flow.

Surface runoff becomes particularly enriched in these nutrients as watersheds erode. This highlights the need for erosion control.

Importance of Wetlands and Natural Vegetation. Wetlands are a crucial buffer between the land and receiving waters. The marsh vegetation performs two important functions: 1) It removes nutrients; and 2) It slows the flow of water permitting all but the finest sediment to settle out. Perhaps most important to the Lake Tahoe ecosystem is the ability of wetland bacteria to convert nitrogen compounds, so stimulating to lake algae, to unusable nitrogen gas by the denitrification process.

Fertilizer Applications. More information is required in order to assess how quickly and to what extent fertilizers applied to the basin's lawns and golf courses travel to the lake. Studies of shore-zone attached algal growth indicate that fertilizers are transported both by groundwater and surface runoff to the lake's edge. Excess nutrient loading caused by fertilizer application could easily be corrected through use of slow-release compounds, more careful management practices, and by intercepting and treating runoff. Basic information on nutrient flow and cycling within soils, together with applied research can provide a more sound basis for management recommendations and appropriate regulation of fertilizer use.

The flow of nutrients through a plant ecosystem is influenced by the basic properties and characteristics of its soil. Properties that affect the soil-air-water dynamics of an ecosystem (texture, structure, chemical and biological constituents) are particularly important in this process. Nutrient uptake by plants is accomplished through a number of processes: mass flow, the movement of plant nutrients in a flowing solution; diffusion, movement by natural dispersion from areas of high to low concentration; and root growth into untapped soil resources. Once the nutrients reach the root surface they are absorbed into the plant by complex biochemical reactions which are not fully understood.

Soil organic matter plays a crucial role in enhancing nutrient uptake and cycling. Besides supplying some of the important plant nutrients, organic matter has also been shown to: enhance the cation exchange capacity (CEC) of a soil, increase soil water content at field capacity, increase both air and water flow rates through soil, reduce soil erosion, and mobilize micronutrients.

Geochemical cycling is a broad term used to describe the patterns of mineral movement within and between air, soil, and water. These flow patterns can be split into two basic phases: sedimentary and gaseous. All minerals have a sedimentary phase. This means that the minerals are soluble in, and transported by water. Such elements as P, Ca, Mg, and B develop from the weathering of rock and occur exclusively in sedimentary phases. Elements that also occur in gaseous phases are C, H, N, and 0. These may follow a sedimentary pattern as ions moving from the land to water. In addition, these elements may then move as gases to the atmosphere where they eventually return to soil and water in precipitation. Plants play an important part in these processes by providing additional routes for the flow and balance of elements in the ecosystem. For the purposes of this workshop, the nitrogen cycle shows the importance of fertilizer management in conjunction with water use. This is due to the high potential for leaching of nitrates. The phosphorus cycle shows the need for fertilizer management in conjunction with erosion control. This is due to the abundance of phosphorus on the top 1-2 feet of soil which, without vegetative cover, may be subject to loss through erosion.

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Development of a fertilizer management program for turf and ornamentals.

Bowman, Dan

Presentation at Fertilizer Use and Management in the Tahoe Basin. A workshop held 27 April, 1989. North Tahoe Conference Center. 1989

How do we determine the best fertilizer program for turf and ornamentals? In most situations it is a combination of one or more of the following: experience and observation; soil analysis (mainly for P and K); predetermined schedule; and second guessing. Recommended rates will vary widely depending on species, soil type, climate, etc. If using plant tissue analysis the quantity of N in the leaves should be about 4%. The following table gives the range of common rates for a number of turf situations:

Area	lbs N /1000 sq. ft./year
home	1-4
park	1-4
athletic field	2-8
fairway	2-4
putting green	6-10

"There is no great mystery surrounding a proper fertilization program, but there may be different goals for different crops. The agronomist's is to maximize yield and profits. The turf manager's is to promote vigor and appearance of the turf." Both will seek to minimize environmental damage as well. "Considerable scientific evidence from across the country suggests that there is little potential for significant nitrate leaching when sound fertilization practices are followed. This means that small amounts of soluble nitrogen, fertilizers are applied frequently, or that slow release fertilizers are used. Irrigation should be applied wisely to avoid excessive leaching volumes. This is especially true with sandy soils, where the possibility for rapid water movement and nitrate leaching is greatest. It is not unreasonable to expect that less than 5% or even 1% of applied fertilizer N leaches below a turf root system, given careful management." Release rates for fertilizers will vary depending on source and composition, so check with your salesperson to get accurate figures.

Several studies were mentioned which show the potential for leaching of nitrates under turf. Particularly under careful management, very little nitrates were found to move into the subsoil or groundwater. This is due mainly to rapid absorption of N by grass and microorganisms associated with its extensive but shallow root system.

Seven important components of fertilizer management were summarized:

- Use fast release, highly soluble fertilizers sparingly.
- Make use of slow-release forms.

- Know your soil.
- Irrigate carefully and watch the weather.
- Never mow more than 1,3 of total leaf area and return clippings as much as possible.
- Manage for vigorous roots.
- Monitor groundwater if possible.

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Fertilizer management on critical areas.

Jarrell, Wesley

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Fertilizer management on critical areas has three main objectives: 1) Erosion control; 2) Enhanced plant-soil-water relationships; and 3) To sieve excess nutrients out of water moving through the soil profile. The focus here should be on managing the root system. Criteria to measure success of critical areas management would be how well an area is being protected, how long the protection will last, and whether or not the system is low-input and low-maintenance. The factors most likely limiting plant growth in critical areas include: Nitrogen, phosphorus, and soil pH (either too acidic or too alkaline). Plant selection is a major part of managing critical areas. Important species to consider for these areas are:

Legumes (burclover, lupin, medics, vetch, and native species); actinorrhizal plants (alder, ceanothus, cercocarpus, pursia) and other native species.

Important tools in effective management of these areas are a complete and accurate soil survey, access to a soil analysis lab, and a means of plant tissue testing. Determining adequate levels of nutrients in plant tissue for best growth is an area requiring more research. Values have not been determined for most wild species.

(DEC.038) *Contributed by Dave Chaney*

Yield and plant nutrient content of vegetables trickle- irrigated with municipal wastewater.

Neilsen, G.H., D.S. Stevenson, J.J. Fitzpatrick and C.H. Brownlee

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Four years of data for vegetables grown on a loamy sand showed that yields of tomato, sweet pepper, onion, cucumber, bush bean and melon trickle- irrigated with effluent were greater than or similar to yields obtained with well water. The effects of effluent irrigation on nutrient concentrations in plant tissue were variable. For example, Zn concentration decreased while P concentration increased in crops irrigated with effluent. Soil tests indicated a slight increase in the exchangeable Na content of the soil at the 0-0.3 meter depth over the four years of experimentation. "No major limitations were found for the production of high yields of vegetables irrigated with municipal wastewater on the loamy sand soil at the experimental site after 4 years."

Municipal wastewater has long been regarded as a potential source of irrigation water for crop plants. Depending on the particular crop in question, effluent may provide both the necessary moisture and essential elements required by the plant. There are, however, several problems to consider before recommending wastewater as a viable option for growers. In general, these problems relate to: 1) toxic levels of salts or heavy metals; 2) the presence of pathogenic microorganisms; 3) the nutrient concentrations relative to crop needs; and 4) the method of delivery.

Drip irrigation provides a solution to some of these limitations by providing a slower, more easily regulated and directed flow of wastewater to the crop. Drip tubes placed at the soil surface reduce the problem of leaf burn associated with excess Na or Cl levels on foliage. In addition, a Monterey Regional Water Pollution Control Agency study (see reference) has shown that wastewater which has been flocculated and filtered poses a very small risk of viral, bacterial and metal contamination on sprinkler irrigated vegetables. This would imply an even smaller risk when applied through a drip irrigation system. With adequate flocculation and filtration, local municipal effluent should be considered as a potential option for drip-irrigating vegetables.

REFERENCE: Monterey Regional Water Pollution Control Agency. 1987. Monterey waste water reclamation study for agriculture. Univ. of Calif. Engineering-Science, Berkeley.

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Policy and regulations affecting chemicals in the human food chain.

Archibald, Sandra

pp.115-126 in: Chemicals in the Human Food Chain: Sources, Options and Public Policy. Proceedings of symposium sponsored by UC Agricultural Issues Center, June 2-3, 1988. 1988

Regulations affecting the use of agricultural chemicals are made in a policy arena involving consumers, chemical manufacturers, the food industry, and regulators. The study group on public policy and regulations for the Agricultural Issues Center's 1987-88 study of "Chemicals in the Human Food Chain" used both literature and interviews to identify the perspectives of these different groups. Sandra Archibald, of Stanford University's Food Research Institute, summarized their conclusions at the June, 1988 symposium.

Regarding food safety, consumers express concern that suspected or known cancer-causing chemicals are being used on foods. Consumer activists believe that uncertainty justifies doubt: as long as the health risks from exposure to chemicals are unknown or uncertain, they believe it is best to err on the side of being conservative. Producers believe that current safety standards are adequate, and that our food safety and quality are the highest in the world. Processors feel that zero risk is an unattainable goal, and that zero tolerance as a food safety standard makes no sense because our ability to measure 'zero' changes with technology. Retailers hope that a compromise can be made that satisfies both consumer and industry concerns. Chemical manufacturers feel that too much emphasis is being placed on synthetic chemicals, despite the risk from naturally occurring toxins, disease-causing pests, and personal lifestyles such as smoking, drinking and driving cars. Similarly, regulators feel that California's regulatory system is the best in the nation, and that excessive attention to chemicals detracts from regulating greater risks. Risk assessors think that the credibility of existing risk standards is coming into question, due to the inconsistency between regulation of raw and processed foods. A risk-benefit framework is used for regulating raw agricultural produce, whereas a zero risk standard is used for carcinogens in processed food.

"Thus there is an array, a continuum, of differing perspectives about food safety standards. Everybody wants foods to be clean, to be wholesome, to be nutritious, and to be of high quality. Yet there are different perspectives on the policy debate. Hopefully, understanding these different perspectives can move us in a new direction toward consensus."

The study group also outlined the different groups' perspectives on the scientific database, the effectiveness of current regulations, and the compromises that they might accept. The proceedings of the conference, and longer reports from each of the study groups, are for sale by Publications, UC DANR, 6701 San Pablo Ave., Oakland, CA, 94608: Publication Number MC-P3 ($15.00), for the proceedings, and CHEM-2 ($10.00) for the longer report by the public policy study group.

(JSA.O1O) *Contributed by Jill Auburn*
