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In This Issue:

Sustainable almond comparison update.

Hendricks, Lonnie

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Editor's note: This article written by UC Farm Advisor Lonnie Hendricks summarizes results of on-farm research conducted through funding from UC SAREP. (Reprinted with author's permission.)

"During the past three years I have been observing the pest and beneficial levels in first two orchards, and now five orchards with various combinations of cover crops and pest control practices. The observations have been on Nonpareil variety in all cases, and Carmel is the pollenizer. The GA orchard is unsprayed, with a vetch cover crop. The RA orchard has a dense native cover. It was sprayed dormant and in-season in 1988 and 1989, and part was sprayed dormant only and part no spray in 1990. The DB orchard is unsprayed with a moderately dense native cover. The TT orchard has had a heavy spray program with a disked orchard floor in 1989 and a sparse to moderate native cover in 1990. JB has a dormant spray only and a very good native cover. All of these native covers have been mowed on an alternating middle basis so that alternate rows already have a good stand of cover.

"There are many questions to answer about the consequences of reduced pesticide usage and the effects of cover cropping. 'Will rejects increase over time? Will cover crops enhance the beneficial populations? How do spider mites and scale respond?'

"The following tables summarize the reject levels in these orchards for the period each has been in the program. These rejects are based upon hand harvested samples of 1000 or 2000 Nonpareil nuts per sample from the windrows at the grower's harvest. These are usually 50 percent to 100 percent higher than the values from the processor, since we count nuts which may be blown out in the huller.

	% REJECTS 88			% REJECTS 89			HARVEST DATE 89
ORCHARD	NOW	PTB	TOTAL	NOW	PTB	TOTAL	
GA: Vetch/No Spray	0.9	1.9	2.8	0.95	0.15	1.1	9/15
RA: Native/Sprayed	2.4	0.3	2.7	1.6	0.2	1.8	9/18
DB: Native/No Spray	n/a	n/a	n/a	0.85	0.55	1.4	8/18
TT: Disk/Sprayed	n/a	n/a	n/a	8.8	0.7	9.5	8/23

	% REJECTS 1990				HARVEST DATE 90	WINTER 89 MUMMIES/TREE
ORCHARD	NOW	PTB	ANTS	TOTAL		
GA: Vetch/No	0.3	0.1	0.1	0.5	9/12/90	0.4/TREE

Spray						
RA: Native/No Spray	1.9	1.0	0.3	3.2	9/09/90	0.5
RA: Native/Dorm Only	1.5	0.9	0.2	2.6	9/09/90	0.7
DB: Native/No Spray	3.0	1.5	2.0	6.5	8/22/90	0.4
TT: Native/No HS Spray	4.6	1.6	0.2	6.4	8/27/90	1.0
TT: Native/HS Spray	6.0	0.5	0.0	6.5	8/27/90	1.0
JB: Native/Dorm Only	6.9	0.5	0.0	7.4	9/07/90	N/A

Native = Resident Vegetation
HS = Hullsplit
Dorm = Dormant Spray

Comments

"The GA orchard with a vetch cover crop (disked in June) and no sprays has been among the very lowest in worm related reject damage throughout the three year test period. It appears that both peach twig borer (PTB) and navel orangeworm (NOW) are kept under control by general predators. There is also predaceous mite called *Pediculoides* which has been reported to attack PTB in the hibernaculum during the winter. We are searching for this mite this winter. Without pesticide pressure this orchard has not had a scale buildup. This orchard has developed a population of the tydeid mite. The tydeid is a pollen and fungus feeder which may also feed on mite eggs. It is a good prey for the Western orchard predator mite. This mite does little to no damage to the almond leaves, and the trees are still in good shape in mid-October. All of the unsprayed orchards have high numbers of spiders which are excellent predators and very sensitive to pesticides, especially pyrethroids.

"The RA orchard has a much more lush cover crop of alternate middle mowed native species than when we began observations in 1988. The beneficial populations are excellent. The very good predation kept the spider mite population to nearly zero until July. This also meant that the predator mite population was low. The heat of summer brought on a two-spotted mite outbreak which took some time for the predator mite and thrips to control. Sometimes the trees can be too clean! Fortunately tydeids also are slowly building in this orchard, and we hope these will provide food for an early buildup of the predator mite in 1991. In mid-October many predator mites can be found. The reject levels are low this year whether or not a dormant spray was applied.

"The DB orchard has not been sprayed for several years. The cover is improving this year. Worm counts of 4.5 percent are a bit high. This orchard had low mummy counts, but the block adjacent had higher mummy numbers. This shows the importance of neighborhood cooperation in fighting the NOW. This grower also felt that he harvested about a week too late.

"The TT orchard has a first year native cover beginning to become established. In mid-October the germinating cover looks very good for 1991. The mummy levels were reduced from 1989, but were still the highest of the four orchards counted. Reject levels have improved about three percent from 1989, and we think we can make even more progress in 1991 with improved sanitation and a better cover crop stand. Our NOW egg traps showed that the egg laying was out of phase with the hullsplit spray. This may explain the lack of worm control with the hullsplit spray.

"The JB orchard was very clean and no in-season spray was needed for mites. Predator levels were very good, which kept mite levels very low. Unfortunately some neighboring orchards were not as clean as JB's and NOW flew into this orchard. Rejects were unacceptably high. This again points out the need for neighborhood and area sanitation efforts.

Conclusion

"**Sanitation** is a basic requirement for all almond orchards regardless of the other pest control methods used. The ideal is to have no mummies in the trees at bloom. Be sure to check for nuts lodged in the tree crotches.

"**Cover cropping** enhances other pest control measure by providing a refuge for beneficials. Beneficial populations build earlier in the season and have more resilience with a cover crop. Try to maintain as good a cover as possible consistent with the other necessary orchard practices. Sometimes the easiest way to control difficult weeds such as nutsedge is to smother them with a dense, desirable cover crop.

"**The transition** to reduced spraying takes time. Time is needed to reduce mummy load, reduce pest carryover, reduce pesticide residues, establish beneficial habitat, and to build up a useful population of beneficials. Think in terms of several years, not months."

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Field development of resistance to *Bacillus thuringiensis* in diamondback moth (Lepidoptera: Plutellidae).

Tabashnik, B.E., N.L. Cushing, N. Finson and M.W. Johnson

J. Econ. Entomol. 83(5): 1671-1676. 1990

The research results reported in this paper have significance to all growers who use *Bacillus thuringiensis* (Bt) and to researchers involved in the insertion of the Bt toxin gene in crop plants. Bt is a microbial insecticide which has been used for about 20 years, and is sometimes the only effective insecticide available to organic farmers for the control of lepidpoteran insects. Bt becomes active upon ingestion by the larva as the spores readily dissolve in the alkaline gut, releasing the toxin. The toxin paralyzes the guy causing the larva to stop feeding. While resistance to Bt has been developed in laboratory selections of Indian-meal moth and tobacco budworm, there has been no conclusive evidence of field resistance to Bt. Bt's unique mode of action and the lack of reports of field resistance have led many to believe that such resistance is unlikely.

This experiment arose out of a long-term study to determine if diamond-back moth (*Plutella xylostella* L.) populations in Hawaii differed in their susceptibility to Bt and to establish baseline data on susceptibility. The initial survey was conducted in 1986 and 1987 on six commercial farms of broccoli, cabbage, and/or watercress on three Hawaiian islands. Greenhouse bioassays using cabbage leaf disks and Dipel® were performed on collected larvae. On one 4-hectare watercress farm, Bt was used 50-100 times from 1978 to 1982; however, because of perceived decline in efficacy during this period, the grower did not use this formulation of Bt after 1982. In 1988 and 1989, the grower applied Javelin®, a newer formulation of Bt, to his crop 15 times for diamondback moth control. Larvae were retested for resistance in 1989 (using Dipel) from this and one other farm, which received minimal Bt treatments. Previously untreated lab colonies were also treated with the same formulation during both test periods.

The 1986-87 survey found that larvae from the heavily treated watercress population was significantly more resistant to Bt than the laboratory population, based on LC_{50} (concentration required to kill 50 percent of the population) data. The 1989 population from this farm showed a significant increase in resistance to Bt (more than double the LC_{50}) compared to the 1986-87 survey. However, there were no significant differences in the population from the minimally treated farm between the two sampling periods. The data "strongly suggest that field applications of Bt caused evolution of resistance" in the watercress population. These conclusions are supported by the fact that, at the field rate, this population had a mortality in 1989 of only half of that in 1986-87. The mortality of the population from another farm was similar to the watercress farm, but was only test in 1989.

Other data from commercial insecticides and electrophoretic studies "suggest that gene flow among diamondback moth populations in Hawaii is too low to counteract selection for resistance." Furthermore, cross-resistance to different Bt strains has been shown to occur. For instance, laboratory studies from another *Plutella* species found that resistance to Dipel developed in 36 of 57 Bt isolates tested. Data from the watercress study indicated that the use of Javelin increased resistance of diamondback moth to Dipel.

The authors believe that this is the first study which has documented substantial field resistance to Bt. The study therefore may provide a strong argument in favor of extreme caution in developing genetically engineered crop plants in which the Bt toxin gene is expressed: "Expression of Bt toxin genes in crop plants and related advances in technology are likely to intensify selection for resistance to Bt." Reliance on numerous Bt sprays per season may also select for resistance, as with any commercial pesticide. Specific tactics for prolonging the efficacy of *Bacillus thuringiensis* were given. These include: 1) genetically altering crop plants to express the toxin genes in specific tissues and/or under certain conditions; 2) allowing plants to grow in the system which have not been genetically engineered or sprayed; and 3) modifying spray treatments to avoid inducing resistance (no specific methods were given).

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(CI-PEST.026)
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Winter 1991 (v2n1)

Relative efficacy of *Bacillus thuringiensis* insecticides for controlling omnivorous leafroller in grapes.

Norton, Maxwell

Article written for Components. 1991

The developing popularity of biological control and the recent trade disputes over cryolite have greatly increased interest in using *Bacillus thuringiensis* (Bt) insecticides for controlling omnivorous leafroller (OLR), grape leaf folder, and the western grapeleaf skeletonizer. In this trial, we addressed the question of whether there are significant differences among the various Bt insecticides being marketed for use on grapes in California.

Materials and Methods

In this trial, the following materials were evaluated: Javelin (Sandoz), Dipel (Abbott Labs), Biobit (Fermone-DuPont), and Bactospeine (PBI/Gordon). A mature Chenin blanc vineyard with a history of OLR damage was treated on May 8 to 11, 1990 and June 6, 1990 using an electrostatic sprayer at 50 gallons per acre (gpa) in the spring and 100 gpa in the summer using the following rates:

Pounds Formulated Per Acre	
May Treatment	**June Treatment**
0.5 Dipel	0.5 Dipel
0.5 Javelin	0.5 Dipel*
1.0 Dipel	1.0 Dipel
1.0 Javelin	1.0 Javelin
1.0 Bactospeine	1.0 Bactospeine
1.0 qt. Biobit	1.0 qt. Biobit

*The 0.5 Javelin treatment was inadvertently treated with 0.5 Dipel on June 6.

Each treatment was replicated three times with six 230-vine rows per rep in a randomized complete block design. During the growing season, five clusters from each of 12 vines in the center two rows were examined for OLR infestation using a presence/absence method. These surveys were made on: May 3, May 19, May 24, May31, June 16, June 21, July 9, and July 23. Percent OLR infestation during the growing season ranged from zero to 10 percent with none of the treatments nor dates being statistically different from each other.

A pre-harvest cluster evaluation consisting of 100 clusters per rep was made on August 20 and was evaluated for evidence of OLR and any type of bunch rot. It is generally presumed that OLR damage is a major cause of bunch rot.

Results and Conclusions.

The percent of bunches with OLR and bunch rot just prior to harvest are summarized in Table 1.

Table 1		
Material	**% OLR***	**%Rot***
CONTROL	35.7 A	47.7 A
0.5 Dipel	21.3 B	33.3 B
0.5 Javelin/0.5 Dipel	24.0 B	35.7 B
1.0 Dipel	22.7 B	30.7 B
1.0 Javelin	21.7 B	31.0 B
1.0 Bactospeine	27.0 B	33.0 B
1.0 qt. Biobit	22.0 B	33.0 B

*Values within columns followed by the same letter are not statistically different at 5% significance level.

It appears from the above data that all of the treatments and rates significantly reduced OLR infestation and bunch rot, but not to commercially acceptable levels with only the two timings employed. None of the materials or rates were different in efficacy. It may be that the **frequency and timing** of applications are more important than the materials or rates applied.

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Timing *Bacillus thuringiensis* insecticides for omnivorous leafroller control in grapes.

Norton, Maxwell

Article written for Components. 1991

The use of *Bacillus thuringiensis* (Bt) in California vineyards for Lepidopteran pest control has greatly increased in the last five years. This is due primarily to growers' desires to enhance biological control in their vineyards and also to the restriction of cryolite in 1990 as an insecticide alternative. More information is needed regarding optimum timing of Bt applications as well as their frequency.

A common strategy is to treat both the first and second broods and "bracket" each treatment 10 to 14 days later. In this trial, we attempted to address the questions of: how important are second brood applications versus first brood, and how important are 10- to 14-day bracket applications?

Materials and Methods

Four timings were employed:

- Full bloom - 5/11/90
- 10-14 days post full bloom -5/22/90
- Second flight - 7/3/90
- 10-14 days past second flight - 7/18/90

Different combinations of the above timings were employed to provide the following treatments:

1. Full bloom + the second flight (no bracket sprays)
2. Post full bloom + post second flight (the bracket sprays alone)
3. Full bloom + 11 days later (first brood sprays only)
4. Second flight + 15 days later (second brood sprays only)
5. No insecticides (check)

Javelin® insecticide was applied at a rate of 1.0 pound formulated per acre at 100 gallons per acre (gpa) using a power backpack sprayer to both sides of the vine. The plot consisted of eight replications of seven vines per treatment arranged in a randomized complete block design located in a mature Chenin blanc vineyard with a history of OLR damage.

Results and Conclusions

On 8/21/90, 50 clusters were picked from each rep and examined for OLR infestation and bunch rot. The results of the survey are summarized in Tables 1 and 2:

Table 1	
Treatment	**% Bunches with OLR***
CHECK	24.25 A
Bracket treatments only	10.00 B
First brood treatments only	8.50 B
Second rood treatments only	7.75 B
No bracket treatments	5.75 B

*Values followed by the same letter are not statistically different at the 1% significance level.

Table 2	
Treatment	**% Bunches with Rot***
CHECK	37.5 A
Bracket treatments only	30.75 AB
First brood treatments only	21.75 BC
Second rood treatments only	17.5 C
No bracket treatments	17.0 C

*Value followed by the same letter are not statistically different at the 5% significance level.

While each of the above treatments significantly reduced OLR infestation, none were effective enough to stand alone. Since relatively low levels of OLR damage can result in high rot levels in rotprone varieties such as Chenin blanc, the threshold for OLR damage in these varieties is, in reality, quite low.

Some previous studies have shown a correlation between incidence of summer rot and OLR infestation. If we were to presume that a correlation exists here, then the bunch rot data suggests that treatments that included a first brood application were the most important for controlling OLR and subsequent bunch rot. The primary second brood treatment also showed value but the bracket treatments were no better than the check. As stated in the above paragraph, all of the treatments should be considered in light of their contribution to a program that includes all of the timings and none should be considered as stand-alone treatments.

When considered with the results of the previous companion study that showed that 0.5 pound rates of Bt were as effective in controlling OLR as 1.0 pound rates, I conclude that a strategy that employs multiple applications of a low rate of Bt will be more effective than less frequent applications of a 1.0 pound rate. This assumption is borne out by numerous pest control adviser observations in the field.

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Farm drug use: The costly crash.

Bennett, Richard

The Dairyman 71(6): 6, 27 1990

Editor's note: This article written by UC Extension Advisor Rick Bennett raises questions about the true costs of relying solely on drugs to cure livestock diseases. Bennett suggests that managing dairy herds to prevent disease is a better approach. (Reprinted with permission of the publicsher and author.)

"Dairy and veterinary tradition and the public concern for food safety have crashed head-on. The dairy industry is, and will continue to be, the victim. For decades, since the discovery of penicillin and other antimicrobials, human and veterinary medicine have been quick and eager to dispense these so-called 'miracle' drugs. To a great extent, the dairy producer has used animal drugs as an easy out, a crutch, and excuse for inappropriate management systems. The veterinary profession, driven by customer demand to 'do something' has propagated this belief. Unfortunately, there are those who abuse the opportunity. Sure, on occasion animal life has been spared and a case of *Strep. ag. mastitis* has been cured. But few in the industry or profession apply a sharp pencil and determine the cost/benefit of disease prevention and real costs of therapy.

"When will we get beyond the 'treatment mentality' for dairy disease management? When will we begin to closely examine the economics of drug use on the dairy? In most cases the use of antimicrobial drugs has very little to do with lifesaving. Before the needle is plunged in to the hilt, how many producers stop to consider salvaging the carcass value and the real potential of the drug to return the animal to economic lifetime production?

"The great majority of the drug use decisions should be made in light of the prospects for optimizing and protecting cash flow and equity. Despite the economic realities of the big business of dairy production, most dairy producers tend to make drug use decisions as if they were treating people or pets. For others it is almost a reflex 'knee-jerk' reaction to the sight of disease. The reactions seem to say 'I must treat; there is no alternative.'

"From the business perspective, the questions are, 'Why do I have this problem? What are the real costs of treatment? Will it be cost effective?' These questions are worthy of a closer examination.

Why is disease occurring?

"When disease problems arise, why should the dairy producer be concerned about the disease problem? The basics of pathology and epidemiology tell us for every animal that appears to be diseased, there may be others (and in some cases many others) that are also affected. However, the signs of the disease may not be evident to dairy management. This is referred to as subclinical disease. The best example is subclinical mastitis. The costs of this disease and other subclinical diseases can be the financial ruin of a dairy farm.

What is the real cost of treatment?

"The cost of treatment is usually viewed as the cost of the medication. Many producers regard this cost as insignificant. While this may be true for the penicillin class of drug, the newer antimicrobials that are used on the modern dairy are far from inexpensive. The cost of treatment does not end with the drug. Treatment with most drugs means that milk and meat must be free of violative residues before it may be marketed. Federal law stipulates that antimicrobial drugs that are dispensed on the order of a veterinarian, or those used in an extra label, have a zero tolerance residue level for meat and milk. Hence, it is not uncommon to find cows that are out of the production string for ten to fourteen days. Additionally, should a disease cause treatment and culling of the animal, certain drugs may not clear the animal tissues for over sixty days. In this case, that animal would either be rendered or held for sixty days before slaughter. The costs of withholding must be added to the cost of treatment. Studies of a California dairy revealed that the cost of milk discard necessitated by the treatment for coliform mastitis amounted to approximately $24,000 per year, for ten years.

"Another cost that is seldom added to the aggregate cost of treatment is the cost of milk and meat rejected for sale due to violative residues. The loss of a large quantity of milk or even a small bulk tank can amount to significant dollars and should be included in the total cost estimates. Newer, more sensitive residue tests will increase the probability of milk and meat rejections. The producer who avoids the financial calamity of such a loss by routine on-farm milk testing and protection of an insurance policy should add these costs to treatment as well.

Does treatment cure the disease and will it return the animal to full productive ability?

"Many times animals appear to recover after therapy, but without controlled research we cannot know for certain that the treatment worked. Even if the recovery is due entirely to therapy, does it return the animal to full economic potential? In the case of reproductive infections, the answer provided by controlled research is no. Once there has been a major infection of the reproductive tract, there is little hope for a cure. Even if a cure is achieved, the infection will induce some degree of infertility. Hence the cost of under-productivity must also be added to our total costs. Treatment failure is a common problem. There is increasing evidence that such failures are not the fault of the drug, dose, or duration of therapy. Rather we are dealing with cow-specific problems that make the infection incurable. In contrast, we treat diseases like coliform mastitis and fail to see that cows are very good at curing themselves. Hence, our chemical heroics may only *appear* to be working.

What are the labor and service costs of treatment?

"Veterinary advice, labor, and management time for the decisions and application of therapeutics have a cost. Furthermore, since we have not yet figured out how to make days longer than twenty-four hours, extra effort in this regard detracts from time that could be used for dairy management.

Consequently, an opportunity cost in incurred. For example, if an employee is treating many animals, instead of detecting heats, an additional cost is incurred.

What are the milk marketing costs of treatment?

"Perhaps the most nebulous cost of treatment is that of market liability. As regulatory policy and technology keep pace with market and consumer concerns, this cost will represent an increasing share of the cost of treatment. The recent reports of trace residues of animal drugs in retail milk has incurred a new cost of treatment. The precise cost of these reports, as reflected by current and future milk demand and price, is very difficult to determine. Nonetheless, all producers will share this cost, regardless of the individual farm drug use practices. In today's communication and media world, a 'milk' incident in Chicago is tonight's news in California. Furthermore, the intense interest in bovine somatotropin (BST) will serve to place all aspects of the dairy industry under the microscope of the news media.

"I suspect my economist and veterinary friends might be able to develop additional costs, but I think the point has been made. We are not considering the full costs of treatment.

"All these points may seem like just another academic exercise. However, dairy business people who are interested in profit and positioning the business for the future, will take heed. Should the industry loose antimicrobials or otherwise have their use highly constrained, as is the case for most pesticides, those who have sharpened their pencil and done their economic homework will be years ahead.

"The theoretical stuff aside, simple arithmetic will suggest that it may be far less expensive to cull and replace a diseased cow than to incur the costs and uncertainties of therapy.

"Disease prevention is the hallmark of excellence of today's dairy herd management, and will be the typical mode of operation in the next decade. The benefits of disease prevention efforts are generally regarded as highly cost effective. Reports of return investments of 5 to 1, ranging up to 16 to 1, have been made for some of the common dairy disease problems.

"Prevention of disease has costs too. Freestall barns, maternity stalls, paper towels, vaccines, teat sanitizers, have a cost. Capital costs, like barns and housing, are major costs. For some, it may seem to make more sense to spend money for treatment on a monthly basis rather than incur a large debt. In this case, long-term accounting, rather than monthly cash flow budgeting, needs to be employed in the economics of disease management decisions. Management choices about disease prevention need to be cost effective too. There is no point in burning down the barn to kill a few mice.

"In regards to the larger social concerns, disease prevention will act as a highway center-divider, as consumer and dairy interests rapidly approach each other from opposite directions. Prevention provides for 'Win-Win' solutions that prevent head-on collisions. Producers win because the animals remain healthy and economical, and residue-free milk is marketed. Consumers win: they get a 'safe' and high-quality product. Regulators and legislators win too, as there is no political wreckage to clean up.

"There is an alternative; avoid the collision."

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(DEC.219)
Contributed by Rick Bennett
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The role and contributions of animals in alternative agricultural systems.

Baker, Frank H. and Ned S. Raun

Amer. J. Altern. Agric. 4(3,4): 121-127. 1989

Both economic and ecological assessments show that animals play an important role in U.S. agricultural systems. The benefits listed should be particularly germane to farmers with interest in alternative, resource-enhancing production systems:

- Approximately one-half of total U.S. agricultural receipts come from the sale of livestock.
- Livestock occupy many acres of pasture and rangeland and consume large quantities of forage and crop residue.
- Livestock can even-out the negative impacts of low rainfall periods by consuming crop residue that in "plant only" systems would have been considered crop failures.
- The flexibility of animal production systems (in terms of feeding and marketing) helps cushion farmers against trade and price fluctuations.
- Livestock manure contributes to soil fertility, and production of livestock feed (particularly grasses and forages) can reduce soil erosion.
- Including livestock in farming systems results in more efficient use of farm labor.

Despite these advantages, farmers often do not choose to include animals in alternative production systems. They are constrained mainly by: 1) **economic risk factors** - "short-term profit opportunities will generally override investment in longer-term ventures, even though the latter may be more sustainable and profitable over time;" 2) **technology** - particularly for ruminants there is a need for more information about feeding systems that integrate crop, pasture and forage production; 3) **crop choices** - it is difficult to reverse the trend toward specialized one-or two- commodity feed grain operations back in the direction of more diverse systems that include pasture and forages; and 4) **labor costs and management skills.**

The authors make several recommendations for improving livestock production in the U.S. and promoting their use in alternative crop/livestock agricultural systems. First is in the area of farm policy. Government programs should give farmers the necessary incentives to make livestock the key component of production on marginal lands. This would encourage planting of soil-conserving crops. Price support programs should also be changed to include pastures and forages in rotation as part of the crop acreage base.

The second recommendation is for more research that will improve the efficiency of meat and milk production. The authors identify three key areas: 1) developing pasture and forage species that offer higher levels of digestible energy and protein; 2) improving the digestibility of high-fiber feedstuffs; and 3) optimizing the use of forages in producing leaner beef.

Lastly, the wise use of land emphasized in alternative agricultural systems will shift the economic base of marginal lands from crop production to range and pasture. This will require more research and extension on optimal range management strategies, multi-species grazing systems, and pest management.

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Winter 1991 (v2n1)

Crop rotation efficiencies and biological diversity in farming systems.

Bezdicek, David F. and David Granatstein

Amer. J. Altern. Agric. 4(3,4):111-119. 1989

Increasing biological diversity is an important goal for farmers as petroleum-based inputs (mainly fuel and agricultural chemicals) become more expensive and less available. Crop rotations play a key role in improving farm diversity by minimizing pest and disease problems, improving soil quality, reducing risk, and in some instances, increasing yields. The authors elucidate these benefits within the context of four key questions.

Why is Diversity Important?

Diversity in cropping systems is particularly important from the standpoint of pest control. Short rotations of crops with a uniform genetic base are particularly vulnerable to pest pressures. The two prime examples of this vulnerability are the tragic potato blight (*Phytophthora infestans*) epidemic in Ireland in the last century, and more recently, the corn leaf blight (*Helminthosporum maydis*) epidemic of the 1970s in this country. The authors stress the importance of maintaining a diverse genetic base as a resource for plant breeders to develop crop varieties resistant to various pest organisms. Diversity in the soil microbial and arthropod community also enhances the crop's ability to withstand pest pressures, as suggested by Cook and Baker (1983).

Which Inputs are Best--External or Internal?

This is mainly a question of resource renewability and the degree to which farmers depend on a particular input. For example, external inputs such as fuel and petroleum-based fertilizers are not intrinsically bad except to the extent that they derive from a non-renewable resource. A farmer who depends too much on them may be especially vulnerable to changes in supply and price escalations. Because diversity can improve productivity and efficiency, the authors suggest that enhancing crop diversity through rotations and crop-livestock combinations is one way of balancing out the vulnerability that can result from reliance on non-renewable inputs.

What are the Components of Diverse Cropping Systems?

Soil quality. The authors emphasize the importance of good soil structure in promoting plant health and for efficient utilization of nutrients and water. Aggregation and pore size distribution (elements of soil structure) influence bulk density and aeration which in turn affect root growth, water infiltration, and soil flora and fauna populations. Crop rotations are an important management tool in this regard. Certain types of plants, grasses for example, can promote soil aggregation more than others. Including these plants in rotation may be one way of improving soil quality. Soil fertility is another component of soil quality, as discussed in the next section.

Soil fertility. Though P and K fertilization will continue to be necessary in modern agriculture, crop rotations may provide an opportunity for supplying sufficient quantities of nitrogen without the purchase of chemical fertilizers. Many legume species are capable of fixing large quantities of atmospheric nitrogen when managed properly. Cover crop research in various parts of the country is revealing which species are suitable for a particular location and environment.

Nitrogen from legumes. The total amount of N contributed by a legume depends on the amount fixed and the proportion of plant nitrogen removed (or incorporated) at harvest. This makes legume cover crops more valuable from a nitrogen standpoint since their total biomass is incorporated back into the soil. However, even a grain legume such as soybeans may have some beneficial effect on the yield of subsequent crops, though the N contribution may actually be quite small.

The rotation effect. The rotation effect can be defined as the increase in yield that results when changing from monoculture to rotation. It can be attributed to a number of factors including reduced pest pressures, improvements in soil quality, and more nitrogen where legumes are used. (See Pierce and Rice, 1988).

Diseases, pests and weeds. Crop rotations play a key role in breaking the life cycles of various diseases, soil insects, and weeds. Examples are given for Pythium root rot and jointed goatgrass, both problems in Pacific Northwest wheat production, and corn root-worm, a serious pest of corn in many parts of the U.S.

Risk reduction. Some of the inherent risks in farming may be lessened with appropriate crop rotations. The increased diversity makes farmers less vulnerable to the economic fluctuations that may plague a single commodity. More diverse farming systems may also enhance a crop's ability to withstand periods of drought. This seemed to be the case for many farmers in the Midwest during the drought of 1988: Yields in rotational systems tended to be higher than in monocultures.

Socio-economic considerations. The authors consider two areas in particular. First, diversified cropping systems may address consumer concerns about food safety by reducing pesticide use in crop production. Second, citing Strange (1988), they suggest that "diversified farming keeps more farmers on the land, which in turn supports the quality of life in rural communities by maintaining schools, services, and neighbors."

Constraints

The authors list several constraints to improving farm diversity.

1. Government farm policy has been a serious impediment to farm diversity. The 1990 Farm Bill will allow more flexibility and incentives for farmers to include alternate crops.

2. The farmer may need to develop new management skills.

3. The markets for rotational crops can be uncertain and risky.

4. Lending institutions may be adverse to changes in the production system demanded by new rotations and alternative practices.

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(DEC.226) *Contributed by Dave Chaney*

Evaluation of crucifer green manures for controlling Aphanomyces root rot of peas.

Muehlchen, A.M. and J.L. Parke

Plant Disease 74:651-654. 1990

Crucifers have been shown to limit the activity of several soil-borne pathogens including *Rhizoctonia solani, Thielaviopsis basicola, Fusarium oxysporum, Aphanomyces cochlioides,* and *Aphanomyces euteiches*. Researchers think that sulfur compounds released during the decomposition of crucifer tissues may be responsible for inhibiting disease spread and infection.

Aphanomyces root rot (*A. euteiches*) is an important pathogen in the Great Lakes region of the United States. Greatest yield losses (about 10 percent annually) occur in peas, but the disease is also known to affect beans and alfalfa. Currently, the only known method of economical control is to avoid heavily infested fields. Work with crucifers for control of *A. euteiches* has been particularly promising. However, disease suppression has only been demonstrated in the greenhouse and in pots buried in the field. This research project was designed to evaluate control of *A. euteiches* by crucifer green manures in a true field setting.

Initial Screening

Materials and Methods. Six species of crucifer were evaluated in the field for their ability to suppress *A. euteiches*. Treatments included each species as a full season crop (planted late April) and as a fall cover crop (planted mid-August) following peas. Fallow, pea-fallow, and corn treatments were also included. Five plots of each treatment 1.2 m were planted in a randomized complete block design. Each full-season crop was chopped and incorporated into the soil at the point of maximum biomass production. Fall cover crops were incorporated in mid-October. Peas planted the following spring were evaluated for emergence and stand counts and yield. Treatments were compared by two-way analysis of variance.

Table 1 summarizes data for selected treatments (data for curled mustard greens and yellow seed mustard not shown). High variability within treatments precluded any significant differences between the various green manure treatments. Nonetheless, a significant correlation between yield and stand loss ($r = -0.681$, $P < 0.01$) indicated that crucifer amendments could potentially affect yields. The authors selected a fall cover crop of white mustard (*Sinapsis alba* L.) as the most promising treatment.

Table 1. Plant stand loss and fresh yield of peas preceded by various green manure treatments. (Fall cover crops following peas listed as peas/crop.)

Treatment (1986)	Percent stand loss1 (1987)	Pea yield (g/plot) (1987)

fallow	31.2 a2	4283
peas/white mustard	32.8 ab	427
white mustard	33.8 abc	390
rapeseed	34.2 abc	316
peas/fallow	39.8 abcd	299
peas/cabbage	41.4 abcd	323
peas/rapeseed	41.8 abcd	373
corn	42.2 abcd	380
peas/oilradish	42.4 abcd	360
cabbage	52.0 de	351
oilradish	56.2 e	288

1 Percent stand loss = (emergence stand count vest stand count)/emergence stand count x 100.

2 Mean stand losses followed by common letters are not significantly different (P = 0.05) according to LSD test.

3 Differences between mean fresh pea yields were not statistically significant.

White Mustard

A more detailed experiment was conducted in order to evaluate the effects of a fall crop of white mustard in suppressing *A. euteiches*. Following a crop of peas, white mustard was planted in late July in 15 of 30 1.2 m plots. The remaining plots were kept fallow and weed-free. White mustard was chopped and incorporated into the soil in late September. Peas were planted again the following May and evaluated for seedling emergence, root rot severity, and yield. Fallow and white mustard treatments were compared using paired-sample Student's t tests. The experiment was then repeated for a second year.

In both years, Aphanomyces root rot severity was significantly lower in plots cover cropped to white mustard. Pea yield however, did not improve significantly until the end of the second year (two cycles of fall white mustard and spring peas) when cover cropped plots showed a yield increase of 20 percent over fallow plots. This was in spite of lower pea stand emergence in cover cropped plots. Disease reduction was confirmed by a growth chamber bioassay in which a white mustard soil amendment appeared to reduce the number of infective propagates of *A. euteiches*.

Implications

Reviewer's note: This research highlights the potential for crucifer green manures to control A. euteiches in a true field setting, but it does not yet provide a good basis for making recommendations to growers. Several management issues still need to be addressed including:

1. Crucifer cover crops appeared to reduced pea emergence overall: Why did this happen and how can pea stand establishment be improved where cover crops are used?

2. When is the best time to incorporate a crucifer green manure crop for

disease control?

3. What will be the influence of the crucifer cover crop on weeds, insects, nematodes and other diseases?

4. The white mustard/pea system may be useful in the Great Lakes region, but how can this information be adapted to other regions in the U.S.?

Further research into crucifer cover crops may open up new options for disease control for peas and in other cropping systems.

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(DEC.232) *Contributed by Dave Chaney*

Editorial: Organic farming - the origin of the name.

Scofield, A.M.

Biological Agriculture and Horticulture 4:1-S. 1986

Reviewer's note: The term "Organic farming" has been the subject of much contention. By California state law, organic food is that grown and processed without synthetic pesticides, preservatives, and fertilizers. There are certain variances, but the basic thrust is to make use of naturally-occurring substances and processes for pest management and maintenance of soil fertility. Some scientists, however, have deemed the term inappropriate because all agriculture involves the production and disposition of organic matter. Moreover some proponents of pesticides have stated (only half facetiously) that their brand of agriculture is every bit as '(Organic" as any other, because they use carbon-based compounds for pest control. Before substituting alternative terms, this article recommends that we first understand the original meaning of organic farming.

The first use of *organic* in the agricultural sense was by Lord Northbourne, who himself was a biodynamic farmer. From his 1940 work *Look to the Land* (J.M. Dent, London) it is clear that *organic* was used in the philosophical sense (e.g., "having a complex but necessary interrelationship of parts, similar to that in living things"). The emphasis was on caring for the soil as a living superorganism, on the relationship of human communities to the soil, and on mixed farming and the conversion of wastes into fertilizers. Although Northbourne foresaw infinite variety in how mixed farms could be developed, the core idea would always be to develop a farm that behaved, so far as possible, as a self-contained dynamic system: in other words, as an organic whole. Farms should depend to the greatest extent possible on intrinsic resources, and as little as possible on what Northbourne termed "imported fertility."

Scofield concludes that organic farming did not refer solely to the use of living (or formerly living) materials, although such use is clearly included. The main emphasis was on "wholeness." Scofield closes with a pertinent definition of *organic* drawn from the Oxford English Dictionary: "of or pertaining, or characterized by systematic connexion or coordination of parts in one whole."

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(DEC.238) *Contributed by Robert Bugg*

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Marine by-products as fertilizers.

Chaney, David

Article written for Components. 1991

Editor's note: This article is one section of a new publication on Organic Soil Amendments to be released in 1991 through UC ANR Publications. Publication co-authors are Stuart Pettygrove (UC Davis Dept. of Land, Air, and Water Resources), Laurie Drinkwater (UC Davis Dept. of Vegetable Crops) and David Chaney (UC SAREP).

Marine-derived organic materials are a relatively under-exploited class of soil amendments and fertilizers. Research and field experience indicate that these materials can improve soil structure, enhance soil microbial activity, and promote plant growth. Current costs for processing and distribution, however, limit their use on a very wide scale, particularly for medium- to large-scale farmers in California's in-land valleys. Four of the most common materials plus chitin, a relatively new product, are described below.

Fish Waste. Each pound of fish sold in U.S. supermarkets results in another pound of high-nitrogen waste that is discarded in the process of cleaning and packaging. This waste by-product is usually converted through a drying process into regular fish meal which is used as a high-quality, high-value feed for poultry and livestock. As long as fish waste commands a high market value for conversion to feedstuffs, it is unlikely that it will be directed to fertilizer production on any large scale. In local situations, however, where a demand has been created, less costly methods of drying and composting can be used to produce a fertilizer-grade fish meal. This product tests out at about 10 to 12 percent nitrogen, three to four percent phosphorus, and three to four percent potassium.

Dried, composted fish meal is generally applied at rates of 200-300 pounds per acre. Exact rates should be determined through soil analysis and crop nutrient requirements. In addition to supplying nutrients directly, this product is reported to be particularly effective in rebuilding populations of beneficial soil microorganisms which, in turn, can improve overall nutrient cycling in cropping systems.

Spray-dried fish protein is another type of fish meal prepared through a specialized low temperature drying process. The resulting very fine powder is readily digested by bacteria and converted into nitrate forms available to plants. Research by Glenn McGourty and Roland Meyer at the University of California Hopland Field Station on turfgrass indicates that it provides good turf color for up to ten weeks when applied at the rate of ten pounds per 1000 square feet during cool weather. Under similar conditions other organic fertilizers failed to provide nitrates, probably because of low soil temperatures and low biological activity. Spray-dried fish protein can also be injected successfully into drip systems for fertigation. Research from the Hopland field station confirmed successful injection at a rate of 75 ppm nitrogen.

Liquid fish fertilizer is another fish waste product that may be practical in some situations. This material is manufactured through a steam cooking process of hydrolysis which extracts most of the nutrients in a liquid form.

Fish Emulsion. Fish emulsion is a secondary by-product of the fish meal industry. After removal of the solids (which become fish meal) and the oils (which go to oil products manufacturers), the remaining wastewater is usually evaporated to about 50 percent solids, making a thick, viscous end product that is bottled and sold as fish "emulsion." Since the oil has been removed, the term "emulsion" is not completely accurate. "Fish solubles" would be more appropriate, being the nonoil and nonsolid portions of the fish. As sold in gardening sections and in nurseries, this type of fish fertilizer contains about five percent nitrogen, one percent phosphate and one percent potash. The high cost and low nutrient value of fish emulsion, and handling and application problems make it impractical for use in most commercial-scale farming operations. Fish emulsion is practical as a foliar applied fertilizer for high-value crops, including ornamental greenhouse plants. It can rapidly "green up" foliage when used for foliar feeding.

Shellfish Waste. On average, the processing of shellfish generates from 50 to 60 percent solid waste. This waste consists primarily of exoskeleton and ranges from 25 to 40 percent protein, 15 to 25 percent chitin, and 40 to 50 percent calcium carbonate. Shellfish waste has a much lower protein value than fish waste and is therefore not a desirable source of animal feedstuff. It is a more likely candidate for use as a fertilizer source and shows relative fertilizer values of approximately six percent N, two percent P and one percent K. In California, fertilizer is manufactured from shellfish waste by a few small, locally based companies. The availability of this product is still quite limited relative to other more popular fertilizer sources.

Kelp/Seaweed. Though seaweed is the most well researched marine fertilizer material, there is still a great deal of skepticism about its use in agriculture. Studies conducted at various locations notably Clemson University and the University of Maryland (Senn and Kingman, 1978) have established three basic benefits from soil and foliar applications of seaweed products:

- Supplies some plant nutrients. Seaweed products are a particularly good source of micronutrients (trace elements) and chelating agents which promote the availability of micronutrients. Nutrient amounts are shown in Table 1. Nutrient analyses of seaweed materials indicate that they should be used as fertilizer supplements, *not* as fertilizer substitutes.

- Enhances plant growth. Many seaweed products contain active quantities of plant growth regulators. Of particular interest are those known as cytokinins which regulate cell division and cell wall formation and which also delay the process of senescence.

- Improves soil tilth. The colloids (gels and alginates) found in seaweed are reported to increase soil aggregation promoting a more crumb-like structure.

The benefits of seaweed depend largely on the particular product used, the method of application, and crop and soil conditions. A variety of seaweed materials are available including:

1. Wet seaweed from beaches. Washing off salt, and composting improve its usefulness.

2. Dry seaweed meal. Seaweed is dehydrated and ground into meal. May be applied straight or mixed with other fertilizers. Typical straight application rates range from 300 to 500 pounds per acre depending on crops, soils, climate, and quality of the meal.

3. Liquid seaweed concentrate. Wet treated and cooked under pressure nutrients and other compounds. Used foliar spray, seaweed concentrate anywhere from one part concentrate parts water.

4. Seaweed powder. Seaweed is liquefied then processed into a soluble powder. Seaweed powder is generally reconstituted into a liquid form and then diluted in a ratio similar to liquid concentrate for foliar feeding.

5. Seaweed and fish blend. Either in liquefied or dry meal form, this product is formulated to combine the benefits of each material.

Chitin. Chitin is a by-product of the shellfish industry and consists of the shells of crabs and lobsters, usually in a pulverized form. While it usually contains about three percent nitrogen, it is really too expensive to be used as a source of nitrogen. However, chitin may be the first organic soil amendment to be used as a specific biological control agent. Recent studies have shown that chitin additions suppress pathogenic nematodes and fungi. This research is still in the field trial stage, however the preliminary results look very promising.

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Perennial grasses as roadside cover crops to reduce agricultural weeds.

Bugg R.L., L.H. Anderson, J.W. Menke, K. Crompton and W.T. Lanini.

Article written for Components. 1991

Experiments are now underway to establish perennial grasses, including native Californian species, in various monocultural and polycultural schemes along roadsides amid Yolo County agricultural lands. The aim of these studies is to determine their relative expense and effectiveness at suppressing roadside weed populations, particularly major agricultural weeds, compared to conventional control methods including mowing, plowing and use of herbicides.

The current schemes for managing Californian road-side vegetation include frequent mowing, blading, and herbicide application, which are time-consuming and expensive. Yolo County currently spends over $40,000 a year for herbicides applied along some 800 miles of county roads. Blading costs are over $100 per mile treated (Garrison, 1989). Existing practices for road-side maintenance and control of erosion encourage invasion and domination by noxious, undesirable, and highly invasive weeds. Thus, roadsides have become significant reservoirs for such agricultural weeds as yellow starthistle (*Centaurea solstitialis*) and various other thistles, wild oats (*Avena fatua*), ripgut brome (*Bromus rigidus*), field bindweed (*Convolvulus arvensis*), redroot pigweed (*Amaranthus retroflexus*), and others. Current practices have also led to unsightly ditches, and much erosion and siltation. In the long run, these practices discriminate against desirable plant species. Moreover, the general public is increasingly concerned with the roadside use of herbicides and possible health implications. The authors believe that California could benefit from developing alternative management schemes.

In much of California, including the Sacramento Valley and the surrounding foothills, the dominant plants were once the perennial sod-forming grasses and bunchgrasses (Ornduff, 1974). These remained green during most of the year and gave the landscape a soft, tufted appearance. However, the native grasses were nearly wiped out during the mid-1800s, through drought, overgrazing by cattle and competition from weedy annual grasses and forbs introduced from the Mediterranean area (Dassman, 1973; Menke, 1989).

Opportunities exist to reestablish portions of the native prairie. There are several large producers of California native grass seed, and there is increasing public awareness of native grasses and interest in restoring them for improved biodiversity (Meyer, 1989; Northington, 1990). In several states, particularly in the Midwest, native grasses are being used successfully along highway corridors (Harrington, 1989) and ditches (Bright, 1988). Once established, perennial grasses reduce erosion and fire hazard, and preclude the establishment of seedlings of most agricultural weeds. Maintenance is reduced to, at most, a single timely mowing per year.

There are numerous perennial grasses, both native and introduced, that appear particularly along rights-of-way, because they thrive under existing rainfall and soil regimes. They begin growth earlier in and remain green later into the spring than do the introduced annuals. Trials in Yolo County, elaborate and extensive demonstration plots at Hedgerow Farms (owned by John H. Anderson), clearly show that perennial grasses can be efficiently established on roadsides and thereafter suppress most noxious weeds. Our observations also suggest that ground squirrel population densities are greatly reduced when perennial grasses dominate roadsides (see Daar et al., 1984). On the other hand, desirable wildlife such as pheasant can be greatly increased.

Cover crops have long been known to be useful in suppressing weeds. Weed-suppressive cover crops have sometimes been termed "smother crops," and modes of action can include competition for resources or exudation of allelopathic compounds. In the case of perennial grasses, both mechanisms can be at work in the suppression of weed seedlings. Ecological studies have shown that perennial bunchgrasses have root masses that extend laterally, leading to suppression of weed seedlings at some distance (Ornduff, 1974, p. 23). The approach developed by one of the authors (Anderson, 1989) involves selective herbicides for weed suppression during the first two years of bunchgrass establishment. Thereafter, herbicides can be discontinued, and management will be by mowing or controlled burning as needed. In many instances, no management at all will be required. Native grasses are slow to establish, and will not invade the farmers' fields like the noxious weeds that currently dominate roadsides in most agricultural lands (Crampton, 1974).

These studies are intended to test whether established perennial grasses can preempt and greatly reduce roadside weeds. The study will also clarify the types of planting arrangements that are most advantageous. Ideally, this will assist in developing statewide erosion control specifications that include perennial grasses. It would also provide information on ecologically-based, long-term control of noxious weeds to land-owners and governmental agencies. Such an approach will become particularly important with increasing regulatory restrictions on herbicide use. Projections by one of the authors (Anderson) indicate that roadside maintenance costs and herbicide use could be greatly reduced through the establishment of perennial grasses.

Rural roadsides typically include several topographic zones (Fig. 1): 1) pavement edge; 2) berm or shoulder; 3) inner ditchbank; 4) ditch bed; 5) outer ditchbank; and 6) field edge. These zones present a range of environmental conditions, and require a range of plant materials. Fortunately, various perennial grasses have different environmental optima and tolerances and varying growth habits. Low-statured, non--rhizomatous species (e.g., sheep fescue [*Festuca ovina* cv 'Covar') are desired for the pavement edge, because they permit maximum visibility by motorists, are unlikely to break up pavement, and, although they tolerate close mowing, require no mowing in many cases. Red fescue (*Festuca rubra*), pubescent wheatgrass (*Agropyron trichophorum*), and California brome (*Bromus carinatus*), and lower-growing forms of blue wildrye (*Elymus glaucus*) are intermediate in height and are appropriate on the berm or shoulder. Short-lived, moisture-loving perennials like meadow barley (*Hordeum brachyantherum*) are well suited for inner and outer ditch banks and the ditch bed if ditches only have water intermittently. If ditches contain water most of the time, spike-rushes (*Heleocharis* spp.) would be better adapted. The outer ditch bank can be assigned to taller-statured grasses, such as tall wheat-grass (*Agropyron elongatum*), blue wild rye (*Elymus glaucus*), or orchard-grass (*Dactylis glomerata* cv 'Berber'). If mowing is frequent, these species can also be used on the inner ditchbanks and on the beds of intermittently-flooded ditches. The field-edge niche is subject to inadvertent damage by herbicides and agricultural implements. Therefore, tough, resilient, rhizomatous grasses such as creeping wild rye (*Elymus triticoides*) are particularly appropriate. This species is tall statured, recovers rapidly from mechanical damage, and shows resistance to a commonly-used herbicide, glyphosate.

The authors are requesting funding from several agencies. If funded, a replicated trial will be conducted in Yolo County on county roadsides containing typical topography and weed flora. The experiment will test the weed-suppressive effects of the plant materials already mentioned when planted in various combinations and spatial arrangements. In future years of this study, the authors also plan to evaluate the following native grasses: Davis slender wheatgrass (*Agropyron trachycaulum* var *majus*), California oniongrass (*Melica californica*), Idaho fescue (*Festuca idahoensis*), nodding stipa (*Stipa cernua*), pine bluegrass (*Poa scabrella*), squirreltail (*Sitanion jubatum*), and three awn (*Aristida hamulosa*).

Cooperating and interested organizations are the USDA-SCS Plant Materials Center, Yolo County Resource Conservation District, ConservaSeed, and the California Native Grass Association.

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