WHAT IS SUSTAINABLE AGRICULTURE AND HOW DOES ALFALFA FIT INTO THE CONCEPT?

by

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SUSTAINABLE AGRICULTURE

Sustainable agriculture is a relatively recent concept. There are numerous definitions or thoughts about what sustainable agriculture entails. Many groups have attempted to define sustainable agriculture and this dialogue continues today. In general, the definitions attempt to deal with the viability of farming systems as they now exist or with what we would like them to be in the future. In November 1988 a group of about 300 people attempted to define sustainable agriculture at the American Society of Agronomy meetings. That group said, "A sustainable agriculture is one that, over the long term, 1) enhances environmental quality and the resource base on which agriculture depends, 2) provides for basic human food and fiber needs, 3) is economically viable, and 4) enhances the quality of life for farmers and society as a whole." The concept of sustainability touches on a number of very broad issues that agriculture is attempting to address. Sustainable agriculture is not something we will achieve tomorrow, next year, or four or five years down the road. It does not consist of a formula or standard set of practices, but should probably be viewed as a goal. There are clearly both short- and long-range implications for what sustainability means.

ALFALFA PRODUCTION SYSTEM

The second part of the title is how does alfalfa fit into the concept of sustainability? We might also ask the question, **where** does it fit? In order to answer that question we must take a systems view of alfalfa in California agriculture and determine what its impact is with respect to the physical and biological environment. To do that we must first look at the market for alfalfa and then work backwards to see what the market forces might suggest.

Alfalfa is a premier forage which is used extensively by the livestock industry to produce milk and meat, with the greatest quantities being consumed on the state's dairy farms. Alfalfa production in California will, therefore, be influenced by these markets. During the next decade, consumer demand for both meat and dairy products will likely be affected by three main factors:

1) Nutritional concerns--fat content of meat and dairy products that consumers are to accept. An increasing demand for leaner meat could result in some substitution forages like alfalfa for grain as a feed for cattle.
2) Food safety concerns--because milk is a particularly important component of children's diets it will likely come under closer scrutiny for pesticide residues.
3) Bovine somatotropin (BST) hormone--a controversial material pushed by some researchers and companies as an important means to increasing milk production. Numerous consumer groups, dairy farmers, dairy marketing organizations, and some scientists are opposed to the introduction of BST. It is unlikely that increasing milk production through the use of this hormone would also increase demand for milk in the U.S. Indications are that a significant proportion of the population may decrease their milk consumption should BST be fully introduced into the dairy industry. The outcome of the debate over this technology clearly has implications for alfalfa growers in California.

Given a continuing demand for dairy products, alfalfa production in California will continue to be an important element of the State's agricultural economy. The characteristics of the production system, however, will be shaped mainly by the issues of water use, pesticide use and crop nutrient management. It is in these three areas that alfalfa growers will likely face their greatest agronomic challenges in the years ahead.

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ISSUES OF SUSTAINABILITY

Alfalfa has a long history as California's most important forage crop. Climatic adaptation of different varieties have made it one of the most widely grown crops in the state with production fluctuating around 1 million acres during the 1980's. As a perennial legume, alfalfa has a unique position in many annual cropping systems in California including cotton-, vegetable- and grain-based rotations. An average alfalfa stand in California is usually farmed for three to five years before rotating to another crop. Alfalfa has long been regarded as a soil building, soil conserving crop which helps improve soil chemical, biological and physical properties. It may therefore have an important role in many California production systems with respect to what it contributes to the soil and the crops which follow.

Water

Alfalfa's adaptability to diverse climatic conditions also allows it to grow under a wide range of soil moisture regimes. The amount of water required to sustain current economic yields, however, is relatively high compared to other crops grown in California (Table 1). Seasonal evapotranspiration (ET) for alfalfa grown in the San Joaquin Valley totals about 48 inches. In the San Joaquin Valley this translates into annual water applications of about 5 acre feet to obtain average yields depending on irrigation efficiency and the amount of water stored in the soil profile. Lower amounts of water are necessary in the coastal and intermountain valleys due to cooler climates and lower evapotranspiration rates.

Recent studies and reports on potential climate changes in California have indicated that further drought years and/or global warming trends will have serious implications for forage production. Both the availability and cost of water may seriously limit where and how much alfalfa is produced in the future. The impact of water limitations on dairy and meat producers in California (who also use large quantities of water) may affect alfalfa growers indirectly.

Pesticides

Alfalfa is subject to a number of weed, insect, and disease problems at different points in its life cycle. Pesticides are a principal means of control for many of these pests. 1.15 million acres of alfalfa were treated with approximately 2.14 million pounds of active ingredients in the 1987 season. Of the approximately 70 chemicals used on alfalfa in California, 13 compounds represent a majority (70%) of applications (CDFA, 1988). Table 2 lists these pesticides along with the total pounds of active ingredient applied and the acres treated.

The current regulatory climate could potentially limit the use of several of these chemicals. Of the 13 compounds listed in Table 2, all except dimethoate and malathion have entered the risk assessment process under SB 950 (Birth Defect Prevention Act of 1984). In addition, carbofuran, methomyl, parathion, paraquat, and phosmet were targeted as "high-hazard pesticides" in the recently proposed AB 417 legislation.

The food safety controversy has centered mainly on fresh produce up to this point. There are some indications, however, that milk products could also be pulled into the debate particularly since milk is a significant component of children's diet in the United States. Preschoolers consume 5-6 times more milk than adult women (age 22-69) on a body weight basis. As a proportion of total dietary intake, dairy products constitute about 12% by weight of the total diet for 1 to 5 year-olds. Though current data regarding dietary risk are incomplete, both the Food and Drug Administration and the California Department of Food and Agriculture have residue monitoring programs for milk products.

Tracking the source of pesticide residues in milk could be extremely difficult. Nonetheless, if alfalfa hay should be implicated in the bioconcentration process, farmers could expect to see identified compounds severely curtailed or eliminated altogether. Table 3 shows some of the pesticides found as residue on various livestock feed products.

Looking for alternatives to pesticides should be a high priority for the alfalfa industry in California. For example, a number of the problem weeds in alfalfa could be a result of the monoculture aspects of the production system. A mixture of alfalfa in combination with other summer or winter grasses as complementary species could fill in the canopy and reduce or eliminate certain weed problems. The demand for pure alfalfa hay is a driving factor in the current production system in California. Assessing the benefits and risks of a mixed hay stand could lead to the development of alternatives to herbicides for the state's alfalfa growers.

Nutrient Management

Nitrogen

Alfalfa has a relatively high potential for fixing atmospheric nitrogen compared to other legume speother legumes. Data from other sources, however, estimate N-fixation rates for alfalfa ranging all the way from 46 to 413 lb/a/yr depending on Rhizobia species, plant genotype, climate, and management practices (Vance et al., 1988). The actual contribution that alfalfa makes to total soil N depends largely on the date of plowdown, the age of the alfalfa stand and the type of plant material present in the field at the time (Heichel and Barnes, 1984).

A more recent study conducted in a temperate climate (central Pennsylvania) estimated the fertilizer N equivalence of a 3-year alfalfa stand for a succeeding corn crop at 167 lb/acre (Fox and Piekielek, 1988). Table 5 provides estimates for the amount of nitrogen contributed by several legumes (including alfalfa) to a succeeding corn crop. The alfalfa stand was three years old when it was plowed down and yielded 5.7 and 4.5 tons/acre respectively, during year 2 and 3. Where a large quantity of nitrogen is turned in to the soil at plow down, further consideration must be given to the leaching potential of the initially mineralized N from the incorporated alfalfa biomass. Under California conditions where the production season extends over a longer period of time, nitrogen budgeting and dynamics are less clear and not as well studied. In some situations there could very likely be a net loss of N.

Potassium

Alfalfa requires more potassium than any other plant nutrient. A 7 to 8 ton/acre hay yield may remove from the soil anywhere from 300 to 350 lb K/acre per year (Meyer, 1975). Cassman (1986) suggests that alfalfa's enormous K extraction plays a significant role in the development of potassium deficiency/disease syndrome in cotton-based cropping systems in the San Joaquin Valley.

Nutrient Cycling

The efficiency of nutrient cycling in alfalfa cropping systems must take the dairy industry into account. Nearly all of the dairy waste in California is returned to the agricultural system in some form though not necessarily to alfalfa. Statewide, about half of all solid manure is used as fertilizer on the ranch of origin. The remainder is largely sold to organic fertilizer manufacturers or used as bedding material on the ranch. Liquid waste is almost entirely disposed of as fertilizer (Meadows and Butler, 1989.) The fate of the nitrogen contained in livestock waste depends on how it is managed. Potential gaps in the recycling of nutrients exist in two areas:

1) A significant portion of livestock waste is held for some time in lagoons or holding ponds before actual disposal. Nitrate contamination of groundwater is likely where these storage areas are leaky or improperly managed.
2) If manure applications to agricultural land are not timed properly with other practices, there could be a loss of nitrogen both through volatilization and/or leaching of nitrates.

SUMMARY AND KEY QUESTIONS FOR ALFALFA PRODUCERS IN THE 1990's

What are anticipated trends in consumer demand for meat and milk products?

2. What are the implications of decreasing water availability and increasing water costs for a high water use crop like alfalfa?

3. How can soil moisture monitoring and water application efficiency be improved?

4 How will potential regulations (particularly those targeting children's food supply) affect the viability of pesticides in the alfalfa production system?

What influence does growing alfalfa as a monoculture have on pest management problems?

6. What are the short- and long-term effects of alfalfa rotations in relation to nitrogen budgeting and nitrogen use efficiency?

7 How does the alfalfa-dairy industry complex affect groundwater quality in California? How can dairy waste management problems be solved?

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Table 1. Seasonal evapotranspiration for several crops grown in the San Joaquin Valley.

Crop	Estimated Annual ET (in.)
alfalfa	48
cotton	31
wheat	17
corn	25
tomatoes	26
melons	18
decid. orchard (clean cult.	37
citrus	34
grapes	27

Source: Interagency Agricultural Information Task Force, Drought Tips: Crop Water Use.

Table 2. Major pesticides used in alfalfa.[a]

Common Chemical Name	Total lbs. applied	Acre-[b] Treatments
carbofuran	103,983	216,353
chlorpyrifos	219,033	348,209
diazinon	36,192	74,143
dimethoate	62,728	181,603
diuron	104,012	76,341
hexazinone	54,152	92,080
malathion	223,961	161,787
methomyl	128,525	248,135
methyl parathion	50,102	120,757
paraquat dichloride	56,240	96,376
phosmet	75,192	104,746
propargite	116,042	73,344
trifluralin	256,176	142,673

[a]Specific pests targeted by these chemicals are described in the UC IPM **IMPACT** Pest Management Guidelines.
[b]Acre-treatments. Some acres were treated more than once.

Source: California Dept. of Food and Agriculture, **Pesticide Use Report**, January through December, 1987. Currently, the California Administrative Code mandates that the use of restricted materials which require a permit (Category I) be reported for this compilation. For non-restricted materials, the Pesticide Use Reports reflect only those applications made by licensed pest control operators. The percentage of non-restricted materials applied by pest control operators varies from crop to crop and between areas of the state. Thus, these figures reflect a portion of the total pesticide use in alfalfa.

Table 3. Summary of pesticide residue findings for alfalfa hay. October 1, 1981 through September 30, 1986. U.S. Food and Drug Administration, Los Angeles.

Pesticide	Number of Findings	Number of Violations
azinphosmethyl	1	0
chlorpyrifos	13	0
diazinon	1	0
dimethoate	3	0
endosulfan	2	0
malathion	8	0
methamidophos	1	1
methyl parathion	3	0
parathion	12	0
permethrin	1	
phosmet	1	0

Source: Hundley et al. (1988)

Table 4. Sample of research estimates for N_2 fixation by four legume species.

Species	Annual fixation rate (lb N per a)
Alfalfa	102-200
Birdsfoot trefoil	44-100
Red clover	62-119
Subterranean clover	52-163

Source: Adapted from Vance et al. (1988)

Table 5. Fertilizer N equivalence of legumes for corn as estimated by fertilizer N response functions.

Legume	Years after legume production 1	2	3	TOTAL
	lbs/acre			
Alfalfa	121	32	14	167
Birdsfoot Trefoil	84	42	21	151
Red clover	96	26	9	131

Source: Fox and Piekielek (1988).