MITIGATING WATER QUALITY CONCERNS: HOW THE ALFALFA INDUSTRY MIGHT RESPOND

By Dan Putnam[1]

ABSTRACT

While alfalfa provides many positive attributes contributing to environmental health, several issues associated with water quality have become apparent in recent years. Although alfalfa is not highly pesticide intensive, several pesticides have been implicated in water quality contamination. Specifically, the potential for contamination of surface waters with Organophosphate. insecticides and the potential for contamination of groundwater with winter-applied herbicides have been shown. A range of mitigation measures, which differ from farm to farm and soil to soil, may be appropriate. It is important for alfalfa growers to take leadership on development, demonstration, and research towards mitigation measures for these water quality problems, so that they are compatible with profitable crop production. An Environmental Stewardship Program for alfalfa producers that assists in addressing water quality concerns may be helpful. Public articulation of an 'environmental balance sheet' for alfalfa may also assist in public discussions about the role of alfalfa in the environment.

Keywords: Environmental issues, pest management, Chlorpyriphos, insecticides, herbicides, mitigation.

INTRODUCTION

In the ever-widening array of challenges in producing a crop for a profit, the issue of environmental regulation has come to the top of the list over the past 10 years. 'Environmental Regulation' takes many forms, from air quality controls on diesel engines, to transfer of water for endangered species or habitat restoration. It is not an exaggeration to state that agriculture's response to regulatory issues will be one of the most important determinants of farm viability in the future in California.

Alfalfa, as the state's largest acreage crop, and the state's largest single agricultural user of water, undoubtedly will play a part in this unfolding drama. While public concerns about the environment cut across commodities and individual enterprises, the problems and solutions are quite specific to enterprises (e.g. what is the impact of dairies upon air quality, or orchard sprays on water quality?). In this article, I discuss an overview of the environmental challenges facing alfalfa, and suggest approaches the industry might take in tackling them.

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AN ALFALF ENVIRONMENTAL BALANCE SHEET

Similar to the propensity of news organizations to focus only on bad news (e.g. reports on failing schools, ignoring the majority of schools which may be successful, or air accidents, ignoring thousands of normal flights), regulators tend to focus only upon the potential for pollution, and may ignore many of the positive impacts of an activity on the environment.

Alfalfa – A Balance

Key Facts

- 1.1 Million Acres in CA, 3rd largest crop in USA
- $700 million -$1 Billion in value (CA), largest in US
- Key crop for state's 4.5 billion dairy Industry, #1 in nation
- Key cash or rotation crop in all agricultural regions
- 'Engine' of food production, nutritious food for millions
- Uses 19% of State's agricultural water

Key Challenges

- Water supply impacts on habitat, endangered species, other uses.
- Off-site movement of OP insecticides.
- Groundwater contamination with herbicides.
- Phosphorus runoff
- Energy use.

Key Positive Attributes

- Alfalfa acts as 'filter strip' to stop sedimentation of water and soil erosion.
- Prevents air particulates.
- Mitigation of nitrate contamination.
- N_2 Fixation saves trillions of BTUs of fossil fuels
- Sequestration of carbon.
- Important wildlife habitat

Agriculture interacts in a much more complex way with the environment than, say a factory or a waste treatment plant. While it is true that agriculture has a large impact on the landscape, and sometimes this impact is negative, this is not always the case. In fact, as many parts of our crowded world are realizing, farms have intrinsic value beyond just their importance in producing food and fiber. Europeans and Japan, for example, have a number of public policies that favor farming landscapes as a vital component of the culture and environment. While these policies remain controversial in the context of world trade, the implications are important. Is it possible to think that some components of agriculture could actually be solutions to environmental problems, to urban sprawl and environmental impacts, rather than problems themselves?

Thus, the development of an 'environmental balance sheet' seems appropriate for agricultural enterprises (see box). A balance sheet which weighs both environmental positives and negatives of a crop or individual agricultural practices may be worthwhile, particularly since no practice may be conceived of as entirely positive or negative—all technologies typically have both negative and positive impacts. For example, the substitution of herbicides in favor of greater tillage to control weeds may reduce total pesticide use, but allow greater air and water erosion of soils, a known hazard of tillage.

Alfalfa growers, through their organization the California Alfalfa & Forage Association have taken a lead on this issue through the publication of 'Alfalfa, Wildlife, and the Environment' (Putnam, et al., 2001), a booklet which describes in detail the benefits of alfalfa to the environment. Growers have taken a tremendous amount of leadership in making sure that the positive side of the alfalfa story was told. However, this analysis should also require a candid assessment of some of the environmental negatives associated with alfalfa, and descriptions of efforts to address these.

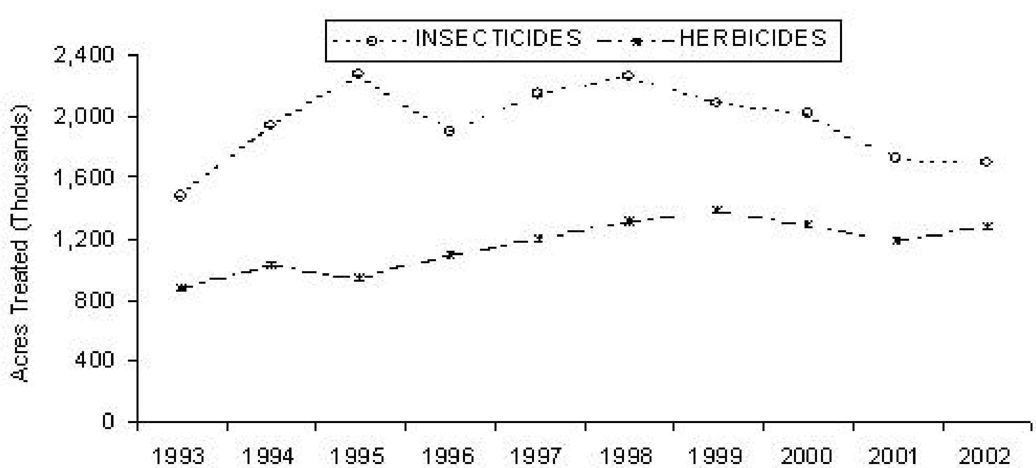

Figure 1. Alfalfa Pesticide Use, past 10 years in California (CA Department of Pesticide Regulation, Pesticide Use Reports - http://www.cdpr.ca.gov).

PESTICIDE USE IN ALFALFA

While pesticides are not the only aspects of crop impacts upon the environment, they are frequently the subject of public debate. Alfalfa is not a particularly pesticide-intensive crop. The multiple insect and disease resistance of alfalfa varieties, as well as a plethora of beneficial insects helps growers avoid sprays. However, there are several insects and weeds for which effective non-chemical control has proved elusive. The alfalfa acres treated are shown in Figure 1 for the past ten years. The acres treated frequently exceeds the total number of acres for most crops due to multiple applications during a season. The majority of the treated acres are for insecticide use, which exceeds that of herbicides (Figure 1). The majority of the insecticides used in alfalfa are Organophosphate class, particularly chorpyrifos. Fungicides are rarely used in alfalfa. Herbicides are used primarily during stand establishment, but also for annual maintenance, usually during winter or spring periods.

Over the past year, a few trends were seen (DPR, 2003). Insecticide use in pounds was reduced by 12 percent overall from 2001 to 2002, despite the increase in acreage of 15%. Of the major insecticides, chlorpyrifos, methomyl, and endosulfan use decreased 20, 52, and 61 percent, respectively. Chlorpyrifos (*Lorsban* or *Lockon*) is used primarily for Egyptian alfalfa weevil, and the pyrethroids (such as lambda-cyhalothrin, cyfluthrin, and permethrin) have been replacing chlorpyrifos during the winter and early spring in some regions. The decrease in methomyl is likely attributed to the rapid acceptance of indoxacarb (*Steward*) for late season armyworm control. Indoxacarb, a new insecticide for lepidopteran pests and leafhoppers, became the tenth most popular AI in a single year, going from no use in 2001 to 7,211 pounds AI in 2002. It was the seventh most popular insecticide in terms of acres treated (96,735 acres). Malathion (16 percent), dimethoate (11 percent), and carbofuran (6 percent) use increased moderately.

The Alfalfa Weevil, a dependable pest each spring in most alfalfa fields in California, a complex of aphid species populations, and summer and fall worm species are the most common causes of insecticide sprays in California (see UC IPM website). Weeds are an issue during stand establishment of alfalfa, so herbicides are commonly used during stand establishment, during winter dormant periods, or during specific infestations.

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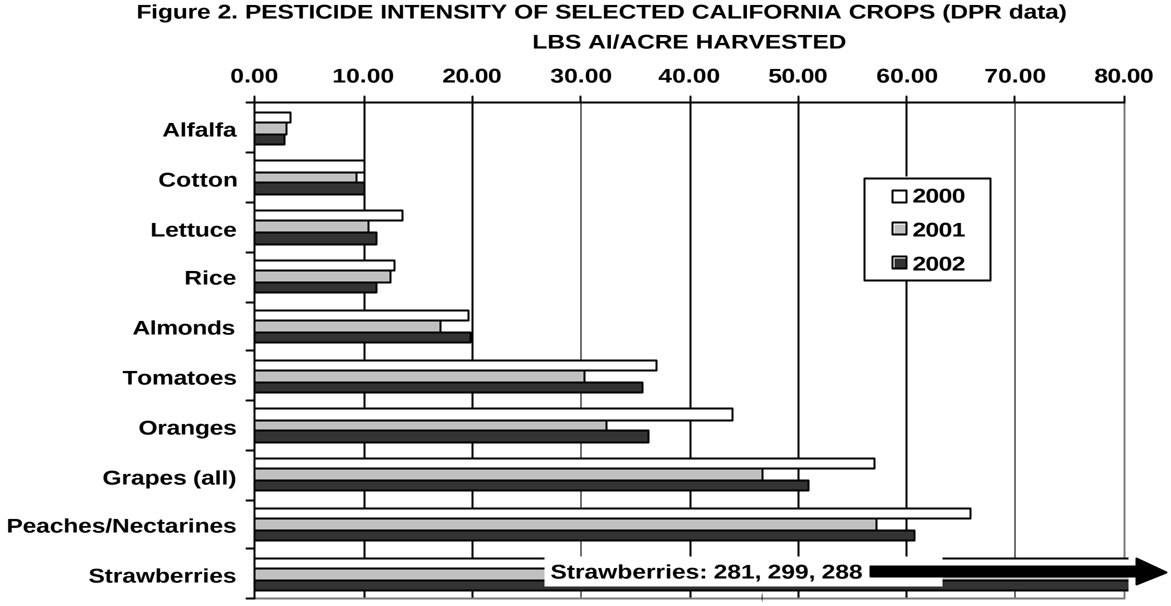
However, it is clear that the pesticide intensity of alfalfa is less than most other crops grown in California (Figure 2). The crops listed in Figures 2 and 3 are those featured by

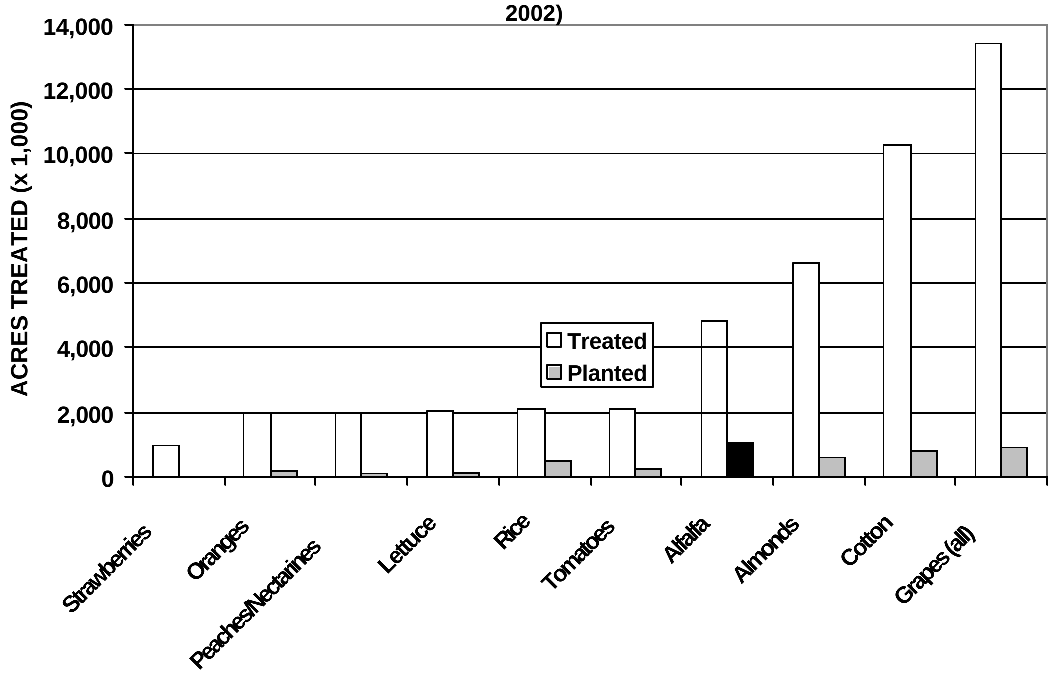
Figure 2. PESTICIDE INTENSITY OF SELECTED CALIFORNIA CROPS (DPR data)



CA Department of Pesticide Regulation as the major crop species grown in California, and those that contribute in a major way to pesticide use. Alfalfa pesticide intensity (defined as the pounds of active ingredient applied per acre of crop harvested), averaged about 3 pounds/acre over the past three years, about 1/3 that of cotton, a quarter that of lettuce and a small fraction of the pesticide intensity of many of the higher value orchard and horticultural crops.

This does not mean that alfalfa is a non-player in terms of pesticide applications to the landscape, since alfalfa occupies such a large acreage in California. The major crop acreage treated with pesticides is shown in Figure 3. For most field crops, the acres treated represent a larger figure than the acres grown, indicating multiple applications per year or season. For alfalfa, approximately 4.8 million acres were treated (on a little over a million acres), on the average for the years 2001-2002.

Figure 3. PESTICIDES APPLIED TO SELECTED CALIFORNIA CROPS (Ave. 2000-2002)



While these figures (1, 2, and 3) give a general idea of the applications of pesticides to field crops, they are not particularly enlightening in terms of environmental impact. For example a very large component of the applications to grapes each year is for control of fungal diseases, particularly the application of sulfur, a naturally occurring element in soils. Most of the pesticide use for strawberries are soil fumigants, applied at hundreds of pounds per acre (rather than 1 or 2, which is the case for most pesticides), accounting for its high intensity. Applications of a number of pesticides, for example glyphosate, do not represent substantial environmental risks, and are not really on the radar screen in terms of water quality. The pesticides used in alfalfa which are of environmental concern are primarily in two categories: OP insecticides used for control of insects, and herbicides used for winter weed control in alfalfa.

KEY ENVIRONMENTAL IMPACTS AND CHALLENGES FOR ALFALFA

While agriculture has a legitimate complaint to urge balance in the public debate on environmental regulation, including the environmental benefits of agriculture, a candid assessment of the impacts of agricultural enterprises is also needed. The issues are not only confined to pesticides, but to particulate off-site movement (sedimentation), and other impacts. With alfalfa, these issues are primarily associated with the following:

1) ***Water supply.*** The fact that alfalfa consumes substantial quantities of water each year is an inescapable fact of life for alfalfa in western states, and an important component of its environmental impact. It is estimated that alfalfa consumes about 19% of the agricultural water in California, more than any other single crop (DWR estimates). While it is clear that alfalfa is one of the more efficient users of water (see discussion in Putnam, et al., 2001), it is also clear that efforts to improve the water-use efficiency of alfalfa may be productive. Since improved water management is critical also to water quality issues it seems reasonable to place efficiency of water management in general at the top of the list of mitigating measures with regards to alfalfa's impact upon the environment. However, efforts to improve water use efficiency should be tempered with a realistic understanding of just how much water is required for plants and for crop production—a dimension rarely understood by critics of agriculture.
2) ***Insecticides and surface waters.*** Alfalfa is a crop with a relatively low intensity of insecticide spray use compared with many crop species (see above). However, Organophosphate (OP) insecticides used in alfalfa (as well as

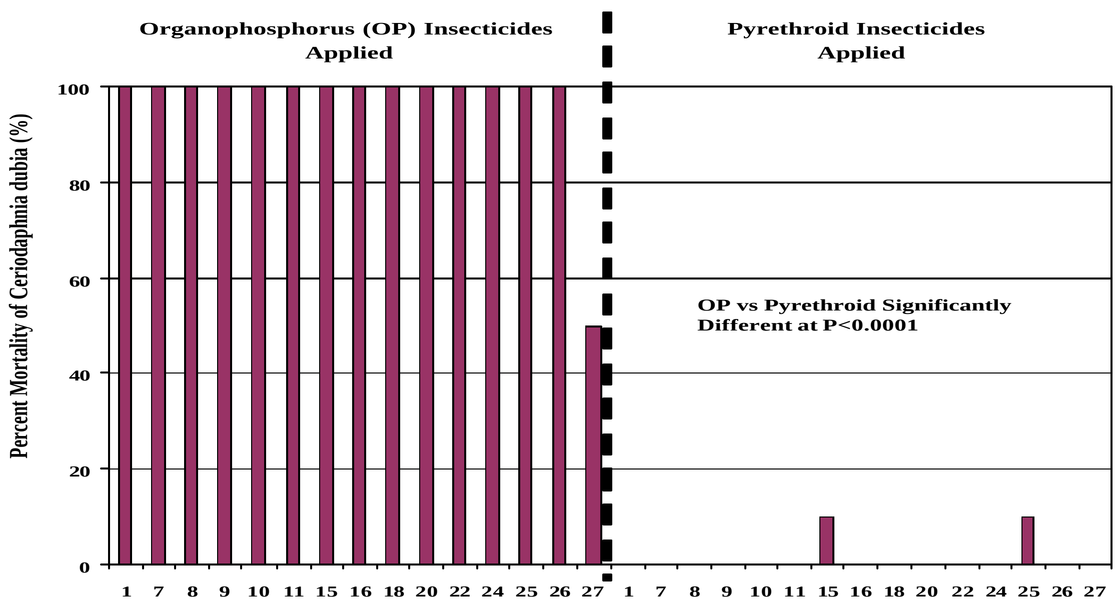


Figure 4. Death of test organism Ceriodaphnia dubia in tailwater measured in 27 alfalfa fields in the Sacramento Valley to which either OP insecticides or Pyrethroid insecticides were applied. (Long et al., 2002). Off site movement of OP pesticides is a concern of water quality boards.

prominently in orchard sprays and in several other crops), such as chlorpyriphos (Lorsban or Lock-on) and diazonon have been detected in spikes in the San Joaquin delta in levels of sufficient to be toxic to test aquatic organisms. These levels are below drinking water standards, but thought to be important for the food chain in natural waterways. These levels are in violation of toxicity objectives of the Central Valley Regional Water Quality Control Board. Under the Federal Clean Water Act, the San Joaquin River and associated delta/estuary have been listed as an impaired waterway due to these detections. Organophosphate pesticides are predominantly used for control of the alfalfa weevil in alfalfa during the early spring, particularly Chlorpyrifos (Lorsban and other formulations), and during the summer. Off-site movement of OP pesticides into surface waters from alfalfa fields has been detected (Figure 4). In measurements in the Sacramento Valley, all of the fields to which OP insecticides were applied exhibited death of the test organisms in the tail water, even when that water was monitored 3-6 weeks after applications (Figure 4). Since these OP pesticides are sufficiently soluble in water, and toxic to test organisms at very small concentrations (in parts per trillion), these are the subject of scrutiny by the State and Regional Water Quality Control Boards. It is important for alfalfa growers who farm near natural waterways which drain into impacted waters to avoid using these sprays, or to look for ways of preventing off-site water movement in the months following application.

3) ***Herbicides and Groundwater.*** Several years ago, herbicides commonly used in alfalfa (for example hexazanon) were detected in a few wells in the upper San Joaquin Valley. Research by UC Cooperative Extension and DPR has examined the fate of hexazanone and diuron sprayed onto alfalfa fields for control of winter weeds (Prichard, 2002). It was found that there was no significant movement of these herbicides through the soil profile (where they might affect the groundwater). Instead, it was clear that concentrations of these pesticides were present in water that would run off the fields and collect in ditches and collection ponds at the ends of the fields. Given the particular nature of these soils, and the proximity of the groundwater table to the bottom of this tailwater collection pond, a rout for contamination became apparent. This study pointed to two issues: 1) Management of groundwater may be closely tied to management of surface waters, and irrigation water in general, and 2) Solutions to one water quality problem (surface water pollution) should be understood within the context of the potential for other problems (groundwater pollution). Tailwater ponds, which collect and control 'wastewater' for potential re-use and recirculation are widely considered an advance for surface water management. This water is conserved , prevented from off-site movement, and made available for re-use. However, it is obvious from this study that design of these systems to prevent groundwater contamination from the ponds themselves is critical.
4) ***Phosphorus and Nitrate Contamination.*** Pesticides are not the only issues associated with potential pollution from agriculture. Nitrates contamination of groundwater has been brought forward as an issue for some crops (usually non-legumes) and for animal production systems. This is not a large issue for alfalfa (alfalfa is excellent at taking up nitrate from contaminated soils). However, we

should not dismiss this, since quite a few growers continue with the practice of water-running nitrogen, opening the possibility that nitrate could become a problem in tailwater (there has been no evidence of this to date). Phosphorus, however, has been identified as a key water quality issue for desert soils. Phosphorus fertilizer practices are important for maintaining high yields on desert soils. However, high P levels in surface waters contribute to the eutrification of lakes, particularly for the Salton Sea. Efforts to manage P fertilizer practices for regions where P contamination of surface waters is an important goal. Although P fertilizers typically do not move in soils, due to tight affinity for soil particles, movement of soil particulates from fields have the potential for increasing P content of lakes and streams. Fertilization practices which conserve P, and irrigation practices which minimize soil erosion from fields, ditches and water systems is important to prevent P contamination of surface waters.

5) ***Energy Use.*** All modern crop production methods require some subsidy of energy (typically from fossil fuels) for crop production. Alfalfa, with its frequent harvests, bulky transportation needs, and requirement for irrigation water (often from pumping) contributes its share to energy demand from agriculture. On the other hand, the energy saved from the use of a productive Nitrogen-fixing crop such as alfalfa saves large amounts of fossil fuel for protein production each year (we estimate that over 9 trillion BTUs of energy for N fertilizers would be required each year to equal the protein produced from alfalfa, should that be produced through a non-legume). There is a need for a search for opportunities for efficiency in energy use in alfalfa production. However, since this paper concentrates on water quality issues this issue will not be examined in greater detail.

HOW THE INDUSTRY MIGHT RESPOND

Members of the UC Alfalfa Workgroup and growers through the California Alfalfa and Forage Association have been discussing methods to address these issues over the past approximately five years. The case has been made that growers need to be proactive with these issues, and actively work towards mitigation of the pollution problems that are caused by (or perceived to be caused by) the alfalfa industry. Although there are remaining technical questions about the nature, mechanism, intensity, and scope of the problems, there is a general consensus that in principle it is desirable to prevent entirely the movement of pesticides off of alfalfa production fields. As the summary above indicates, improvements in water management in general are a key aspect of mitigation measures, and must be important components of the solution.

MITIGATION MEASURES – SEARCHING FOR MULTIPLE SOLUTIONS

There are several mechanisms by which pesticides can move off of production fields and into streams, estuaries, and into groundwater. First, accidents or oversprays from equipment can occur during application. Secondly, pesticides can move in solution during rain events or during later irrigations. Thirdly, pesticides may be associated with soil or plant particles that are eroded off of fields. It is not entirely clear how pesticides move from alfalfa fields, but there is ample evidence that it does occur. Further research is clearly needed to understand these issues.

Alfalfa is produced in a wide variety of ways throughout the state. There are a wide range of irrigation practices from region to region and from farm to farm. Soil type and infrastructure differ greatly. Thus, there is likely no 'one size fits all' series of 'best management practices' that will work in all cases. A series of ideas for addressing this issue have been developed, to be integrated carefully for each situation. There are economic and practical constraints, and environmental implications for each of these methods.

The following mitigation measures arose through discussions with UC Cooperative Extension farm Advisors, PCAs and growers, as techniques that may be of use to mitigate the off-site movement of pesticides. These should not be considered complete, since some practices may be best for some circumstances and not as appropriate for other circumstances. Some are not economically viable. Considerably more research and experience is required to understand the value of many of these ideas. Typically, an integration of many techniques will likely be most appropriate. These are not listed in any particular order of importance. These are meant to be a starting point for further development, not a finalized listing.

Switching of Insecticides. On sensitive soils, where off-site movement of irrigation water is very difficult to avoid, it is likely that certain classes of insecticides, which have the potential for off-site movement should be avoided. Evidence has shown (Long et al., 2002) that alternative pesticides can avoid completely the death of test organism on farmer's fields. However, these alternatives themselves (pyrethroids) present challenges in terms of toxicity to fish from oversprays and effects on beneficial insects. Efforts to identify and incorporate more environmentally-friendly methods are needed.

Catch basins and re-circulation of tailwater. Catch basins, with recirculation systems to the same or neighboring fields are common improvements of flood irrigation systems. In addition to preventing off-site movement of pesticides, they can save water. Costs may be high in some cases. However, unlined catch basins can contribute to downward movement of pesticides towards groundwater, as has been shown with some studies, so must be designed carefully.

Lining or Sealing of Catch Basins and Tailwater Ditches. The lining of Catch basins where below-grown movement of pesticides to groundwater is likely to be important on those soil types where water from ditches or catch basins have the likelihood of entering into groundwater supplies. Lining of ditches aids in the prevention of soil erosion; soil particles often contain high phosphorus levels and sometimes pesticides. Lining of ditches has the added benefit of conserving water. Inexpensive methods of lining (such as sturdy tarp linings) are needed.

Improved Management of Spray Technology. Education and Outreach efforts towards Applicators to reduce offsite movement may help to reduce accidental offsite movement of pesticides. These may include controlling droplet size, stopping spray near windrow ends, sprayer maintenance, mixing wagon calibration, dry lock etc. This will only effective if oversprays are a key aspect of offsite movement.

Modifications of Labels. Suggestions have been made to change pesticide labels so that spray numbers per year are reduced, irrigation is restricted, or applications are restricted when conditions for higher runoff occurs. This would have the advantage of being communicated widely and uniformly. However, label restrictions would have little relevant in situations where water movement is already restricted, as with sprinklers and some flood systems and may be overly restrictive in those cases.

Use of Polymers (PAM) to reduced Sediment Movement. Polyacrylimides (PAMS) aggregate soil particles, and allowing them to precipitate from the soil solution. Although further experimental data is required, PAMS may prevent movement of pesticides if they are associated with soil particles. PAMS have the disadvantage of high cost, and may be impractical due to the frequent irrigations of alfalfa. They would not be effective in preventing solubilized pesticides from moving off site.

Activated Charcoal or other Filter ditches. Suggestions have been made to construct ditches or areas filled with activated charcoal, peat, or other filtering agents at locations where water leaves a ranch. These could be replaced periodically. This would act to filter pesticides before the soil solution reaches surface water. This idea requires further research, and would have the difficulty of increased maintenance and costs.

Non-Sprayed Buffer Zones between Alfalfa and Waterways. Maintenance of non-sprayed areas between alfalfa and waterways or tail end areas, may result in reduction in

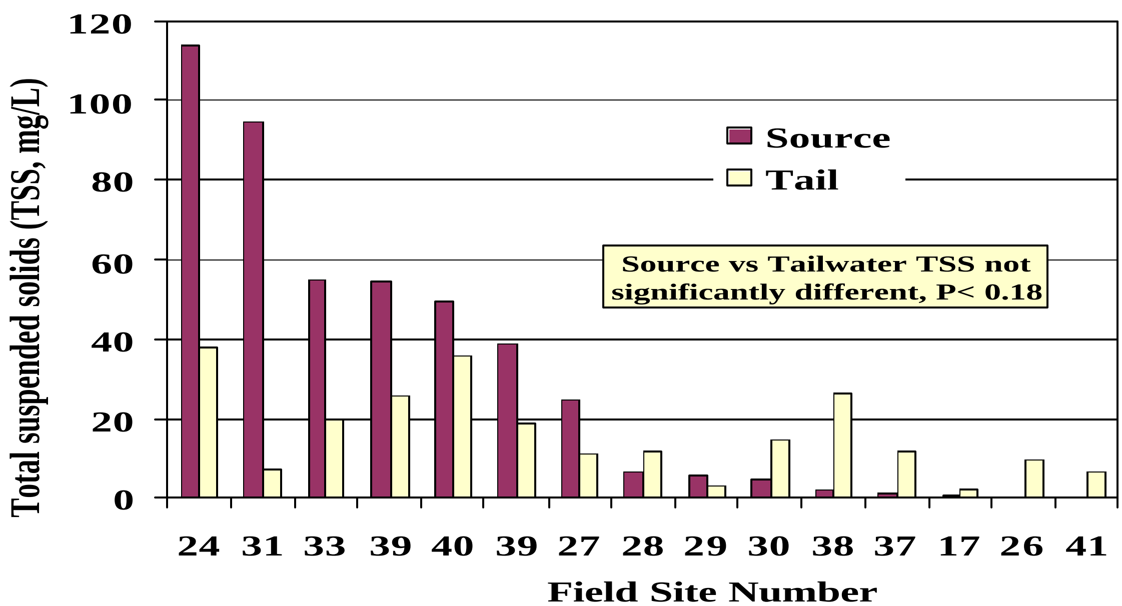


Figure. 5. Total Dissolved Solids (particulates) in source and tailwater measured in alfalfa fields in the Sacramento Valley. When TSS values in source water were high, tailwater solids were always less than source water solids (Long et al., 2002).

offsite movement. However, this would only be effective if water or suspended sediment did not carry the compound a greater distance than the buffer zone. Additionally, insect damage would presumably occur in the non-sprayed zone.

Use of Filter Strips. Filter strips of grasses and legumes have been used in the Midwestern regions to mitigate offsite pesticide movement, with some effectiveness in row crops. However, alfalfa itself is a good filter, similar to grasses. In a study by Long et al. (2002) dissolved solids were always less in the tailwater of alfalfa fields when source water solids exceeded 20 mg/L (Figure 5). Grasses may serve this function in alfalfa as well, but their effectiveness remains to be shown. Filter strips would reduce the quality and value of the hay, depending upon size of strips.

Overseeding into Alfalfa. The use of berseem clover, oats, ryegrass, or red clover overseeded into alfalfa may negate the need for an insecticide if yields are maintained. However, weevil damage is not reduced in Sacramento Valley studies. Overseeding may significantly change the quality and value of alfalfa, especially with oats or grasses. This is a technique most appropriate for older stands of alfalfa, not vigorous young stands.

Restricting Pesticide Use in Thin or in Newly Cut Alfalfa Stands. There is some evidence that open canopies may lead to offsite movement of chlorpyriphos than vigorous closed canopies, possibly due to greater pesticide attenuation in foliage. However, this is not yet fully confirmed, and whether it would be fully effective is unclear.

More Vigorous Implementation of IPM techniques. While IPM techniques have been developed decades ago, greater monitoring, and implementation of IPM techniques might lead to lower overall less pesticide use. Techniques such as more careful parasite accounting, and revision of thresholds may aid in better spray decisions. However, it is not certain the degree to which these techniques are not already widely used by growers.

Improved Irrigation management. A range of methods, from improved tailwater management, to improved monitoring of soil water, improved irrigation timing techniques, and better application technologies, such as improved flood designs and sprinkler systems may prevent irrigation runoff, and offsite movement of pesticides. Irrigation management is so central to the offsite movement of soluble components in irrigation water, that it is difficult to overemphasize this as a central theme for prevention of offsite movement of pesticides. Limitations occur in situations where offsite irrigation drainage is very important for salt leaching.

AN ENVIRONMENTAL STEWARDSHIP PROGRAM FOR ALFALFA PRODUCERS

The expiration of the broadly based Agriculture waiver in 2002 has precipitated a series of steps to address non-point source discharges into natural waterways (see article by K. Briggs, this symposium). Although the size and shape of emerging entities which are meant to monitor and regulate water quality are still unclear, it is clear that these water quality issues are likely to be of public concern for some time. Several agricultural groups, most notably the rice and grape industries, and Farm Bureau have stepped forward to aid in addressing these issues. In my view it is important for the alfalfa industry to do the same, developing a series of methodologies which can help mitigate those sources of pollution known to originate with alfalfa.

This program would contain the following elements: 1) Training and Education of growers about water quality and the issues associated with it 2) Development of information sources for those attempting to address these issues, and 3) Demonstration and research on mitigation measures to assure their appropriateness and effectiveness in line with profitable crop production. The Alfalfa Workgroup and CAFA have been working on these issues—somewhat slowly due to lack of funding. However, the development of an environmental stewardship program may aid in mitigating these problems on acreage devoted to alfalfa, and potentially at the same time assist alfalfa growers in avoiding burdensome regulatory measures.

SUMMARY

Water quality issues have come to the forefront for alfalfa producers, and are tied in closely with overall water-management issues as alfalfa industry in California moves into the 21st Century. Primary among these are off-site movement of pesticides into surface waters where they have the potential to impair public waterways such as the San Joaquin Delta, and the potential for surface runoff which may contaminate wells when catch-basins or ditches are too close to groundwater. There are a wide range of possible on-farm solutions to prevention of the off-site movement of pesticides. There are likely few solutions that are universal to all farms in all regions. It is important to consider economic and practical constraints, efficacy of pest control, and both ground and water quality as well as agronomic constraints when considering these methods. Improvements in irrigation management (monitoring, time, and system infrastructure) are key unifying aspects of this problem. An environmental stewardship program which includes training, research and information sharing may be helpful in mitigating these concerns.

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