USGS

WATER RESOURCES RESEARCH GRANT PROPOSAL

Title: Benefits of Various Best Management Practices in Reducing Herbicides in Runoff Water

Focus categories: NPP, WQL, SW

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Water Problem, Need for Research, etc.

The major factors causing water quality impairment in the Mississippi Delta, one of the most intense agricultural areas in the U.S., arise from movement of water from land surfaces. The rainfall amount and intensities often are high, causing rapid contaminant movement through the ecosystem. Since agrichemical use is high, applications immediately followed by rainfall create a significant probability of their mobilization in the environment. The erosive nature of precipitation to bare soil disperses soil particles. As they travel across the soil surface with runoff, coarser sediments are left behind. What reaches streams and lakes are highly adsorptive colloidal materials that remain suspended for long periods, are pollutants themselves, and are carriers of pollutants. Although a number of laboratory and small-plot studies have developed potential best management practices (BMPs), data are lacking at the watershed scale, particularly in the Mississippi Delta. A Management System Evaluation Area (MSEA) has been established that focuses specifically on BMPs and their effects on production agriculture and oxbow lake quality in the Mississippi Delta, with maximized profitability and minimized environmental impact. BMPs implemented in this project range from low-input (e.g. vegetative filter strips, riparian zones) to high input (no-till or conservation tillage). In some instances we know that these systems work, but at the watershed level do not 1) understand the mechanisms, and 2) understand how multiple BMPs may interact. To develop recommendations that apply to areas outside these watersheds, a fundamental understanding of these issues is imperative.

Expected Results, Benefits, Information, etc.

This research will have two principal thrusts. The first will be to evaluate the effect of a stiff-grass vegetative filter strip composed of switchgrass in conjunction with conventional and conservation tillage systems on off-site movement of two widely used soil-applied herbicides. It will also evaluate this off-site movement over time within a runoff event. Second, laboratory studies will be initiated to determine herbicide adsorption and degradation in the filter strips, the treated fields, and at various intervals moving into the riparian forest at one of the watersheds. This information will benefit the environment, as well as the producer, by determining maximum benefit of filter strips while minimizing the amount of land taken out of production. These results will provide critically needed data on mechanisms which can effectively reduce erosion, thus meeting compliance with federal conservation programs, and concurrently reduce herbicide content in runoff exiting fields. The dual benefits of reduced sediment and herbicide movement, coupled with other advantages associated with clean tillage between the vegetative filters, will present a clear, viable alternative to other conservation programs which reduce erosion but often lead to increased herbicide movement in runoff. Additionally, determining benefits, if any, of linking multiple BMPs (vegetative filter strips and conservation/no-till) will provide invaluable information for modeling purposes, and for recommendations from various governmental agencies.

Nature, Scope, and Objective of Research

The Mississippi Delta is a major crop producing area in the United States, matched only by portions of the Midwest in farming intensity. Due to a humid sub-tropical climate, both insects and weeds have a far greater impact on farming than in most portions of the nation. Similarly, high levels of microbial activity promote oxidation of native soil organic matter, requiring nutrient replenishment through synthetic fertilizers. As a consequence, the intensity of agrichemical use is exceptionally high, particularly in cotton. There is clear evidence that agriculture has had an impact on surface water resources of the region. This was especially true in previous decades with poor soil conservation practices, intensive fertilization, and heavy use of long-lived pesticides such as DDT. Although management practices have changed, many of the impacts continue. The infrastructure has been established to measure how alternative agricultural systems impact water quality and sustainability in Delta farming.

The major factors causing water quality impairment in the Delta center on movement of surface waters. The rainfall amounts and intensities are seasonally high, causing significant contaminant flux through the ecosystem. Since pesticide and fertilizer use is high, unfortunate timing of application allows a significant probability of mobilizing these compounds in the environment. Cotton and soybean farming usually leaves the soil almost completely exposed for several months annually. The nature of normal precipitation events on relatively bare soil disperses soil particles. Thus, they generate sufficient sediment loss to cause environmental problems. What reaches the streams and lakes are highly adsorptive colloidal materials which can stay suspended for extremely long periods. Thus, the system selectively delivers colloidal materials (fines), which are pollutants themselves and are also carriers of other pollutants.

In surface waters, suspended colloids block sunlight, one of the essential factors for production of phytoplankton, the base of the aquatic food chain (Avinmelech et al. 1982; Threlkeld and Soballe 1988). Under these conditions nutrients (e.g. nitrogen and phosphorus) can accumulate so that as waters clear, algal blooms proliferate. The decomposition of dead algae consumes oxygen, selectively killing those species of fish which are most valued for game fishing. Heavy rains also carry fertilizers into streams and lakes, amplifying this process. Depending on the type used, pesticides which have not degraded travel in runoff, either as a solute or adsorbed to suspended particles.

The keys to protecting the surface waters are: 1) to protect the soil from the impact of rain; 2) to reduce the usage of chemicals to just those levels necessary to produce and protect the crop; 3) to slow the movement of runoff sufficiently to allow sediment to settle or be filtered out before it reaches a lake; and 4) to enhance utilization of field edges and riparian zones for contaminant filtration.

Although significant changes in agricultural practices have occurred in recent years, there are several barriers to a broad acceptance of methods for improving the quality of Delta streams and lakes. While a significant amount of laboratory and plot-scale research on best management practices (BMPs) has been conducted, very little information is available for watershed-scale processes. The premier research projects attempting to demonstrate the viability of BMPs at these large scales are Management System Evaluating Area (MSEA) studies. There are five of these projects at present in Midwestern states, stretching as far east as Ohio and as far south as Missouri (USDA-ARS 1993). Generally funded by a combination of USDA-ARS and USDA-CSREES funds, the data from this research are providing guidelines for determining practices acceptable to both producers and enforcement agencies. Importantly, however, these results are not likely to be applicable to farming practices in the southern United States.

Agriculture in the southern United States differs significantly from that of the Midwest. In addition to increased dependence on pesticides, climate and soil differences, the crops and cultural practices dictate a different array of pesticide and nutrient management schemes. Fortunately, the South has many potential BMPs, but both the sources of recommendations and concerns over their utilization have varied, and farm-level testing is sparse. For example, Ducks Unlimited has sponsored broad use of slotted board risers and winter flooding. These allow more settling of eroded sediments and control weeds with reduced pesticide use by creating anaerobic conditions for the weed seed. But, there is little information on the magnitude of their impact on receiving waters or their place in an economical farm management system. Data from potential BMPs developed for southern U.S. farming, though sparse, are in great demand from producers, environmental enforcement agencies, and private interest groups.

The Mississippi Delta is an alluvial plain, typically with low slopes and poor drainage. One of the primary objectives for row crop producers is moving water off fields as quickly as possible. Thus, many are surprised that substantial quantities of sediment, along with nutrients and pesticides, are moving off these fields, and that BMPs are needed to control this movement. However, McDowell (1989) and McDowell et al. (1981) reported movement of sediment and pesticides from these soils. Most troubling in these losses were the high levels of colloidal clays, which tend to remain in suspension much longer and create more water quality degradation than other particulates.

Various BMPs may be optimized for use on these soils. These would include:

Vegetative filter strips. These strips of perennial, non-invasive grasses are typically composed of tall fescue (Festuca arundinacea), are 2 to 10 m in width, and are either placed at the turnrow or at intervals in the field. Research in Mississippi has demonstrated their effectiveness in reducing sediment and herbicide loads in runoff water (Murphy and Shaw 1997; Webster and Shaw 1996). Alternative species of tall perennial grasses have also been effective (Rankins et al. 1997).

Reduced- or no-till. Numerous studies have demonstrated that reductions in tillage and/or crop residues on the soil surface will reduce sediment losses (Griffith et al. 1986; Hairston et al. 1984). Less clear is the impact that these systems have on pesticide movement. In some instances moving to a no-till system reduced pesticide movement in runoff while in other instances, sometimes in the same study, increases were noted (Hall et al. 1972; Ritter et al. 1974; Shaw et al. 1992; Webster and Shaw 1996).

Riparian zones. Most of the Mississippi Delta was originally in hardwoods, and there are many areas which remain out of crop production. These often are drainage systems for agricultural fields, and are a rich resource to serve as a natural biological system to selectively filter runoff.

A large-scale project aimed at the study of practices that are environmentally sound, economically effective, and acceptable to Southeastern producers is needed to develop a watershed-level database to validate BMPs and increase their acceptance. In order to address this critical need, a MSEA project has been established in the Mississippi River Delta to address a common goal of agricultural productivity and nonpoint-source concerns for the Southern region.

Many of these BMPs have proven to be effective at the plot level, but many have not been adopted on a widespread basis for various reasons. All of these BMPs will be evaluated at the watershed level in some portion of the proposed MSEA project. This will allow a demonstration of how BMPs developed and tested on a small-plot scale can be utilized at the watershed or regional level. In addition, research at this level can develop accurate and credible economic analyses that further demonstrate the feasibility of these BMPs.

The project is located within three oxbow lake watersheds. These offer an excellent opportunity to thoroughly test management practices tailored to Southeastern crops and cultural preferences. The large number of oxbow lakes in the region allows selection of several similar watersheds. Unlike many watershed studies, data collection need not be limited to groundwater and short-term runoff data; the presence of lakes allow long-term study of the impacts of runoff: short-term losses, impact on quality of lake waters, life span of chemicals, impact on lake ecology, accumulation of pesticides in fish tissue, and changes in sediment quantity and quality.

In reviews conducted by the Natural Resources Conservation Service, they have begun to request more work tying plot-level, field-level, and watershed-level models together more closely. This project offers an unusual opportunity to do so. This will enable other researchers to begin to gain a better sense of the extent to which the various models can be scaled to the watershed level.

These data can be used to educate producers, enforcement agencies, and the public regarding: 1) past and present impacts of agriculture on ecosystems; and 2) the environmental benefits of installing management systems of acceptable cost and wide acceptance. These studies also will expand the number of practices available by generating researchable issues.

The specific objectives of this proposal are: 1) to evaluate the effect of a stiff-grass vegetative filter strip composed of switchgrass in conjunction with conventional and conservation tillage systems on off-site movement of two widely used soil-applied herbicides. It will also evaluate this off-site movement over time within a runoff event. 2) Laboratory studies will be initiated to determine herbicide adsorption and degradation in the filter strips, the treated fields, and at various intervals moving into the riparian forest at one of the watersheds. This will provide an understanding of not only the level to which "filtering" is taking place, but also a more fundamental understanding of the mechanisms of how it takes place.