Reducing Atrazine Losses in Central Texas
Texas State Soil and Water Conservation Board
FY03 CWA Section 319

Nonpoint Source Summary Page
CWA, Section 319(h) Agricultural/Silvicultural Nonpoint Source Program

1. **Title of Project:** Reducing Atrazine Losses in Central Texas

2. **Project Goals/Objectives:** 1) Demonstrate the effects of alternative tillage practices and atrazine application practices on protecting water quality by reducing atrazine losses; 2) develop educational materials and present the demonstration results at agricultural meetings, field days, and conferences; 3) validate the *CroPMan* simulation model with measured atrazine losses to facilitate simulating long-term losses of atrazine and the probabilities of meeting EPA standard for safe drinking water; and 4) analyze the economic costs, profits, and the cost effectiveness of alternative tillage methods.

3. **Project Tasks:** 1) Establish corn plots and measure atrazine losses; 2) validate *EPIC*; 3) present results at Styles Farm Foundation field day and develop educational materials; 4) simulate long-term atrazine losses; 5) establish economic and environmental trade-offs

4. **Measures of Success:** 1) Demonstrate the effectiveness of alternative practices to at least 100 producers in the central Texas area; 2) disseminate educational material to no less than 200 producers in the central Texas area; 3) adoption of alternative tillage practices by 25% of producers in the central Texas area.

5. **Project Type:** Statewide ( ); Watershed (X); Demonstration (X)

6. **Waterbody Type:** River (X); Groundwater ( ); Other ( )

7. **Project Location:** Segment 1247A (Willis Creek); Segment 1248 (San Gabriel River)

8. **NPS Management Program Reference:** Texas Nonpoint Source Pollution Assessment Report and Management Program approved October, 1999.

9. **NPS Assessment Report Status:** Impaired ( ); Impacted ( ); Threatened (X)

10. **Key Project Activities:** Hire Staff ( ); Monitoring ( ); Regulatory Assistance ( ); Technical Assistance (X); Education (X); Implementation ( ); Demonstration (X); Other ( );

11. **NPS Management Program Elements:** Milestones from the “1999 Texas Nonpoint Source Pollution Assessment Report and Management Program,” which will be implemented include: (1) Coordinating with federal, state, and local programs, (2) Committing to technology transfer, technical support, administrative support, and cooperation between agencies and programs for the prevention of NPS

12. **Project Costs:** Federal ($101,271); Non-Federal Match ($67,723); Total ($168,994)

13. **Project Management:** Texas A&M University, Blackland Research and Extension Center

14. **Project Period:** Three years from start date.

REDUCING ATRAZINE LOSSES IN CENTRAL TEXAS

INTRODUCTION

Atrazine is the most widely used herbicide in Texas corn and grain sorghum production. With its widespread use, atrazine has been detected in Texas groundwater and surface water. The detections of atrazine in surface water have been concentrated, mainly, in the Central Texas Blacklands including the counties of Milam, Falls, Ellis, Hill and Delta. Reports presented by the Texas Commission on Environmental Quality (TCEQ) (2000) indicate the presence of atrazine in eight public water supply lakes and one public water supply drawn from a river in Texas. These reports indicate that atrazine is entering the public water supplies through surface runoff from corn and grain sorghum cropland and urban landscapes. Banning atrazine does not appear to be the answer because of the adverse economic impact on agricultural producers. It is estimated that Texas corn producers, as a whole, would face a total increase in the cost of production (based on increase in cost of production of using an alternative herbicide and decrease in income caused by yield reductions associated with increased weed populations and crop injury) of over $45,000,000 (USDA 1995). Given the reality that producers economically need to have continued access to atrazine coupled with the need to reduce off-target losses of atrazine in surface runoff, a concerted effort must be taken to study the benefits of reducing tillage, maintaining residues on the soil surface, and using alternative atrazine application practices on the target area to maintain weed control, reduce off-target losses, and maintain/increase yields.

Two BMPs, incorporation of atrazine at application time and banding at a reduced rate at planting, were recommendations of agricultural producers in Hill County which contains the majority of the watershed of Lake Aquilla. Lake Aquilla is the only public water supply reservoir indicated on the 2000 303(d) list as impaired for atrazine (Texas Commission on Environmental Quality 2000). In the draft TMDL Implementation Plan (Texas Commission on Environmental Quality 2001), TCEQ and Texas State Soil and Water Conservation Board (TSSWCB) include incorporation and banding as prescribed methods of atrazine application in the Aquilla watershed. Water quality data from central Texas corn and sorghum production areas need to be collected and evaluated to show that these two BMPs can reduce off-target losses of atrazine in surface runoff without sacrificing weed control and reducing crop yield. According to the Lake Aquilla TMDL Implementation Plan, failure to do so could lead to outright banning of the use of atrazine in the Aquilla watershed by Texas Department of Agriculture.

OBJECTIVES

The primary objective of this project is to demonstrate in field plots alternative means of protecting water quality from atrazine contamination and assess their impacts by simulating field conditions over a long period of time, a shortcoming of year-to-year field demonstrations. Specific objectives include the following:

1. Demonstrate the effects of alternative tillage practices and atrazine application practices on protecting water quality by reducing atrazine losses;

2. Develop educational materials and present the demonstration results at agricultural meetings, field days, and conferences;

3. Validate the ***CroPMan*** simulation model with measured atrazine losses to facilitate simulating long-term losses of atrazine and the probabilities of meeting EPA standard for safe drinking water; and

4. Analyze the economic costs, profits, and the cost effectiveness (amount of reduction in atrazine loss per dollar cost) of alternative tillage methods.

METHODS AND PROCEDURES

The methodological approach will consist of a two-year timeframe in which the first year will focus on establishing four alternative tillage and atrazine application practices in corn production at the Styles Farm Foundation. These plots will be used to measure atrazine runoff losses. They will also be used to educate and demonstrate environment-friendly alternatives at the 2003 Styles Farm Foundation Field Day.

The second year of the project will continue measurements of atrazine losses from the second crop of corn, repeat demonstrations at the 2004 Field Day, and extend project activities to develop educational information for central Texas producers. An educational packet entitled "*Enviro-friendly Use of Atrazine: A Guide to Central Texas*" will include information concerning: (a) the impacts of each of the four tillage practices on measured atrazine losses, both concentrations and loads, and will include supplemental demonstration/research results from past activities; (b) the use of a unique, new computerized crop and pesticide simulation program, ***CroPMan***, which can assess the potential long-term average atrazine loss and the probability of attaining the EPA safe drinking water standard of 3 ppb with improved farming practices; and (c) the economic cost, profitability, and cost effectiveness of each of the four tillage alternatives.

Measuring the Effects of Tillage on Atrazine Losses in Field Demonstrations.

Four tillage treatments will be demonstrated:

1. The common practice of applying atrazine pre-emerge without incorporation;
2. Pre-emerge application of atrazine with immediate incorporation;
3. Banding of atrazine at 33% rate supplanted with seasonal row cultivation; and

4. No-till corn production with spring applied atrazine.

The above descriptions of each tillage practice are self-explanatory. Records of each practice including tillage type and date, fertilizer rate and date, corn planting and harvesting date, atrazine application rate and date, and initial soil characteristics will be used in validating the simulation model and for simulating long-term atrazine losses over time. This complimentary use of a computerized simulation tool is a good example of estimating long-run impacts from short-term field research results.

Prior to preplant fertilization each year, 1-ft soil cores will be mixed from each of four plots to 3 ft depth and split into two samples to: (1) determine preplant soil water in a drying oven, and (2) to analyze for organic carbon, pH, and the nitrogen, phosphorus, sand, silt and clay contents. To avoid discrepancies in atrazine losses caused by unexpected rainstorm events, atrazine will be applied on the same day except for the banding demonstration, which will be applied at planting.

Plots will be evaluated for effective weed control, grain yield, and for each runoff event for which runoff volume and atrazine losses will be analyzed. Runoff collection devices will be placed in four replicated plots to collect water samples. All samples will be analyzed for atrazine concentration using gas chromatography-mass spectrometry techniques. To determine the amount (load) of atrazine lost with each event, the volume of water lost in runoff will also be measured in two plots. Determination of the load of lost atrazine is preferred to the sample concentration since runoff volume is expected to be variable with each storm. Atrazine concentrations will vary widely depending on volume of runoff. For this purpose, six data loggers will be purchased by the project to supplement the two currently needing repairs. This will provide two for each treatment, providing a backup in case one does not work correctly.

Validation of *EPIC*, A Crop and Pesticide Simulation Model.

Successful simulations of various production practices depend on complete and accurate characterization of land and water resources, production inputs, and field operations. This necessitates accurate characterization of soils, slopes, historical weather, cultural practices, crops and rotations, and management options. These data will be developed from several sources including National Weather Service climatic data; Natural Resource Conservation Service soils and land slope data, and Styles Farm Foundation demonstration field records.

The accuracy of simulating long-term impacts on atrazine runoff losses of alternative BMPs depends on validating the ***EPIC*** (***E***nvironmental ***P***olicy/***I***ntegrated ***C***limate) model (Williams et al. 1989), a crop and environmental simulation model, with measured data. Runoff data will be utilized along with measured rainfall and typical soil characteristics of the field site. When simulation deviations depart from measurements, improvements will be made by calibrating soil and crop parameters using the ***CroPMan*** (***Cro***p ***P***roduction and ***Man***agement) model (Gerik and Harman 2001), a Windows® interface for ***EPIC*** to facilitate user-friendly applications.

A basic familiarity with ***EPIC*** is necessary to understand how crops and pesticides are simulated over time. ***EPIC*** was developed for a USDA national study in the mid-1980's to assess the effect of soil erosion on crop productivity. Since the time of the 1985 USDA National Resource Conservation Assessment, ***EPIC*** has been expanded and refined to facilitate simulation of many more processes important in agricultural management including nitrogen and phosphorus uptake, runoff and sediment losses, soil adsorption, volatility, and mineralization. Presently, many pesticides are included in fate and transport functions also.

CroPMan can be used to simulate year-to-year, long-term effects of crop and pesticide management strategies. Major components include weather, hydrology, erosion-sedimentation, nutrient cycling, pesticide fate, plant growth, soil temperature, tillage, and plant environment control. Though weed, insect, and disease control per se are not simulated, a nutrient/pesticide fate model, ***G***roundwater ***L***oading ***E***ffects of ***A***gricultural ***M***anagement ***S***ystems (***GLEAMS***) is contained in ***EPIC*** to simulate pesticide transport by water and sediment as a function of soil organic carbon content and a linear adsorption isotherm (Leonard et al. 1987). Additionally, both long-term mineralization and short-term plant uptake are simulated as a part of the nutrient cycling process.

Long-term Simulations of Corn Production Practices.

A major limitation to demonstrating practices in field plots is the common limitation of the short number of seasons that are usually included in the demonstration. In the case of environmental impacts such as atrazine losses, this is a severe limitation unless by chance wide extremes in rainstorm intensities and amounts occur during the demonstrations. After validation of a crop and pesticide simulator such as ***CroPMan***, a major advantage is that many climatic scenarios can be assessed in a short time and probabilities of losses can be estimated. In this project, validation will be based on the first year of measured runoff losses, sediment losses, soluble and particulate atrazine concentrations/loads, and rainstorm amounts recorded at the Styles Farm Foundation site.

Another advantage of using a simulation tool is that other practices including alternative atrazine application rates and timings of application, tillage intensities, and soil types can be rapidly simulated. The long-term simulation analysis in this project includes twelve simulated situations including two soils typical of central Texas soils—a clay and a loam—each using six tillage/atrazine application practices of which the first four are those being demonstrated and the last two are additional options:

#1-The common practice of no incorporation of a pre-emerge spring application of atrazine preceded by normal preplant tillage operations;

#2-Immediate incorporation of the pre-emerge application of atrazine preceded by normal preplant tillage operations;

#3-Banded application at a reduced rate (33%) at planting time preceded by normal preplant tillage operations;

#4-No-till corn production with a broadcast spring application of atrazine plus fall and spring applications of Roundup® + 2,4D (Landmaster®) at rates adequate for weed control;

#5-Split broadcast applications of atrazine incorporated immediately—one-half rate in the fall and one-half in the spring; and

#6-Banding at the 33% reduced rate at planting preceded by no-till in the fall with fall applications of one-half rate broadcast atrazine followed by an application of Landmaster® at a rate dequate for weed control.

CroPMan will be used to simulate 100 years of randomly generated weather (based on long-term weather records at nearby Thrall, Texas). These 100 simulations will be used to estimate long-term average atrazine losses and probabilities of attaining the EPA safe drinking water standard of 3 ppb with each tillage and atrazine application practice. Each practice will be based on records of field operations in 2003 and simulated for the same dates of tillage, atrazine application dates and rates, seeding rates, and planting and harvest dates. Yearly crop yields as well as monthly and yearly atrazine losses will be simulated for each tillage/atrazine application practice on a soil with characteristics typical of the field soil samples.

Economics of Tillage Practices to Reduce Atrazine Losses.

Farm economic impacts, both short-run and long-term, of atrazine remediation require predicting long-term crop yields and income associated with alternative BMPs and estimating the economic costs of each. Yields, gross income, operating costs, machinery depreciation costs, and profits will be estimated with the economic component of ***CroPMan***. Each of the six tillage/atrazine application practices above utilize different machinery items which affect fuel, labor, and repair costs. Long-run machinery depreciation costs also vary by practice.

In addition to the economic analysis, an enviro-economic tradeoff analysis will be made to evaluate and rank each BMP by the relative cost effectiveness in reducing atrazine losses. The reduction in atrazine load of each BMP from the base alternative (#1 above) will be used to calculate the reduction per dollar of additional cost (or loss of profitability) in comparing cost effectiveness. Ranking of the BMPs by this method provides farmers with decision criteria with which to make their choice of tillage/atrazine application practice. The ranking also provides policymakers, water district managers, environmentalists, and others having an interest in water quality protection an objective means of forming water quality policies and/or developing economic incentives to attain the desired water quality objectives.

TASKS AND TIMELINE OF THE PROJECT

Project Duration- February, 2004-December 2005

Task #1- *Establish 2003 Corn Plots and Measure Atrazine Losses.* **Cost: $35,000**

During the period February-December, 2003, corn plots will be established at the Styles Farm Foundation including four tillage and atrazine application practices described above. Runoff sampling devices will be installed and runoff samples collected and analyzed for each runoff event. Weed control and crop yields will also be summarized by December, 2003.

Task #2- *Validate **EPIC**, the Crop and Pesticide Simulation Model.* **Cost: $ 6,352**

From January-May, 2004, ***EPIC*** will be validated using the ***CroPMan*** interface. Validationwill use actual weather from the Styles Farm Foundation for 2003, soil characteristics of the demonstration plots, crop production practices, and atrazine application dates and rates.

Task #3- *Present Results at Styles Farm Foundation Field Day and Develop Educational Materials for Producers.* **Cost: $ 1,000**

Upon completion of the atrazine analyses, educational materials will be prepared to give producers attending the Styles Farm Foundation Field Day. The materials will include descriptions of the four tillage demonstrations, 2003 corn yields, and 2003 monthly and total atrazine losses. Additionally, other atrazine losses will be included from previous demonstrations/research. Estimates of typical economic costs and profitability will also be determined for each of the four alternatives. Finally, a description of the user-friendly, computerized crop and pesticide simulation model ***CroPMan*** will be included.

Task #4- *Establish 2004 Corn Plots and Measure Atrazine Losses.* **Cost: $ 32,664**

During February-August, 2004, the corn plots will be established for year two of the project, soil samples analyzed, and atrazine losses for each runoff event measured and analyzed.

Task #5- *Simulate Long-term Atrazine Losses.* **Cost: $ 10,000**

During the period June-October, 2004, the twelve simulations using 100-scenarios of weather will be analyzed and summarized for each soil/tillage/atrazine application practice. This analysis will include the estimated yearly average atrazine losses and the probability of exceeding the EPA standard of 3 ppb. Two soil types will be simulated with each of the six alternative tillage/atrazine application alternatives.

Task #6- *Estimate Economic and Environmental Trade-offs.* **Cost: $ 2,545**

Utilizing the long-term atrazine loss of each of the six tillage and atrazine application practices on each soil, a comparative analysis of their cost effectiveness will be made. In this analysis, the amount of atrazine lost using the common practice of non-incorporation versus the amount of atrazine lost and the cost of attaining the reduced loss from each alternative will be conducted in November-December, 2004.

Task #7- *Prepare Final Report of Methods and Results of Reducing Atrazine Losses for Texas State Soil and Water Conservation Board.* **Cost: $ 500**

The two-year results of the demonstrations will be summarized in a final report to the TSSWCB. Additionally, 100-year simulation results of expected long-term atrazine losses and the probabilities of attaining the EPA safe dinking water standard of 3 ppb will be summarized. An economic analysis will also be included for the six alternatives simulated.

DELIVERABLES

December 15, 2003- *Progress Report for 2003 Corn Season*

This report will describe the project activities of 2003 and summarize corn yields and weed control during the crop season. Analyses of atrazine contents in runoff will also be reported if completed at this time.

May, 2004- *Packet of Educational Materials: "Enviro-friendly Use of Atrazine:A Guide for Central Texas"*

The Styles Farm Foundation Field Day is held each year to inform producers of the latest technologies and farming practices in central Texas. The educational materials will include the 2003 atrazine demonstration results, information on ***CroPMan***, a user-friendly crop and pesticide simulation model, and the economics of each of the four tillage practices.

December 15, 2004- *Final Report of Project*

The final report of the project will include several items including the 2003-04 corn yields, weed control, atrazine runoff results, a summary of the long-term simulations of the twelve alternative soil/tillage/atrazine practices, and the economics along with the analysis of their relative cost effectiveness.

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2004-2005 Budget

Object Class Category	Federal Funds	Non-Federal Match	Total Costs
Personnel			
Dr. Monty Dozier, TAES (15%)	0	10,789	10,789
Dr. Tom Gerik, TAES (15%)	0	13,043	13,043
Dr. Wyatte Harman, TCE (15%)	0	13,466	13,466
Roger Cassens, TAES (50%-yr-1: 50%-yr-2)	34,738	0	34,738
TCE Tech, TCE (7.5%- yr-1:7.5%- yr-2)	5,075	0	5,075
Melanie Magre, TCE (12.5% yr-1: 25% yr-2)	15,135	0	15,135
TOTAL Personnel	54,948	37,298	92,246
Fringe			
@15.5%	8,517	5,661	14,178
Health Benefit ($426/mo)	7,796	2,301	10,097
TOTAL Fringe	16,313	7,962	24,275
Subtotal Personnel	*71,261*	*45,260*	*116,521*
Travel			
Dozier	2,000	800	2,800
Subtotal	*2,000*	*0*	*2,800*
Equipment			
Dataloggers	4,000	0	4,000
Subtotal equipment	*4,000*	*0*	*4,000*
Supplies			
	1,500	0	1,500
Subtotal	*1,500*	*0*	*1,500*
Miscellaneous			
Soil Analyses	1,000	0	1,000
Water Analyses	8,000	0	8,000
Printing	300	0	300
Subtotal	*9,300*	*0*	*9,300*
Total Direct Costs	88,061	46,060	134,121
Indirect Costs (15%)	13,210	0	13,210
Indirect Cost (Disallowed by Sponsor 11%)	0	9,687	9,687
Indirect Cost (Non-Federal – 26%)	0	11,976	11,976
Total Project Costs	**$ 101,271**	**$ 67,723**	**$ 168,994**