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University of California Program to Evaluate Water Quality Management Practices at Cooperating Agricultural Sites

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Abstract: Extension is viewed as a critical agent for addressing the water quality impacts of agriculture. To assist growers in implementing management practices (BMPs) and to assess the effectiveness of these BMPs, the University of California undertook two grant projects that assessed cooperator sites for runoff water quality and water conservation. The interdisciplinary approach was largely successful. However, factors creating challenges for quantifying BMP performance included assessing BMPs in a before-and-after manner, limited stormwater runoff, and the limited duration of the projects. Addressing these challenges may help to make similar programs more effective.

Introduction

Potential water quality impacts of agricultural production include runoff and leaching losses of nutrients, pesticides, and sediments (Ribaudo & Johansson, 2006). Extension has adopted water quality protection as a national initiative (Vaughn, 1989), and CSREES coordinates national and regional water programs. Some states employ specialists in water resources or county agents for resource management. Other agents who traditionally deal with agriculture or urban horticulture may find themselves increasingly addressing water quality concerns. Extension may prove to be critical in addressing water quality issues for several reasons, including the following.

- Regulators and other agencies may lack an education component and rely on Extension to educate agricultural producers and other stakeholders. Technology, research, and regulation will be effective in improving agricultural practices only if information is extended to producers.
- Extension practice typically involves not only program delivery, but also an evaluation of program effectiveness. This evaluation is critical for assessing the utility of conservation efforts.
- Extension is suited to translate state-level national programs, regulations, or concerns into local and farm-specific solutions.
- Extension serves as a conduit of information among farmers, local stakeholders, and government agencies, educating each on the needs and perspectives of the others. Extension can help educate regulators to encourage rational water quality policies.

The voluntary adoption of best management practices (BMPs) is the typical method of improving agriculture's water quality impacts (Benham, Braccia, Mostaghimi, Lowery, & McClellan, 2007). A recent survey in Virginia found that 85% and 90% of producers thought that education programs encouraging the voluntary adoption of BMPs were the best way to address water pollution challenges (Benham et al., 2007). However, the inability of the Maryland's voluntary Nutrient Management Program to achieve desired reductions in nutrient loading to Chesapeake Bay, even though agriculture participated in implementing recommended BMPs, has raised questions about the effectiveness of this approach (Boesch, Brinsfield, & Magnien, 2001; Terlizzi, 2006). Technology transfer issues about agricultural BMP adoption include questions about the effectiveness of BMPs, how willing producers will be to adopt specific BMPs, and the costs of implementing specific BMPs (Vaughn, 1989).

This article describes the structure of our water quality evaluation program and enumerates the successes and challenges of this program to guide Extension faculty interested in developing similar programs.

Water Quality Evaluation Program

The University of California Cooperative Extension in Ventura County along with faculty at the Riverside and Davis campuses undertook two large grant projects (Table 1) to assist growers in implementing BMPs to improve runoff and leachate water quality, enhance water conservation, and assess the effectiveness of these BMPs.

The procedure in these grant projects involved: 1) assessing runoff water quality or other relevant metrics at cooperating sites; 2) suggesting appropriate BMPs on a site-specific basis; 3) aiding cooperators in the implementation of BMPs; and 4) re-assessing runoff water quality or other relevant metrics after BMP implementation. These projects included some cost-share or supply money for cooperating producers.

Table 1.
Summary of Grant Projects

Grant Project	Years of Execution	Cooperating Sites	BMPs Evaluated	Grant Budget Awarded
1	2004â 2006	19 production nursery sites	Detention basins; Retention basins with tailwater recycling; Irrigation system improvements	$1.4 million plus $1.2 million cost share for producers
2	2006â 2009	10 orchard sites and 7 production nursery sites	Irrigation system improvements; Irrigation scheduling technology; Mulch; Gravel; Cover crops; and Vegetated buffers.	$977,500 including supply funds for BMP implementation

Principal investigators (PIs) for these grant projects were two county-based farm advisors and four campus-based Extension specialists. Additional county-based faculty included staff research associates responsible for project management, sample collection, photo documentation, and report writing. Additional campus-based faculty included post-doctoral associates and staff scientists responsible for sample analysis, data analysis, and report writing. Funding was supplied by the California State Water Resources Control Board, the state regulatory agency in charge of enforcing water quality regulations. Project direction and plans for the implementation and assessment of BMPs were reviewed by a Technical Advisory Committee that included the Natural Resources Conservation Service, agricultural industry groups, and agricultural producers.

Data collected at cooperating sites, when appropriate for assessing implemented BMPs, included:

- Constituents in runoff water (Table 2)
- Constituents in soil water extracted with suction cup lysimeters
- Distribution uniformity of irrigation systems
- Water use

- Soil infiltration capacity
- Fertilizer and pesticide use records
- Installation costs for BMPs

Table 2.
Constituents in Runoff Evaluated at Cooperating Sites and Responsible Personnel

Constituent	**Principal Investigator (PI) Responsible for Evaluation**	**Place of Analysis**	**Staff Associated with Analysis or Evaluation**
Nutrients (NO_3â N, NO_2â N, NH_4â N, PO_4â P) and pH	Campus Extension specialist for ornamental crops	Responsible PI's laboratory	Junior specialist
Total phosphorus	Campus Extension specialist for ornamental crops	Sent to university tissue analysis laboratory for a fee	
Pesticides (pyrethroid, organophosphate, carbamate, and organochlorine classes) and total suspended solids	Campus Extension specialist for water quality	Responsible PI's laboratory	Assistant project scientist
Turbidity	County farm advisor for environmental horticulture	Responsible PI's laboratory	Staff research associates
Runoff discharge	Campus Extension specialist for water management	On-site / Responsible PI's laboratory	Post-doctoral employees
Temperature and dissolved oxygen	County farm advisor for environmental horticulture	On-site	Staff research associates

Note: The list of tested constituents was determined by agreement between the granting agency and the principal investigators.

Program Evaluation

In general, the multi-campus, interdisciplinary approach was successful for assessing the effectiveness of agricultural BMPs, developing demonstration sites, and gathering water quality data for Extension programming. Having a range of specialties among PIs was useful for producer education. For example, agricultural producers who were already concerned with nutrient runoff were even more motivated to implement BMPs when told that legacy pesticides such as DDT were present in their or their neighbors' runoff. Had there not been a water quality specialist with facilities to analyze pesticides on these projects, these educational opportunities would have been lost.

The effectiveness of certain BMPs was easy to evaluate. For example, it was clear that retention basins with tailwater recycling capabilities were very effective at nearly eliminating the off-site movement of nutrients, sediments, and pesticides in runoff. Likewise, improvements in the distribution uniformity from irrigation system upgrades were easy to quantify. However, the evaluation of other BMPs was more difficult in some cases. Factors leading to difficulty in quantifying BMP effectiveness included the following.

- Assessing BMP effectiveness by comparing measurements taken before and after BMP implementation. Because metrics like runoff water quality and water use can be affected by year-to-year variation in weather and production practices, comparing sub-sites with and without implemented BMPs side-by-side may have been a more effective approach. For meaningful results, using a paired watershed design would be best (USEPA, 1993).

- A lack of stormwater runoff. Below-normal rainfall, sites with sandy soils, and heavily mulched sites contributed to the infrequency of stormwater runoff at some sites. This infrequency created difficulties in evaluation when BMPs were designed to improve stormwater quality. The use of rainfall simulation devices may be warranted when rainfall is not adequate for BMP evaluation (Grismer & Ellis, 2006; Grismer, Ellis, & Fristensky, 2008).

- Cooperators not completing BMP implementation according to the schedule of the project. Delays in BMP implementation left only short durations in which to conduct post-implementation evaluations in some cases. For example, in the first grant, planned implementation of recycling systems would leave an entire year for post-implementation evaluation, but delays left some sites with only a few months of post-implementation evaluation. Timing of project completion relative to the ending of the grant didn't allow for evaluation during the rainy season for some sites. Better scheduling of BMP implementation and longer evaluation periods may alleviate this difficulty. Plans should leave at least a year of post-implementation assessment with considerable buffer for delays.

- Cooperators needing more time to change production practices in response to newly implemented irrigation scheduling technologies. Even once cooperators became comfortable with using technologies, they needed more time to be convinced of the reliability of these technologies before adjusting production practices. At least 1 year of post-implementation assessment with considerable buffer for cooperators becoming comfortable with new technology may give enough time to realize effects.

It is our hope that addressing these concerns will help others developing similar programs for Extension and research purposes avoid some of the challenges we encountered in these projects.

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