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Voluntary Incentives for Reducing Agricultural Nonpoint Source Water Pollution

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Water Quality

***In this report...** Agricultural chemicals and sediment from cropland may reduce the quality of America's surface and ground water resources. The Clean Water Act stipulates that individual States are responsible for controlling agricultural nonpoint source pollution. Most State plans rely chiefly on education and technical assistance to promote the adoption of less polluting practices. Because profitability drives production decisions, these programs tend to be most successful when they promote inexpensive changes in existing practices. This report presents recent research findings on the success of existing incentive programs to control agricultural nonpoint source pollution.*

Impaired surface water quality from cropland erosion alone has resulted in $2-$8 billion in annual losses to recreational and commercial fishing, boating, municipal treatment plants, water storage facilities, and navigable waterways (Ribaudo, 1987). Both voluntary and mandatory policies have been implemented and studied to reduce agricultural pollution. Voluntary incentives rely on providing the farm operator with an incentive to adopt less polluting technologies. These approaches commonly use cost-sharing or education and technical assistance to encourage farm operators to use less polluting practices. Regulations or taxes to force farm operators to reduce pollution levels are two examples of mandatory approaches.

Because nonpoint source pollution is not directly measurable, regulations would consist of design standards governing farmers' land management and cropping practices. Although this option may appear to be a simple solution, administrative costs may be high.

When taxes are levied on a polluting input (such as a chemical pesticide), farmers will reduce their use of that input and substitute other, less polluting inputs to reduce costs. The extent of the change in input use depends on the sensitivity of the demand for the polluting input to price changes, which can change from one area to another.

Education, Technical, and Financial Assistance, a component of the U.S. Department of Agriculture's (USDA) Water Quality Program, is a national effort to encourage the adoption of less polluting farm management practices. Research findings indicate that the adoption of an improved management practice is most strongly influenced by producer perceptions of its effect on profitability. Other important factors include familiarity with the practice and beliefs that it will improve onfarm water quality. This indicates that educational programs are best targeted toward inexpensive, familiar practices with tangible environmental benefits.

The 1990 Food, Agriculture, Conservation, and Trade Act authorized USDA to create the watershed-based Water Quality Incentive Program (WQIP). WQIP encouraged the adoption of less polluting practices via direct incentive payments to farmers. The findings in this report suggest that the adoption of some less polluting practices is highly influenced by the payment level, while the adoption of others is not. Payments that are too low will have little effect on adoption, while those that are too high will result in the same level of adoption that could be accomplished by a lower payment. These findings suggest that WQIP payments should reflect changes in costs of production due to the adoption of an improved management practice.

Alternative Policies for Reducing Nonpoint Source Pollution

Several approaches may control nonpoint source pollution, each with varying success and associated costs.

Both voluntary and mandatory policies exist for the control of nonpoint source pollution. These policies either encourage farmers to adopt less polluting practices through education or incentives or force farmers to be less polluting through higher input costs or regulation.

Voluntary Incentives

The following policies provide farmers with an incentive to voluntarily adopt less polluting technologies. Cost-sharing and incentive payments are commonly used financial incentives, while education and technical assistance are commonly used voluntary incentives.

Cost-sharing and incentive payments are two methods commonly used to induce farmers to voluntarily adopt a less polluting practice. Cost-sharing payments cover some or all of the start-up and/or installation costs of implementing less polluting management practices. Incentive payments are monetary incentives used to encourage farmers to initiate pollution-control practices. Traditionally, cost-sharing has been used to encourage farmers to adopt pollution-control practices requiring initial capital investments. Farmers are encouraged to adopt such practices because they are reimbursed by the Government for part of the costs. Incentive payments are designed to reduce the financial uncertainty associated with adopting an improved management practice by informing farmers of the benefits and costs of less polluting technologies. Subsidized practices must continue to be beneficial to the farmer once the payments end. The main drawback of cost-sharing and incentive payments is the high cost. The estimated cost to encourage the use of improved practices on 176 million acres of cropland that may adversely affect water quality is $3.6 billion (Ribaudo and others, 1993). In addition, it may be costly to identify and administer relevant practices to solve particular water quality problems.

Education and technical assistance are also used to persuade farmers to voluntarily adopt less polluting practices. Programs promoting voluntary adoption have been the primary approach of reducing nonpoint source pollution. Farmers may adopt environmentally beneficial practices once they learn of their existence and benefits. Educational and technical assistance programs may be combined to lower the initial costs of adoption by helping farmers to develop and install the new practices. These approaches work best when they are profitable and require minor, inexpensive changes in existing practices. Since changes in pesticide use require substantial changes in farming practices, the assistance approach is likely to work best for nutrient management practices, for example (Halstead, Padgitt, and Batie, 1990).

Nonvoluntary Incentives

These policies force the farmer to use pollution-control practices through higher input costs or direct regulation.

Taxes levied on a polluting input (such as a chemical pesticide) will cause the farmer to use it less. Taxing inputs in the production process is like raising the input price. Farmers will reduce their input use, substituting other, less polluting inputs as its price rises. The extent of the change in input use depends on how sensitive the demand for the polluting input is to price changes. These sensitivities tend to be small for fertilizer, and to vary over geographic areas (Vroomen and Larson, 1991; Rendleman, 1993; and Fernandez-Cornejo, 1993). A 65-percent tax would be required to achieve a 10-percent reduction in fertilizer applications in Illinois, for example, whereas a 13-percent tax would achieve the same reduction in Indiana (Fernandez-Cornejo, 1993). Similar findings apply to pesticides (Ribaudo and others, 1993; Rendleman, 1993; and Fernandez-Cornejo, 1993). Thus, a successful tax policy consists of relatively high tax rates that vary geographically. The tax could be targeted to areas with known nonpoint source problems to increase the policy's efficiency.

Regulations force farmers to reduce or eliminate the use of certain inputs or to adopt specific pollution-reduction technologies. Direct regulation is the most commonly used approach to reduce point source pollution. The regulations achieve a reduction in pollution levels by requiring operators to meet minimum design standards for various treatment technologies or by requiring operators to comply with minimum performance standards based on actual emission levels. Because nonpoint source pollution is not directly measurable, regulations would likely consist of design standards governing farmers' land management and cropping practices. Although this option may appear to be a simple solution, administrative costs may be high. Because biological and climatic factors vary across geographic locations, the efficiency and cost-effectiveness of abatement technologies will also vary. Tailoring management systems to specific geographic regions is costly. Technical-assistance costs alone have been estimated at $2.6-$3.7 billion over 10 years (Ribaudo and others, 1993). Another option is to require a common set of management systems for all farms. High education and technical assistance expenses would make this option costly.

Trading Between Point and Nonpoint Sources

Point-nonpoint trading occurs between two firms, one a point source and the other a nonpoint source. This type of policy reduces the total amount of pollutants entering a given body of water. If the nonpoint source pollution is significant and the cost of its control is lower than for additional point source controls, trading could achieve water quality goals at a lower cost (Letson and others, 1993). Reductions in pollution result from the point source compensating the nonpoint sources for reducing their pollution levels. Although this approach may offer an efficient solution, it has several problems including the establishment of acceptable levels of nonpoint pollution, government supervision, and high transactions costs. Additionally, this approach requires both point and nonpoint sources to be affecting the same body of water. Currently, less than 10 percent of all impaired bodies of water meet this criterion (Apogee Research, Inc., 1992).

What Is Nonpoint Source Pollution?

Nonpoint source pollution has no observable point source, which makes it more difficult to control. Point source pollution can be monitored and regulated, while nonpoint source pollution can only be decreased indirectly by controlling inputs and management practices that impair water quality. Characteristics of nonpoint source water pollution from farming include:

The inability to monitor agricultural pollutants at the individual farm or source level because they enter bodies of water over a dispersed area rather than at fixed, identifiable points;

An unknown relationship between farm-level input usage and water quality; and

The effect of climatic conditions (wind, rainfall, and temperature) and geographic characteristics (soil type, depth of the water table, and slope of the land) on the concentrations of pollutants (Malik, Larson, and Ribaudo, 1992).

Adoption Results From an Educational, Technical, and Financial Assistance Project

Analysis of the Demonstration Projects shows that adoption levels are affected more by geographic location than by the presence of the program.

The Education, Technical, and Financial Assistance (ET&FA) effort is a part of USDA's Water Quality Program. The goal is to identify and disseminate information about profitable and agronomically sound "best management practices" (BMP's) that protect or enhance water quality. One part of the program focuses on "Water Quality Demonstration Project Areas" (DPA's) to encourage voluntary adoption of BMP's through education. Each DPA contains farms practicing one or more of the BMP's. Producers are encouraged to visit these farms to learn more about the BMP's.

A producer adoption survey was conducted to evaluate the success of the ET&FA program (Nowak and O'Keefe, 1992). The survey sampled both DPA's and "comparison areas" (comps), which are locations similar to DPA's but without demonstration farms. Five of the most commonly practiced BMP's were selected for analysis (see box). The adoption of each of these practices occurs on a voluntary basis without any cost-sharing assistance (except the construction of manure storage facilities in a few States). The results show that BMP's requiring minor, inexpensive changes in existing practices (manure crediting, legume crediting, and irrigation scheduling) are adopted more frequently than those involving more expensive changes (nitrate testing and split application of nitrogen) (fig. 1). This indicates that voluntary adoption may be most successful when changes are minor and clearly beneficial to the producer.

In an econometric model, Feather and Amacher found significant statistical differences in adoption between DPA's and comps for only two BMP's (split application and legume crediting). Disaggregating the data to the State level yielded similar results. In only 3 of 16 cases did the adoption rates between DPA's and comps differ significantly. In contrast, the same study concluded that significant differences exist among States for all BMP's considered (fig. 2).

Best management practices selected for analysis

Manure crediting—Commercial fertilizer applications are made after considering the amount of nutrients provided by manure applications.

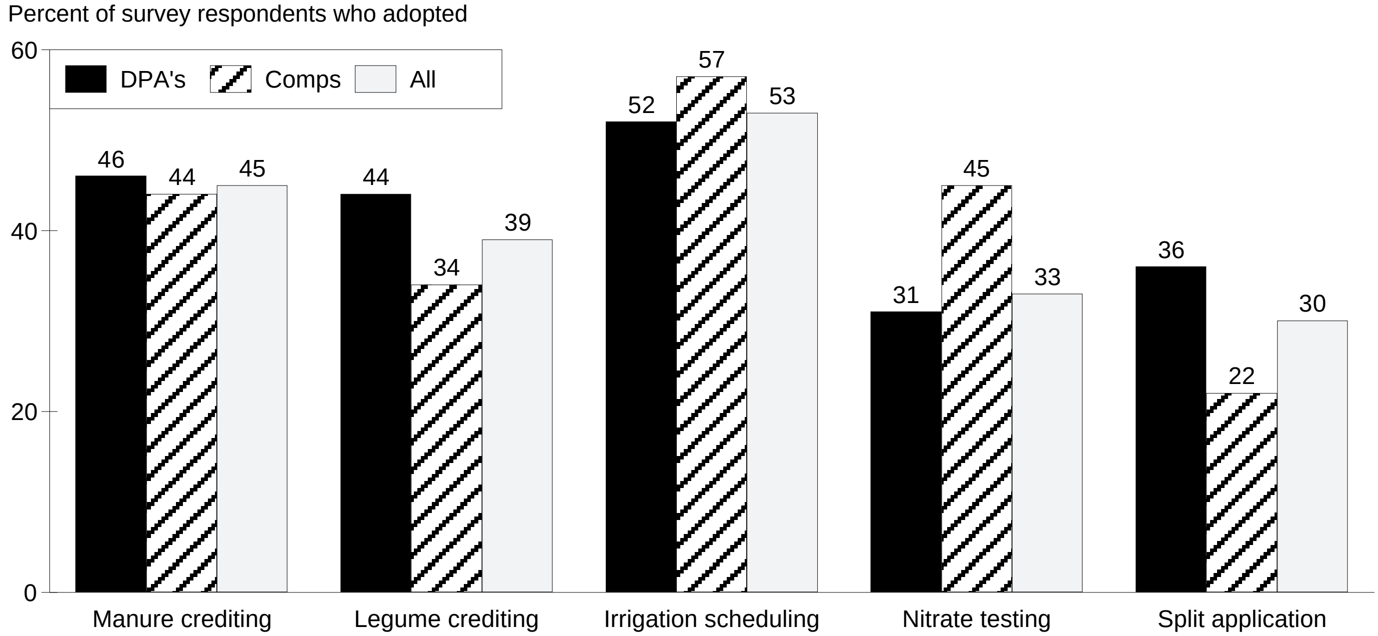
Legume crediting—Commercial fertilizer applications are made after considering the amount of nutrients provided by legume crops.

Split application—Approximately half of the required amount of nitrogen for corn production is applied at or before planting. The remainder is applied after the crop begins to grow.

Irrigation scheduling—A variety of practices and techniques are used to minimize the quantity of irrigation water applied while avoiding crop stress from too little moisture.

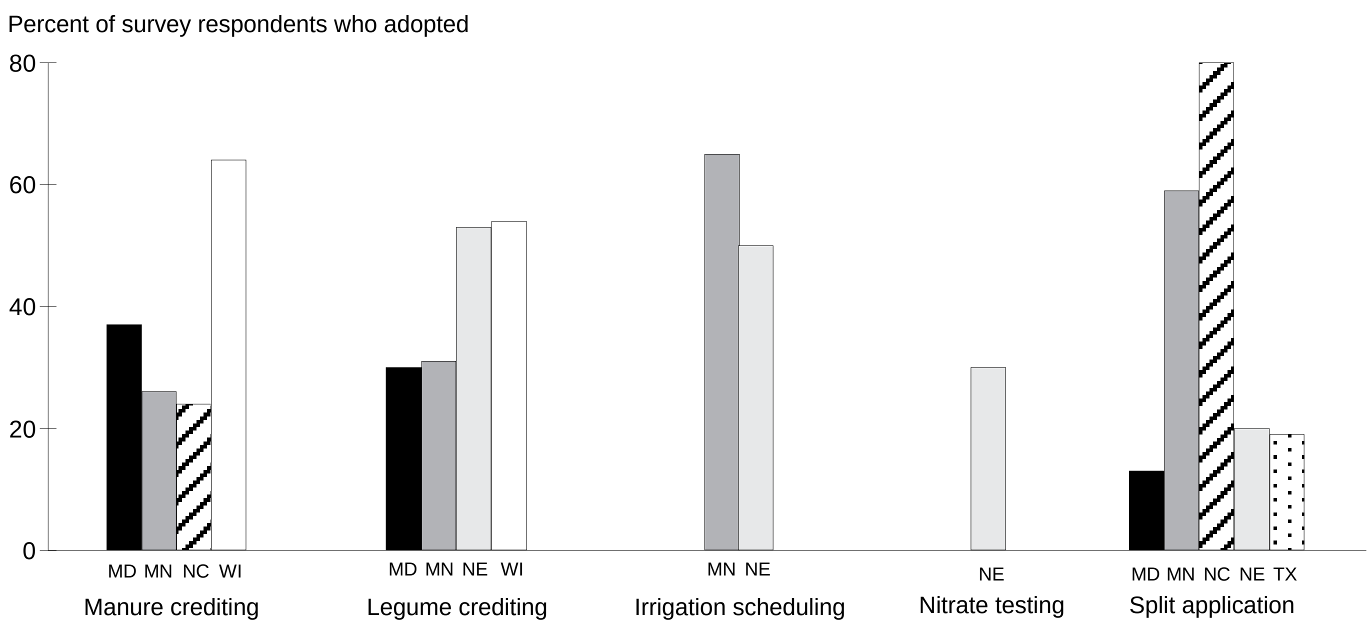
Deep soil nitrate testing—The amount of residual nitrogen in the soil profile is measured to determine the levels of commercial fertilizer application needed.

Figure 1
Program adoption levels in DPA's and comparison areas (comps), by practice



Source: Feather and Amacher, 1994.

Figure 2
Adoption levels across States, by practice



Source: Feather and Amacher, 1994.

The Role of Incentives in the Voluntary Adoption of Less Polluting Management Practices

Water quality benefits, producer knowledge, and farm size influence farmers to adopt less polluting management practices, but profitability is the primary factor.

Educational programs that encourage farmers to voluntarily adopt less polluting BMP's have been partially successful. These programs are most successful when they promote BMP's that are inexpensive and provide obvious benefits to the producer. Identifying other important incentives will improve the success of future educational programs, while practices that producers perceive to be beneficial could continue to be promoted through educational programs. Practices that are perceived as less beneficial could be promoted by using more costly options such as financial incentives. For five BMP's analyzed, increased profitability is the most important determinant of adoption, but producer familiarity is also important (table 1). The following categories of incentives may lead to the voluntary adoption of BMP's:

Increased profits—BMP's that increase profits by reducing input costs or increasing yields are best suited for voluntary adoption programs. Once the producer is made aware of these BMP's through an educational program, voluntary adoption often occurs.

Water quality benefits—Even if a BMP is not profitable, farmers may adopt it if the perceived water quality benefits outweigh the additional expense. This incentive is especially important in areas where agriculture is responsible for the impairment of groundwater used for drinking (Halstead, Padgitt, and Beatie, 1990).

Practice familiarity—Adoption usually occurs after producers are made aware of benefits of the BMP's. ET&FA increases adoption levels by displaying the use and benefits of the BMP's in a field setting. These demonstrations show farmers how BMP's function in a real-world setting.

Table 1—Effect of producer perceptions on the adoption of five BMP's[1]

Producer perception/ knowledge	Expected result	Best management practice: Manure crediting	Legume crediting	Irrigation scheduling	Soil nitrate testing	Split application of nitrogen
Aware of the ET&FA program	+	+*	+**	—	+*	—**
Familiar with BMP's	+	+**	+**	+**	+	+**
Consider BMP risky	—	+	—	+	—	—**
Consider BMP labor intensive	—	+	—	—	—	—
Believe BMP increases profits	+	+**	+**	+**	+**	+**
Believe BMP improves farm water quality	+	+**	+**	+	+	—
Acres in corn	+	+	+**	+**	+*	+*
Dairy cattle present[2]	+	+**	NA	NA	NA	NA
Beef cattle present[2]	+	+	NA	NA	NA	NA

*Statistically significant at the 5-percent level. **Statistically significant at the 10-percent level.

NA = Not applicable.

[1]The effects of producer knowledge, characteristics, and perceptions of each BMP on the adoption rate derived from a probit analysis of adoption behavior. The dependent variable equals one if the individual adopted the practice, zero otherwise. A "+" means a variable has a positive effect on BMP adoption rates; a "—" means a variable has a negative effect on BMP adoption rates.

[2]Used to describe the decision to adopt manure crediting only.

Source: Feather and Amacher, 1994.

Results From an Adoption Study of Incentive Payments

Large incentive payments may be necessary to achieve high adoption levels.

The 1990 Food, Agriculture, Conservation, and Trade Act authorized the USDA to create the watershed-based Water Quality Incentive Program (WQIP). The goal of WQIP is to provide monetary incentive payments to farmers to encourage them to adopt less polluting BMP's. The 1993 funding level of $15 million limited this program to farmers in a few watersheds.

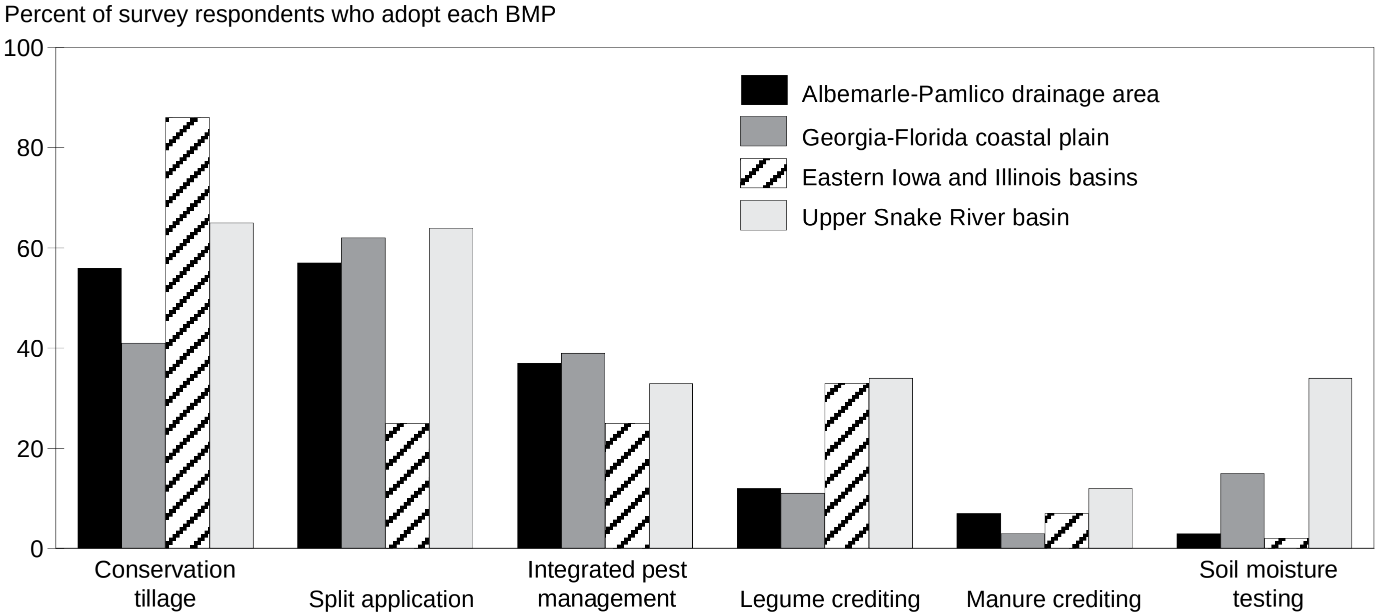
Since actual WQIP payments are not necessarily based upon market interactions or costs of production, the success of the program in increasing voluntary adoption based on existing payment levels is uncertain. Six BMP's that are part of the WQIP program were examined under various hypothetical incentive payment levels (table 2). Adoption data were collected from the four 1991 Area Studies Project sites, a joint effort involving USDA and the U.S. Geological Survey (Department of the Interior). In addition, farmers from the four areas (Iowa and Illinois Basin Area, Albemarle-Pamlico Drainage Area in Virginia and North Carolina, Georgia-Florida Coastal Plain Area, and the Upper Snake River Basin Area in Idaho) that were not eligible for WQIP and do not currently use the BMP were asked if they would adopt the BMP given various hypothetical incentive payments.

Although differences in observed adoption occurred across the four areas, the differences were not statistically significant. Large variations in adoption were observed, ranging from a 73-percent average adoption rate for conservation tillage to a 7.2-percent average adoption rate for manure crediting without incentive payments (fig. 3). The schedule of hypothetical incentive payments and predicted percentage adoption rates reveals that the payment levels required to achieve a 50-percent adoption rate are, in many cases, much greater than the WQIP payment listed in table 2. At the $10 per acre incentive payment level, the predicted adoption rates of only conservation tillage and split application of nitrogen exceed 50 percent (table 3). Integrated pest management requires an incentive payment of slightly over $20 to achieve a 50-percent adoption rate, while the remaining three practices (legume crediting, manure crediting, and soil moisture testing) do not achieve a 50-percent adoption rate even with a $40 per acre incentive payment.

Table 2—Best management practices

Practice	Description	Incentive payment level under WQIP
Manure crediting	Commercial fertilizer applications are made by considering the amount of nutrients provided by manure applications.	Not to exceed $10 per acre.
Legume crediting	Commercial fertilizer applications are made by considering the amount of nutrients provided by legume crops.	Not to exceed $10 per acre.
Split application	Approximately half of the required amount of nitrogen for crop production is applied at or before planting, with the remainder applied after the plant emerges.	Not to exceed $10 per acre.
Integrated pest management	A pest control strategy that indicates a pest population is approaching levels at which net returns will decrease if control measures are not used.	Not to exceed $12 per acre.
Soil moisture testing	Measures the amount of water available from topsoil and subsoil.	Not to exceed $12 per acre.
Conservation tillage	At least 30 percent of the soil surface remains covered by plant residue after planting.	Not to exceed $12 per acre.

Figure 3
Adoption levels across Area Studies Project regions, by practice



Source: Cooper, Keim, and Osborn, 1994.

Table 3—Adoption rates for BMP's under various incentive payments[1]

	Per acre incentive payment[2]				
Practice	$0	$5	$10	$20	$40
			Percent		
Conservation tillage	73.0	81.0	82.0	84.0	88.3
Split application	41.1	52.2	56.0	65.1	84.5
Integrated pest management	29.9	39.9	42.4	48.3	63.3
Legume crediting	27.4	31.6	32.9	36.3	46.7
Manure crediting	7.2	14.5	16.4	21.4	36.1
Soil moisture testing	8.2	16.3	17.3	25.7	45.3

[1]Percentages of farmers across all four regions who would adopt each practice under various hypothetical incentive payment levels. [2]Observed percentages appear under the $0 column; predicted percentages appear under the $5, $10, $20, and $40 columns.

Source: Cooper, Keim, and Osborn, 1994.

Increased payments net little increase in already high adoption levels.

Over 65 percent of farmers would adopt with a $20 per acre incentive payment.

Even at $40 per acre, less than half of farmers interested in these practices.

Conclusions

BMP adoption rates differ both across practices and across geographic areas. Programs involving cost-sharing and incentive payments could be more successful if monetary incentives were altered to account for these differences.

Some practices require small incentive payments to reach a desired participation rate, while others require large payments. Designing policies using benefit-cost analysis techniques will improve the efficiency of financial-incentive programs. This could be accomplished by determining which practice, or set of practices, provides the largest reduction in pollutants per dollar of expenditure. Financial resources could then be allocated to achieve a desired target reduction in pollutant loadings. If the marginal benefits of pollutant reductions are known, then economic efficiency can be achieved by reducing pollution to a point where the marginal benefits and costs of reduction are equal.

Educational programs seem to be most successful with practices that involve small, inexpensive changes in the operation and are profitable to the producer. Water quality benefits can influence adoption decisions, but profitability is the most important factor. Educational programs may have limited success encouraging practices involving large expenditures by the producer.

Using both educational and financial incentives requires less resources and may be more successful than implementing each program separately. A financial incentive program, for example, could be combined with an educational program targeting different practices. These two programs could be combined by requiring producers to enroll in the educational program in order to receive incentive or cost-sharing payments.

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