Are Large Farms More or Less Environmentally Friendly?

By Daniel Bernardo, Terry Kastens, and Kranti Mulik

Abstract

Adoption rates of nutrient and pesticide best management practices are investigated across farm types. Using a survey of corn and grain sorghum producers from Kansas, larger family farms are more likely to adopt best management practices aimed at reducing nitrate and pesticide runoff than smaller producers. Managers' perspectives about water quality and environmental stewardship do not differ significantly across farm types.

Introduction

Rapid and dramatic changes in the structure of U.S. agriculture have caused significant debate about the pros and cons of various sizes of farming operations. Advocates and opponents of both large and small farms have argued their points from a variety of perspectives, including efficiency of resource use, environmental impacts, profitability, and rural development impacts. An interesting question is whether differences exist across farm sizes in terms of their adoption of environmentally oriented production practices.

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An environmental issue that has received considerable attention throughout the nation is the impact of agricultural production on the quality of surface water resources (Caswell et al., 2001). Crop production has been cited as a potential contributor to the degradation of surface water (U.S. Environmental Protection Agency, 1998). Nitrate is the most commonly detected agricultural chemical in water supplies; however, several herbicides have also been documented in groundwater and surface water with notable frequency (U.S. Geological Survey, 1999).

One means of minimizing the detrimental effects of agricultural production on the environment is through the adoption of best management practices or "BMPs." Significant research and educational effort has been directed by land-grant universities and government agencies (e.g., the Natural Resource Conservation Service, state-level agricultural and environmental agencies, local soil conservation districts) to develop BMPs and disseminate information about the efficacy of their adoption (Emmert, 1993; Amacher and Feather, 1997). Despite these efforts, past studies have shown significant variability in the voluntary adoption of BMPs (Bernardo, et al., 2001; Khanna, Epouhe, and Hornbaker, 1999).

This paper investigates whether adoption rates of water quality best management practices differ across farm size. On one hand, smaller farms may be more oriented toward sustainable production and managers more influenced by environmental objectives. On the other hand, managers of larger farms may have a greater economic incentive to adopt BMPs.

If differences exist in BMP adoption rates across farm size, then a question worthy of consideration is which factors contribute to these differences. More specifically, "Do the underlying management objectives that guide the selection of farm management practices change across farm sizes?" and "How do managers' opinions about environmental stewardship and the state of the environment change across farm sizes?"

This study reports findings from a survey of Kansas crop producers to address two objectives:

1. To contrast adoption rates of various water quality best management practices across farm sizes; and
2. To compare the management objectives and environmental perspectives of managers of different farm sizes.

Farm Typology

Farms vary widely in size and other characteristics. A farm typology recently developed by the USDA's Economic Research Service categorizes farms into eight fairly homogeneous groups for policy development and evaluation purposes (USDA, Economic Research Service, 2001). The typology is based upon the sales class of farms and occupation of operators. A summary of the USDA farm types is provided below.

USDA Farm Typology Groups

Small Family Farms (sales less than $250,000):
Limited-resource. Any small farm with gross sales less than $100,000, total farm assets less than $150,000, and total operator household income less than $20,000. Limited-resource farmers may report farming, a non-farm occupation, or retirement as their major occupation.
Retirement. Small farms whose operators report that they are retired (excludes limited-resource farms operated by retired farmers).
Residential/lifestyle. Small farms whose operators report a major occupation other than farming (excludes limited-resource farms with operators reporting a non-farm major occupation).
Farming-occupation/low sales. Small farms with sales less than $100,000 whose operators report farming as their major occupation (excludes limited-resource farms with operators reporting farming as their major occupation).
Farming-occupation/high-sales. Small farms with sales between $100,000 and $249,999 whose operators report farming as their major occupation.

Other Family Farms:
Large family farms. Farms with sales between $250,000 and $499,999.
Very large family farms. Farms with sales of $500,000 or more.

Non-family Farms:
Non-family farms. Farms organized as non-family corporations or cooperatives, as well as farms operated by hired managers.

For purposes of this study, the surveyed farms were categorized into four groups. These groups closely follow the USDA typology and actually represent combinations of one or more of the USDA farm types. The four farm categories are:

1. "Lifestyle Farms" – this group includes the "limited-resource," " retirement," and "residential/ lifestyle" farm typology groups. These farms have gross sales below $100,000 and the operator does not report farming as his/her principal occupation.
2. "Low-Sales Farms" – this group is comprised of farms with gross sales below $100,000, and the operator reports farming as his/her principal occupation.
3. "High-Sales Farms" – this group is comprised of farms with sales between $100,000 and $250,000, and the operator reports farming as his/her principal occupation.
4. "Large Family Farms" – this group includes "large family farms" and "very large family farms" in the USDA typology. These farms have gross sales above $250,000 and the operator reports farming as his/her principal occupation.

Study Area and Survey Design

This study analyzes best management practice adoption in corn and grain sorghum production in Kansas. Corn and grain sorghum are two of the top three crops produced in the state, accounting for an annual average of 7.7 million acres of production over the past three years. According to the Kansas Department of Health and Environment, the twelve river basins in Kansas contain contaminants that create substantial water quality concerns (Kansas Department of Health and Environment, 1998). Two contaminants that have been frequently identified as present in lakes and rivers are nitrates and agricultural pesticides (Kansas Department of Health and Environment, 1996).

A survey of Kansas corn and grain sorghum producers was conducted to collect information about managers' nutrient and pesticide management practices. The sample was stratified based upon farm size: 30 percent with gross sales below $100,000; 30 percent with gross sales between $100,000 and $250,000; and 40 percent with gross sales exceeding $250,000. This stratification scheme was employed to obtain a relatively even distribution of respondents across the four farm categories described above.

The survey instrument was comprised of three sections: (a) farm and demographic information; (b) management objectives and environmental perspectives; and (c) nutrient and pesticide management practices. A majority of the questions were followed by response choices with bounded values. In general, respondents were asked to answer questions in a manner that describes "typical" or "dominant" practices.

The survey was conducted in January 2001 and mailed to 1,750 feed grain producers. A total of 650 surveys were returned, resulting in a 37 percent response rate. The number of responses in each of the four farm categories is as follows:

"Lifestyle"	155
"Low-sales"	157
"High-sales"	171
"Large farms"	167

Best Management Practices

Best management practices considered in this study are divided into nutrient and pesticide practices used in the production of feed grains (more specifically, corn and grain sorghum).

Nutrient BMPs

Once nitrogen is applied to the soil, it is very dynamic and difficult to control. Nitrate moves easily into soil water, and this form of nitrogen is especially susceptible to leaching and runoff. Effective management of nitrogen involves three basic principles: (1) determining proper application rates and applying no more than necessary; (2) using the appropriate source of nitrogen for the plant, soil, and residue situation; and (3) applying the nitrogen at the correct time (Devlin et al., 1996).

Five prominent nitrogen management BMPs were included in the survey:

1. ***Setting realistic yield goals and fertilize to these goals.*** This practice limits the potential for excess soil levels of nitrogen that are available for runoff or leaching. Respondents were asked whether they employed yield goals to determine nitrogen applications, and if so, their target yield relative to average actual yield. For purposes here, the BMP was considered in place if the target yield was below 110 percent of actual yield.
2. ***Soil testing.*** Soil tests can help fine-tune nitrogen recommendations otherwise based upon only yield goals

and credits for previous crops and residue. The actual BMP evaluated here is annual soil testing.

3. ***Split application.*** Split application involves applying nitrogen in two applications, typically pre-plant and post-planting. The practice places nitrogen in the soil when it is most likely to be taken up and prevents large runoff events.
4. ***Site-specific management.*** Varying nitrogen rates across a field helps ensure that no area of the field receives more nitrogen than necessary. In this case, the specific BMP is the use of variable-rate technology when applying nutrients.
5. ***Incorporation.*** Incorporation of nitrogen reduces the potential for nitrate runoff. This BMP is considered in use if the producer applies and incorporates a nitrogen source other than anhydrous ammonia.

Detailed descriptions of these BMPs can be found in Devlin et al. (1996).

Pesticide BMPs

Most of the attention concerning management of pesticide runoff and leaching has focused on a selected set of chemicals. In Kansas, significant concern has been raised about levels of atrazine in surface waters used for drinking water. Recent chemical use surveys indicate that atrazine or pesticides containing atrazine are used on 80 percent of the state's corn acreage and 71 percent of the state's grain sorghum acreage (Kansas Cooperative Extension Service, 1999). As a result, most of the pesticide-related questions in the corn and sorghum sections of the survey addressed atrazine management.

Five atrazine management BMPs promoted by Kansas State Research and Extension were included in the survey (Regher, et al., 1996):

1. ***Incorporation of atrazine.*** Applying atrazine pre-plant and incorporating it into the top two inches of the soil with a field cultivator, disk, or other implement reduces the potential for atrazine runoff.
2. ***Early spring application.*** Applying the atrazine prior to April 15, compared to traditional application in May and June, helps avoid large runoff events associated with higher rainfall periods.
3. ***Fall application***. Application of atrazine during the fall prior to planting can provide effective weed control and reduce runoff losses.
4. ***Split application.*** Applying atrazine in split applications, for example, 1/2 to 2/3 in March and 1/3 to1/2 following planting reduces runoff potential.
5. ***Use of alternative herbicides.*** Use of post-emergence mixtures that contain low amounts of atrazine decreases atrazine runoff potential. In addition, several newer-vintage herbicides, particularly those with low application requirements, can serve as substitutes for atrazine, and hence, eliminate atrazine runoff. This BMP is considered in use if the respondent listed use of one or more of the substitute herbicides recommended by Kansas State Research and Extension.

BMP Adoption Across Farm Types

Nutrient BMP Adoption

Average adoption rates for nutrient BMPs in corn and grain sorghum production are presented in Table 1. Incorporation of nitrogen is the most frequently used BMP in corn production, followed by setting realistic yield goals, annual soil testing, and split application. In sorghum production, setting realistic yield goals is most popular followed by incorporation, split application, and annual soil testing. With the exception of setting realistic yield goals, adoption rates for each BMP are higher in corn production than sorghum. The adoption of variable-rate nutrient application technologies has been limited in both sorghum and corn production.

Nutrient BMP adoption rates by corn producers are presented by farm size category in Figure 1. Adoption rates are shown to increase with farm size for three of the five BMPs (setting yield goals, soil testing, and split application). Adoption rates of "large family farms" are statistically different from each of the three smaller size groups for both setting realistic yield goals and annual soil testing. In the case of split application, only differences in the adoption rates between the "lifestyle" and "large family farms" are statistically significant. Adoption rates for variable-rate application and incorporation do not change significantly across farm size.

Under sorghum production, adoption rates for setting yield goals and split application increase across the farm size categories (Figure 2). The adoption rate of setting realistic yield goals by "large family farms" is statistically different (in this case, higher) from each of the three smaller farm size categories. For split application, significant differences in adoption rates exist between "large family farms" and both "lifestyle" and "low sales" farms.

Atrazine BMP Adoption

Average adoption rates for atrazine BMPs are reported in Table 1. Use of alternative herbicides is the most widely used BMP in both corn and grain sorghum production, followed by incorporation of atrazine and early-spring application. Adoption rates are higher in corn production than sorghum for split application and the use of alternative herbicides, while adoption rates for the remaining BMPs are higher in sorghum production. Despite Kansas State Research and Extension's effort to encourage fall application of atrazine as a viable BMP, the adoption of this practice has been limited.

Adoption rates for the five atrazine BMPs are compared across farm size categories in Figures 3 and 4. Trends across farm sizes are similar for corn and grain sorghum. Farm size has little impact on timing of atrazine applications; adoption rates for both the fall and early-spring application BMPs are not statistically different across farm types in either corn or sorghum production. However, the use of split application and alternative herbicides increases with farm size in both corn and grain sorghum production. In sorghum production, the adoption rates between "large family farms" and both "lifestyle" and "low sales farms" are statistically different for both BMPs (figure 4). In corn production, differences in adoption rates between "large family farms" and "lifestyle farms" are statistically significant for split application and use of alternative herbicides. In the case of incorporation, contrasting results were found. Adoption rates of corn producers increase with farm size, while a decline in use of the BMP as farm size increases occurs in sorghum production.

Does BMP Adoption Differ Across Farm Types?

From these findings, there appears to exist a clear relationship between farm size and BMP adoption within this sample of Kansas farms. In the case of corn production, a significant increase in the adoption rate of six of the ten BMPs occurs in moving from smaller to larger farm types. No significant trend exists for the other four BMPs. Comparing "lifestyle" farms and "large family farms," adoption rates for five of the BMPs are statistically different (higher). In the case of "low sales farms," adoption rates for four of the ten BMPs are statistically different (lower) than "large family farms." Differences in adoption rates between "high sales farms" and "large family farms" exist in only two of the ten cases.

Findings for producers of grain sorghum are similar to those found for corn producers. The adoption rates of five of the BMPs by sorghum producers are shown to increase across farm types, and no significant relationship between farm type and BMP adoption is present in four of the others. Differences in adoption rates between "high sales farms" and "large family farms" are not statistically significant for any of the ten cases.

Across both corn and sorghum producers, the adoption rate of only one (incorporation of atrazine in sorghum production) of 20 BMPs (10 BMPs x 2 crops) is shown to decrease as farm size increases.

Farmer's Perspectives About the Environment

One possible explanation for observed differences in BMP adoption that exist across farm size categories is that farm managers may have different levels of environmental consciousness and/or perspectives about agriculture's impact on water quality. Respondents were asked to rate the quality of Kansas surface waters on a 1 to 5 scale (1 = not acceptable, 5 = excellent). Nearly two-thirds of the managers rated the quality of surface water resources in the state as "very good" or "excellent," while less than five percent rated surface water quality as "unacceptable." Managers' perceptions of the overall quality of surface water improve when moving from small to large farm size categories. Ratings of surface water quality by respondents from the "large family farm" group were statistically different (higher) from the three other groups (Table 2).

This result does not appear to explain differences in BMP adoption rates across farm types. One would expect that if perceptions concerning surface water quality were influencing BMP adoption, then managers comprising the "large family farm" group would actually be less inclined to adopt practices aimed at reducing runoff.

Farmer's Management Objectives

Another possible explanation for differences in BMP adoption rates among farm size categories is that farm managers comprising each group may apply different management objectives. Respondents were asked to rate the importance of the following basic management objectives using a 1 to 5 scale (1= not important, 5 = most important):

- Maximize profitability
- Environmental stewardship
- Passing the farm to the next generation
- Obtain sufficient income to cover family living expenses
- Maintain quality of life.

Overall, respondents rated "quality of life" as the most important objective in managing their farm, followed by "obtaining sufficient income to cover family living expenses" and "maximizing profitability" (Table 2). Environmental stewardship was ranked fourth among the five objectives by all respondents, as well as respondents comprising each of the four farm size categories. Thus, among farmers comprising the survey sample or any of the four subgroups, environmental objectives do not appear to have a pronounced influence on farm management decisions.

In comparing respondents' ratings of management objectives across farm types, the most interesting results occur in responses to the profit maximization objective. The importance of this objective clearly increases in moving from smaller to larger farm sizes. Differences between the responses of "large family farm" group and each of the other three farm types are statistically significant. In addition, managers comprising the "high sales" and "low sales" groups rated "quality of life" more important than the "large family farm" group. Thus, managers of "large family farms" appear more income motivated and less concerned about maintaining rural quality of life than their counterparts with lower gross sales or who do not list farming as their principal occupation. Hence, if BMPs are indeed profitable, this difference in profit motivation could partially explain differences in BMP adoption across farm types.

Summary and Conclusions

This study provides evidence that larger family farms (defined as those with gross sales above $250,000 and where the operator reports farming as his/her principal occupation) are more likely to adopt best management practices aimed at reducing nitrate and pesticide runoff than smaller producers. In the case of corn production, a significant increase in adoption rate of six of the ten BMPs occurred in moving from smaller to larger farm types, while the adoption rate of five of the ten BMPs by sorghum producers was shown to increase across farm types.

Little evidence was found to explain these differences in adoption rates across farm sizes. Farmers across all farm sizes expressed similar beliefs about the relative importance of environmental stewardship in their farm management decision making. Also, farmers shared common perspectives about the quality of Kansas surface waters and agriculture's contribution to surface water contamination. Differences do exist across farm size categories in terms of the importance managers place on various management objectives. Most notably, managers of larger farms place more importance on profit maximization. Thus, to the extent that BMP adoption contributes to profits (Valentin, Bernardo, and Kastens, 2004), this factor may be important in explaining higher rates of BMP use on larger farms.

Other explanations can also be posited for higher BMP adoption rates on larger farms. First, BMPs are in essence new technologies, and most technologies are adopted earlier and at higher rates by larger farms. Because the transaction and implementation costs of new technologies are spread over more acres, the "costs" of BMP adoption are lower on larger operations. Similarly, although the per-acre benefits of adoption may be similar across farm sizes, the total economic benefit from adoption will be larger as farm size increases. Also, because a growing number of managers comprising the lower sales groups are part-time operators, they may not have as much incentive to invest their limited management time in assessment of new technologies such as BMPs.

These findings have important implications for the development of future policies aimed at reducing the impact of crop production on surface water quality. Most states have taken an approach of developing and encouraging voluntary adoption of best management practices to comply with federally mandated water quality standards. Although average adoption rates of several BMPs may not be overly impressive (e.g., adoption rates for half of the BMPs in the study were below 33%), because adoption rates of larger producers are so much higher, BMPs are being applied on a larger share of total crop acreage. For example, roughly three-quarters of crop acres in Kansas are controlled by one-quarter of producers. Thus, although only 35 percent of corn producers have adopted annual soil testing, the practice is used on over 53 percent of the corn acreage.

The results also illustrate that the education and voluntary adoption approach is effective in reaching larger, commercial-sized farms, but less effective in reaching smaller-sized units. Since these farms represent an expanding segment of the farm sector, policies will need to be developed to reach managers whose principal occupation is outside of agriculture.

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Table 1. Average Adoption Rates for Nitrogen and Atrazine Best Management Practices Under Corn and Grain Sorghum Production

Best Management Practice	Corn	Sorghum
Nitrogen Management BMPs:	---- percent ----	
Setting realistic yield goals	42	54
Annual soil testing	35	14
Split application	30	18
Site-specific management	6	4
Incorporation	51	44
Atrazine Management BMPs:		
Incorporation	30	35
Early-spring application	29	32
Fall application	5	6
Split application	28	19
Use of alternative herbicides	88	61

Table 2. Respondents' Perceptions of Overall Quality of Surface Water and Rating of Importance of Management Objectives, by Farm Types

	Total	Lifestyle	Low Sales	High Sales	Large
Perception of Surface Water Quality [b]	3.74	3.30^{*}	$3.62^{\#}$	$3.70^{\#}$	3.97
Maximize Profit [c]	4.27	4.14^{*}	4.19^{*}	$4.27^{\#}$	4.43
Environmental Stewardship [c]	4.02	3.92	4.15	3.94	4.03
Pass to next generation [c]	3.58	3.47	3.82	$3.42^{\#}$	3.69
Quality of life [c]	4.44	4.35	4.66^{*}	$4.56^{\#}$	4.42
Cover family living expenses [c]	4.31	3.94^{*}	4.47	4.4	4.3

[a] * = Statistically different from the "large family farm" group at the five percent level, and # = statistically different from the "large family farm" group at the ten percent level.

[b] 1 = Not acceptable, 2 = low, 3 = acceptable, 4 = very good, 5 = excellent

[c] 1 = not important, 2 = marginally important, 3 = important, 4 = very important, 5 = most important

*Figure 1. Adoption Rates of Nutrient BMPs in Corn Production, by Farm Size Type (statistically different from "large family farm" group is indicated by * [95% confidence] or a # [90% confidence])*

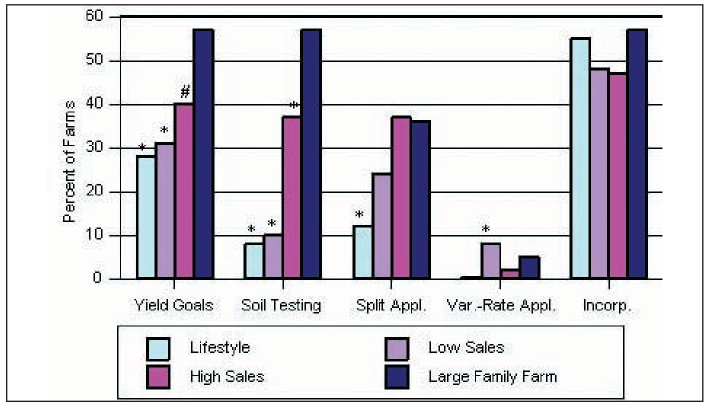

*Figure 2. Adoption Rates of Nutrient BMPs in Grain Sorghum Production, by Farm Size Type (statistically different from "large family farm" group is indicated by * [95% confidence] or a # [90% confidence])*

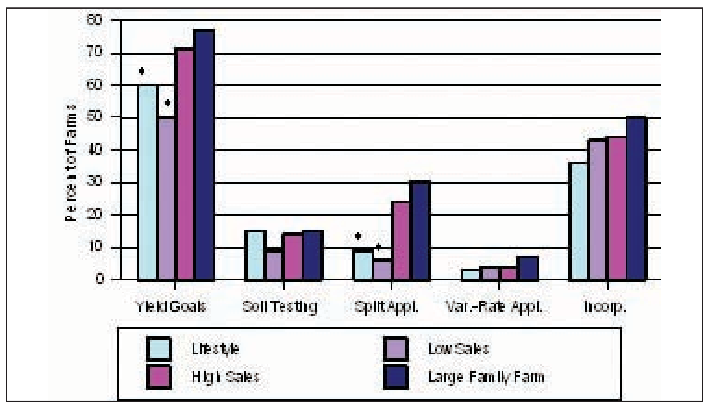

*Figure 3. Adoption Rates of Atrazine BMPs in Corn Production, by Farm Size Type (statistically different from "large family farm" group is indicated by * [95% confidence] or a # [90% confidence])*

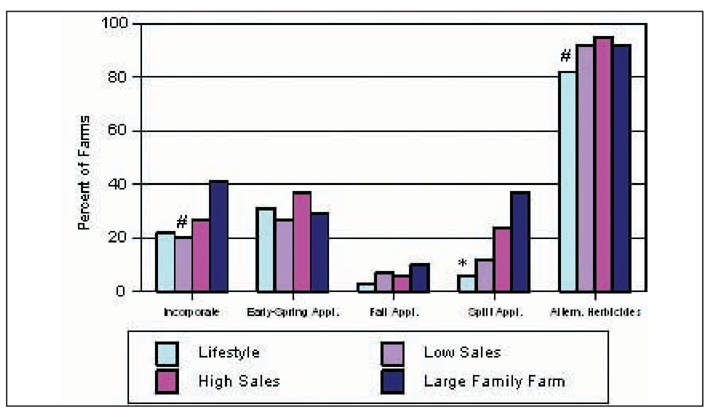

*Figure 4. Adoption Rates of Atrazine BMPs in Grain Sorghum Production, by Farm Size Type (statistically different from "large family farm" group is indicated by * [95% confidence) or a # [90% confidence])*