CROP FARMERS' WILLINGNESS TO USE MANURE

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Abstract

As a consequence of the changing structure of livestock industries, many farmers lack the amount of land required to apply manure based on either nitrogen or phosphorus requirements. Therefore, there is a need for non-livestock farms to use manure as an alternative to commercial fertilizers in order to efficiently utilize nutrients in manure without degrading water quality. However, few if any studies have examined whether or not crop farmers will in fact accept manure, nor do they examine the factors affecting acceptance. For these reasons, farmers in Missouri and Iowa were surveyed to identify the factors affecting crop farmers' acceptance of manure. Logit model results show that awareness of others using manure, off-farm income, location, transportation costs and smell are significant factors affecting the use of manure.

Keywords: manure, land application, adoption

Introduction

In order to efficiently use the nutrients in manure and to prevent water pollution caused by run-off or leaching of excess nutrients, it is important that land application of manure be based on crop nutrient needs. Since farms have increased in size and since specialization has caused concentration of livestock production in recent years, many farmers lack the amount of land required to apply manure based on either nitrogen or phosphorus needs (Ribaudo, *et al.*). If livestock production is to continue in its current form, there is a need for non-livestock farms[1] to use manure as an alternative to commercial fertilizers in order to efficiently utilize nutrients in manure without degrading water quality. If crop farmers are not willing to accept manure for use as a fertilizer, then livestock farmers will face an ever-increasing problem of how to dispose of the animal waste produced on their farms. While alternative uses of manure are being studied, land application will remain important.

Understanding why crop farmers will or will not accept manure as a fertilizer can facilitate the development of research programs and government policies to improve water quality. Although studies such as Ribaudo, *et al.* stress the need for crop farmers to accept and apply manure to their crops, few, if any, examine whether or not crop farmers will in fact accept manure, nor do they examine the factors affecting acceptance. For these reasons, this study proposes to identify the factors affecting crop farmers' acceptance of manure.

In order to frame the problem, the next section discusses the literature on adoption and diffusion. Then, the variables are described, followed by the econometric model and data collection method. Finally, the results are presented and discussed.

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[1] For the purpose of this paper, the terms "crop farms/farmers" and "non-livestock farms/farmers" will be used to indicate those farms/farmers not producing livestock for sale. Some in this group will have a few animals for household consumption, but the majority is involved solely in the production of crops.

Literature Review

The literature regarding adoption and diffusion theory as well as the adoption of agricultural technologies and practices was reviewed to gain an understanding of what factors may affect a farmer's decision to use manure as a fertilizer. Generally speaking, adoption and diffusion theory explains the uptake and spread of innovations (Rogers). An innovation is anything perceived as new to potential adopters; ideas and practices as well as objects can all be innovations (Rogers). The use of manure as a fertilizer is not a new idea; but as farmers began specializing and commercial fertilizers became the norm, less and less manure was applied to crops. Thus, the use of manure by non-livestock producing farms seems unconventional. Also, since the use of manure as an alternative to commercial fertilizers by crop farmers would require a change in conventional farming practices, it can be considered an innovation. Thus, it is appropriate to use an adoption and diffusion framework to examine factors affecting the willingness to use manure as a fertilizer.

Past studies suggest three broad categories of variables affecting the adoption and diffusion of agricultural innovations: personal characteristics of farmers, farm characteristics, and perceived characteristics of the innovation (Rogers, Stoneman, Sunding and Zilberman). Personal characteristics of farmers such as their age and education can influence adoption decisions in some cases (Rogers). Access to resources, which depends on wealth and personal social networks, is a personal characteristic influencing the adoption of innovations (Feder and Umali, Rogers, Sunding and Zilberman). Another personal characteristic is awareness of the innovation, which was the focus of many early adoption and diffusion studies using the epidemic model (Rogers, Stoneman). Finally, Rogers notes the importance of a person's values and beliefs in the adoption decision.

The second group of characteristics includes those related to the farming system. Farm size and location as well as land tenure have been found important to the adoption of agricultural innovations (Feder and Umali, Sunding and Zilberman). Although Rogers discusses compatibility, in regard to an individual's beliefs and values, Contant and Korsching as well as Stoneman note that compatibility among the innovation, previous investments, other inputs and the production system is important. Thus, indicating the importance of compatibility between the innovation and the overall farming system.

The last category includes the perceived characteristics of the innovation. Rogers notes that perceptions are important because people make decisions based on their perceptions. One important perception for the adoption is that of relative advantage, which is the additional benefit from using the innovation (Rogers). Relative advantage could mean lower cost of production, increased efficiency or increased quality, all of which lead to increased profitability. Several studies find that increased profitability is an incentive for adoption (Contant and Korshing, Fuglie and Kascak, Griliches, Sturm and Smith). Relative advantage can also take the form of incentive payments and subsidies, which encourage adoption of conservation agricultural practices (Cooper and Keim). However, profitability and payments ultimately contribute to utility. Other costs and benefits, such as the presence of externalities and the social costs and benefits associated with them, personal satisfaction, convenience, environmental quality and discomfort are other factors that affect a person's utility and have been found to affect the adoption decision (Nowak and Rogers). Although discomfort is mentioned in the theoretical adoption and diffusion literature (Rogers), there was little empirical work on this factor.

Besides the perceived relative advantage of adopting an innovation, perceived complexity and uncertainty are other perceptions that impact adoption. Rogers, as well as Contant and

Korsching, have found that adoption and diffusion occurs more readily and rapidly with innovations that are easily understood and used. The uncertainty associated with adopting an innovation is a barrier to adoption (Lindner, *et al.*, Llewellyn, *et al.*, Nowak, Pannell, Rogers, Sunding and Zilberman). These authors stress the importance of information to reduce uncertainty. In particular, observability and trialability are noted as increasing information to help eliminate uncertainty and thereby increase adoption.

Variables

The objective of this research was to determine factors affecting manure use by crop farmers. Thus, the dependent variable, manure use, was measured in terms of whether or not crop farmers applied manure to any of their land in 2003. As discussed above, previous literature suggests that a crop farmer's willingness to use manure depends on farmer characteristics, farm characteristics, and the perceived characteristics of using manure. Below are descriptions of each independent variable included in the model, how it is defined and measured and how it is predicted to affect the use of manure. For a summary of the variables, see Table 1.

Independent Variables

The first group of variables includes farmer characteristics. Age, education, off-farm income, awareness, concern for water quality, and belief that land application of manure improves water quality were included.

Age is sometimes found to be an important characteristic in the adoption of innovations, with younger people generally being more likely to adopt (Rogers). However, in this case, it is predicted that older farmers will be more likely to use manure. Older farmers may have more experience using manure, as they are more likely to have used it before commercial fertilizers were widely available on the market. Age is a continuous variable measured in years.

Education is a dummy variable with one being at least some college education and zero otherwise. Generally higher levels of education are linked to higher levels of adoption. In this case, it is expected that education will result in lower information costs and therefore farmers will be better able to deal with complexity. Thus, education is expected to positively influence the use of manure.

Off-farm income is a categorical variable. Participants were asked to choose from six categories: no off-farm income; $0 to $9,999; $10,000 to $24,999; $25,000 to $49,999; $50,000 to $99,999 and $100,000 or more. The base category was $10,000 to $24,999. Previous research suggests that the off-farm income affect on adoption depends on the type of technology being adopted. Feder, Just and Zilberman suggest that off-farm income lessens the constraint on working capital thus increasing the probability of adoption. Gillespie, on the other hand, suggests that this argument is feasible for capital-intensive technologies but that the opposite would be true for management-intensive technologies. This is because higher off-farm income suggests that less time is available for farming activities. Thus, management-intensive technologies are less likely to be adopted when off-farm income is high. For this reason, it is predicted that higher off-farm incomes will result in less use of manure by crop farmers.

Awareness is a dummy variable measured by whether or not the farmer knows of any crop farmers using manure as a fertilizer. Although awareness of innovations is important for adoption, it may be less so for manure use because most, if not all, farmers are likely to be aware of this practice. However, when a farmer is aware of other crop farmers using manure, he or she may be more likely to do so as well because it is seen as more socially acceptable or appropriate.

Therefore, the awareness of other crop farmers using manure is predicted to be associated with greater likelihood of use.

Water quality concern and belief that land application of manure will improve water quality is an interaction term. Water quality concern was included because environmental empathy can impact the adoption of agricultural conservation technologies (Nowak). However, it is included as an interaction term with a dummy variable measuring belief that land application improves water quality because water quality concern is only likely to result in the use of manure when the respondent also believes that land application will improve water quality. Likewise, a belief that land application improves water quality will likely result in a greater likelihood of adoption when the individual is also concerned about water quality.

Next, a group of farm characteristic variables is included. This group includes crop acreage, farm sales, land tenure and farm location.

Crop acreage is included as a measure of farm size and is reported as the total acres of crops in 2003. It is unclear how farm size will impact manure use. Large farms could spread the costs of equipment (tanks or wagons used for transporting and spreading manure) over more acres. However, transportation and time costs would be higher due to the larger area over which manure would be spread.

Farm sales is a categorical variable with five categories: $0 to $9,999; $10,000 to $99,999; $100,000 to $249,999 (this is the base group); $250,000 to $499,999; and $500,000 or more. The farm sales variable is used as a proxy for farm income. Generally, adoption and diffusion theory suggests that higher farm income leads to greater likelihood of adoption. However, given that manure could be viewed as more management-intensive than capital-intensive, it is unclear how farm income or farm sales will impact manure use.

Land tenure sometimes impacts adoption (Sunding and Zilberman). The percent of land rented was calculated as a measure of land tenure. Land tenure is important because of the time horizon issue. With conservation agricultural practices such as manure application, which can reduce erosion by adding tilth and organic matter to the soil, there is little incentive for renters to invest in conservation practices because they will not necessarily reap the long-term benefits from such practices. Therefore, it is predicted that a greater proportion of rented land will result in less likelihood of adoption.

Location is a dummy variable where zero is a farm located in Missouri and one is a farm located in Iowa. Missouri and Iowa were chosen to represent farms in the Midwest United States due to time and funding limitations. Missouri and Iowa share some similarities but also differ in a variety of ways. According to the USDA 2002 Census of Agriculture, Iowa has fewer but larger farms than Missouri. Missouri has many more cow and calf operations, ranking second in the United States, not only in the number of operations, but also in the number of beef cows and calves. Missouri also ranks second in hay production when alfalfa is excluded and third when it is included. Iowa, on the other hand, leads the U.S. in pork, corn, soybean and egg production. Missouri has more poultry farms but less total production of layers, pullets, and broilers. A study comparing hog farmers in Iowa and North Carolina found that Iowa farmers were more interested in conserving manure nutrients for crop production than North Carolina farmers (Hoag and Roka). One study calculated the net crop demand for phosphorus throughout the U.S. by first calculating the phosphorus supply produced on livestock farms and the total phosphorus demand from crops and then subtracting supply from demand to get the net supply (Benson, *et al.*). Evidence from this study shows that net crop demand for phosphorus is greater in Iowa than in Missouri (and North Carolina). Thus, it is predicted that Iowa crop farmers will be more likely to use manure than Missouri crop farmers.

The final group of variables includes perceptions of profitability, transportation costs, problems with weed seeds, difficulty in determining application rates, uncertainty of crop response, and discomfort in terms of smell. Data regarding these perceptions were obtained using a Likert scale of one to five on the questionnaire. Later, due to low degrees of freedom and convergence problems, each was transformed into a dummy variable with one being agreement with a statement (either a one or two response) and zero otherwise (neutral or disagreement with the statement; a three, four or five response).

Perceived profitability. As discussed above, when an innovation is perceived as profitable, it is more likely to be adopted and vice versa. Therefore, it is expected that those who agree that it is not profitable to apply manure will be less likely to adopt than those who are neutral or disagree with the statement.

Perceived transportation costs have been identified as one of the problems with using manure for land application on crop farms (National Research Council, Lazarus and Koehler). The statement, "transportation costs are a problem with applying manure to my crops," was used to measure perceived transportation costs. It is predicted that those who agree with the statement will be less likely to use manure.

Perceived problems with weed seeds are another issue that farmers often bring up when discussing the use of manure (Wang and Sparling). Therefore, participants were asked to what extent they agreed or disagreed with the following statement, "Weed seeds are a problem with using manure as a fertilizer." It is hypothesized that respondents who agree with the statement will be less likely to adopt than those who are neutral or disagree.

Perceived complexity or difficulty in figuring application rates is expected to result in a lower likelihood of use. To measure how complex farmers believe manure application to be they were asked to what extent they agreed or disagreed with the following statement: "It is difficult to figure out how much manure to apply to my crops." It is predicted that those agreeing with the statement will be less likely to use manure than others.

Uncertainty is a recurring theme in the adoption literature as noted above. Uncertainty generally proves a disincentive for adoption. Thus, it is predicted that the more uncertain farmers are of the results of using manure, the less likely they will be to use it. To measure uncertainty, farmers were asked to what extent they agreed or disagreed to the following statement: "I'm not sure how my crops will respond to manure as compared to commercial fertilizers." Those agreeing with this statement are predicted to be less likely to use manure.

Discomfort with using manure was measured in terms of smell. Farmers were asked to what extent they agreed or disagreed with the following statements: "The smell of manure bothers me," and "the smell of manure bothers my neighbors." It is hypothesized that agreement with either of these statements will result in less likelihood of the use of manure.

Model

Since a probability associated with a crop farmer's willingness to use manure is desired, a binary logit model was used. Below is a mathematical representation of the model.

$$\log\left[P_u/(1-P_u)\right] = \alpha + \sum_{i=1}^{5}\beta_i X_i + \sum_{j=1}^{4}\beta_j X_j + \sum_{k=1}^{7}\beta_k X_k$$

where P_u = Probability of using manure

$(1-P_u)$ = Probability of not using maure

X_i = farm characteristics

X_j = farmer characteristics

X_k = perceived characteristics of manure use

The statistical hypotheses used are H_0: $\beta = 0$ and H_a: otherwise. If it is found that β is significantly greater than zero, the null hypothesis, H_0: $\beta = 0$, can be rejected and it can be concluded that the variable does impact the adoption decision. A positive parameter estimate (β) suggests a higher likelihood of manure use. On the other hand, a negative parameter estimate suggests a lower likelihood of manure use.

Data Collection

In order to collect the needed data on manure use and management as well as information about farmer characteristics, farm characteristics and perceptions of manure use, a questionnaire was sent to a random sample of 1500 crop and livestock farmers in Iowa and Missouri in the winter of 2004. The total design method, described by Dillman, was used for survey development and implementation. The questionnaire included a wide range of questions regarding manure use and management, water quality perceptions and attitudes, as well as farmer and farm characteristics. Various types of questions, including Likert scales, yes/no, categorical and fill-in the blank, were used to elicit responses.

Dillman's total design method uses a system of four mailings. The first mailing was a postcard, which notified individuals that they had been selected to participate in the survey and that a questionnaire would arrive shortly. The second mailing consisted of a cover letter explaining the research project, a questionnaire and a postage-paid return envelope. Also, included in this mailing was a card to fill out for the chance to win a gift certificate, which was included as an incentive to complete the survey. Next, a reminder postcard was sent. Finally, a second questionnaire, cover letter and incentive drawing card were re-sent to those who had not yet responded.

Of the 1500 mailings sent, 750 were sent to Missouri farmers and the other 750 to Iowa farmers. Of the 1500 people included in the sample, 67 were either deceased or had an undeliverable mailing address. Another 196 responded by saying they were not farmers. Therefore reducing the sample by 263 (196 + 67), for a total sample of 1237. Of the 1237 farmers in the sample, 634 responded for a response rate of about 51%. (In Missouri, 353 of 624 responded for a rate of almost 57% and in Iowa 281 of 613 responded for a rate of about 46%.)[2] Of the total 634 responses, 175 (28%) were considered crop only or non-livestock producing farmers and were the basis for this study.

Results and Discussion

As noted above, 175 of the returned surveys were from crop only farmers. However, due to the fact that not all of the surveys were completely filled out, there were 138 usable observations. Descriptive statistics of the variables are given in Table 1.

Variables describing farmer characteristics show that the average age of farmers was almost 59 years and a little over half of the farmers had at least some college education. Frequency tables (not shown) indicate that about 5% did not finish high school, 41% had only a high school diploma, 27% had some college or vocational schooling, while 24% had a bachelor's degree and 4% had a graduate degree. As for off-farm income, 17% reported none, 14% reported up to $9,999, 22% reported $10,000 to $24,999, 24% reported $25,000 to $49,999, 17% reported $50,000 to $99,999 and 6% reported off-farm incomes of $100,000 or more. About 54% of the crop farmers reported being aware of other crop farmers who used manure. Nearly 88% were concerned about water quality in their county and only 16% believed that manure use would improve water quality.

[2] Note that when responses include those that responded that they were not a farmer the response rate is 830/1433 or about 58%.

Descriptive statistics of the farm characteristics indicate that the average farm size was almost 800 acres, about 40% of which were rented. A slight majority of the crop only respondents were from Iowa. Farm sales data indicate that 12% had farm sales up to $9,999, 40% were in the group ranging from $10,000 to $99,999, 25% were in the $100,000 to $249,000 range, 13% were in the $250,000 to $499,999 range, and 10% had farm sales of $500,000 or above.

Surprisingly only about 24% of the respondents agreed that manure application was *not* profitable, thus indicating that 76% perceive manure application to be profitable or were indifferent between its profitability and non-profitability. However 51% agreed that transportation costs are a problem with manure use. Nearly 58% perceived weed seeds in manure to be a problem and almost 40% agreed that it was difficult to determine appropriate application rates. Only 28% indicated that they were uncertain about how their crops would respond to manure as compared to commercial fertilizers. Interestingly, about half of the crop farmers agreed that the smell of manure bothered them, while nearly 63% said that the smell bothered their neighbors.

As shown, about 19% of the respondents use manure. Most used hog manure but some reported using cattle or poultry manure. The species from which manure came could potentially impact both payments for manure and transportation costs. For example, hog manure in the form of slurry is more costly to transport and less dense per unit compared to broiler litter. Whether or not payment is made and the magnitude of payment relates to whether or not manure is seen as valuable. About 36% of those using manure said they paid for manure. Payments ranged from equipment fees to $0.007/gallon to $30/load for hog manure and from $10 to $35/acre for poultry manure, with much variation. No one reported receiving money for taking manure. The mean number of miles manure was transported was 1.6 ranging between 0 and 5. It should be noted that manure is generally transported very short distances due to transportation costs. Therefore, it is important that crop farmers be located near livestock production facilities. Of those who use manure, all reported learning of manure availability by word of mouth: a livestock farmer contacted them, they contacted the livestock farmer, or a friend or neighbor notified them. No one reported using newspaper or radio advertisements to find manure.

Most farmers who use manure reported that either the livestock farmer or a custom applicator applied manure for them; therefore, some of the prices quoted above include transportation and application costs. Only a few said that they applied manure themselves. About half of those using manure said that either they or the livestock farmer tested the manure for nutrient content. The fact that most crop farmers had custom applicators or the livestock farmer apply manure indicates that many crop farmers lack the necessary equipment to apply manure and therefore livestock farmers wishing to dispose of manure may have to offer to apply it to the crop farmers' fields. This may require gaining the trust of the crop farmer that manure will be applied correctly or at an acceptable rate without causing damage to soil structure or plants.

Table 2 reports the results of the logit model. The first column, labeled "estimate," gives the logit coefficient estimate for each variable, while the third column, "probability" gives a more meaningful interpretation to the estimates. In order to calculate the probability, the following equation was used: $(\partial p_i) / (\partial x_i) = \beta p_i (1 - p_i)$. This means that for every one-unit increase in x, the change in the probability depends on the logit coefficient for x as well as the probability itself. Thus, it is necessary to have an initial probability and it is generally assumed most natural to choose the probability of current users (Allison). Therefore, the probability of crop farmers currently using manure, 0.19, is used in the above equation to calculate how the probability changes with respect to a change in x.

Goodness of fit measures indicate that the model is acceptable. The likelihood ratio was significant at the 0.0001 level. Also a Hosmer-Lemeshow statistic was calculated using SAS with a resulting p-value of 0.8172, indicating that the model fits very well (Allison). The coefficient of determination, or R^2, was calculated to determine the predictive power of the model and was found to be 0.4324 with a max-rescaled R^2 of 0.6720. Note that these R^2 values measure the predictive power of the model, unlike the R^2 statistic reported when using OLS models, which measure the proportion of variance explained by the independent variables (Allison).

As shown in Table 2, variables in each vector were found significant. Of the farmer characteristics, education, two off-farm income classes, awareness, and the interaction term between water quality concern and belief that manure application will improve water quality were found significant (using 0.10 level of significance).

Education was negatively related to manure use; thus, indicating that those with at least some college were about 22% less likely to use manure than those with no college education. Because education is generally thought to lower information costs, it was expected that a higher level of education would lead to the ability to better deal with complexity and thus they would be more likely to use manure. However, it was found that only about 40% of crop farmers thought it complex to use manure (as shown in table 1). This could be related to the opportunity cost of time or that more educated people see manure use as backward.

Those with no off-farm income were about 19% less likely to use manure than the base group of farmers with off-farm income between \$10,000 and \$24,999. However, those with off-farm incomes between $0 and $9,999 were 44% more likely to use manure than the base group. It was predicted that low levels of off-farm income would result in more manure use due to time availability. Thus, the mixed results are difficult to explain. It makes sense that the crop farmers earning $0 to $9,999 are less likely to use manure than the base group given that they have more time available to manage manure. On the other hand, a similar result was expected for those with no off-farm income because it was assumed that they too would have more time for farm activities than the base group. However, those with no off-farm income might have other lifestyle differences not accounted for in the model that constrain their time more than those farmers in the base group. More information on the lifestyles of each group and the nature of off-farm income could help in explaining these mixed results.

Awareness was another farmer characteristic found significant. Those crop farmers who know of other crop farmers using manure are 38% more likely to use manure than those who do not know of crop farmers using manure. This could be due to increased knowledge, social acceptability or both. It could also relate to manure availability in the area.

The interaction term between water quality concern and belief that manure application improves water quality was also found significant at the 0.10 level. As expected, those who were both concerned with water quality in their county and believed that manure application would improve water quality were about 28% more likely to use manure than others.

In the farm characteristics group, one farm sales class and location were found to be significant. The farm sales category of $0 to $9,999 was found significant at the 0.10 level. Those in that group were about 39% more likely to use manure than the base group with sales between $100,000 and $249,999. Farms with sales of only $0 to $9,999 are most likely very small farms with low production and might be considered hobby farms. The goals, preferences and lifestyles of these farmers may differ from those with higher farm sales and thus result in more manure use. More information and research is needed to understand these differences. Also, by definition, hobby farms have a higher opportunity cost of time and therefore it was expected that these farms would be less likely to use manure. On the other hand, it was found that crop farmers that use manure do not apply it themselves; therefore, the opportunity cost of time is not as relevant.

Location was the other farm characteristic found significant at the 0.01 level. Iowa crop farmers were about 71% more likely to use manure than similar farmers in Missouri. This indicates that similar to the North Carolina and Iowa study (Hoag and Roka), Iowa crop farmers view manure as a valuable input. Also, as mentioned above, there is more net crop demand for phosphorus in Iowa than in Missouri (Benson, *et al.*). (Missouri actually has several counties with a net supply of phosphorus.)

Land tenure was another farm characteristic variable included in the model; it approaches significance at 0.13. Surprisingly, though, it seems that more rented land results in a greater likelihood of adoption. This is contradictory to other studies examining natural resource conserving technologies that indicate renting land results is less likelihood of adoption due to the time horizon issue. It is possible that these crop farmers are renting from farmers focusing on livestock production and thus have greater access to manure. (Unfortunately, data from the survey do not specify who these farmers are renting from.) However, this shows the importance of understanding how different technologies and farm characteristics impact technology adoption.

Finally, of the variables included to measure perceptions associated with manure use, only transportation costs and smell were found significant. Those crop farmers agreeing that transportation costs were a problem with using manure were about 24% less likely to use manure as expected, suggesting that perceived transportation costs are a barrier to manure use. Likewise, those who agreed that they experienced discomfort in terms of smell were about 22% less likely to use manure.

Conclusion

The results of this study indicate that manure users are more likely from Iowa than Missouri. They are generally aware of other crop farmers using manure and are concerned about water quality and at the same time believe that applying manure to their crops will improve water quality. They have between $0 and $9,999 of off-farm income and farm sales between $0 and $9,999. Generally they do not have any college education. They do not perceive transportation costs to be a problem with manure use and the smell of manure does not bother them.

Currently, manure poses many environmental and social problems and this will likely continue. Thus, it is important to create policies that address problems such as reduced water quality due to excess nutrients. One way water quality could be improved is for crop farmers to apply manure to their crops based on the nutrient content of manure and nutrient needs of crops. Policies that encourage appropriate application can be developed by understanding factors motivating farmers' decisions. The results of this study indicate some policy possibilities. Because awareness, water quality concern and belief that manure application improves water quality were significant variables, one policy alternative would be to further education and extension programs that increased awareness of the potential for manure application by crop farmers to improve water quality. It would also be important for environmental incentive programs to recognize the benefits of land application of manure. Also, funding for further research to increase the distance over which it is economically viable to transport manure, either by increasing the value of manure as a fertilizer or lowering transportation costs would be important. Waste management policies should take a broader view, examining livestock production in the context of a region, rather than just at the farm level. Thus, another policy alternative would be to encourage future livestock producers to locate in areas of net nutrient demand.

More research is needed to address the environmental problems posed by manure. Further research is needed to compare farmers' perceptions to reality, which could help develop extension and education programs to better inform farmers. Although there is research being done to lower transportation costs and reduce the odor associated with manure, economic analyses of these technologies is important. Another line of research might investigate factors affecting the substitutability between commercial fertilizers and manure. This study found Iowa crop farmers are much more willing to accept manure than Missouri crop farmers; further research might investigate whether or not this is due to local manure availability or the net crop demand for nutrients in manure or some combination of these two. Finally, while not the focus of this study, research on alternative uses for manure holds great promise, especially for areas where there is a net surplus of manure nutrients.

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Table 1: Descriptive Statistics of Variables

Variable	Description	Mean	Std. Dev.	Min.	Max.
Farmer Characteristics					
Age	Years of age	58.73	12.39	28	90
Education	At least some college = 1, otherwise = 0	0.55	0.50	0	1
Off-farm income	Categorical Variable	---	---	---	---
none	Category 1	0.17	---	---	---
$0 to $9,999	Category 2	0.14	---	---	---
$10,000 to $24,999	Base Category	0.22	---	---	---
$25,000 to $49,999	Category 3	0.24	---	---	---
$50,000 to $99,999	Category 4	0.17	---	---	---
$100,000 or more	Category 5	0.06	---	---	---
Awareness	Know of other crop farmers using manure = 1, otherwise = 0	0.55	0.50	0	1
Water Quality Concern	Concerned about water quality = 1, otherwise = 0	0.88	0.33	0	1
Belief	Believe manure application improves water quality = 1, otherwise = 0	0.16	0.37	0	1
Farm Characteristics					
Total Crop Acreage	Acres of crops	791.69	1426.66	2	12300
Farm Sales	Categorical Variable	---	---	---	---
$0 to $9,999	Category 1	0.12	---	---	---
$10,000 to $99,999	Category 2	0.40	---	---	---
$100,000 to $249,999	Base Category	0.25	---	---	---
$250,000 to $499,999	Category 3	0.13	---	---	---
$500,000 or more	Category 4	0.10	---	---	---
Percent Rented	Proportion of total land farmed that was rented	0.40	0.39	0	1
Location	Iowa = 1, Missouri = 0	0.57	0.50	0	1
Percieved Characteristics of Manure Use					
Profitability	Perceive profitability problem = 1, otherwise = 0	0.24	0.43	0	1
Transportation Costs	Perceive transportation costs problem = 1, otherwise = 0	0.51	0.50	0	1
Weed Problems	Perceive weed seeds problem = 1, otherwise = 0	0.58	0.50	0	1
Difficulty	Difficult to figure application rates = 1, otherwise = 0	0.39	0.49	0	1
Uncertainty	Uncertain of crop response = 1, otherwise = 0	0.28	0.45	0	1
Smell (personal)	Smell bothers respondent = 1, otherwise = 0	0.50	0.50	0	1
Smell (neighbors)	Smell bothers neighbors = 1, otherwise = 0	0.63	0.48	0	1
Dependent Variable					
Use Manure	Use Manure = 1, otherwise = 0	0.19	0.40	0	1

Table 2: Results of Logit Model of Manure Use

Variable	Estimate	St Error	Probability
Constant	-0.1212	3.1732	
Farmer Characteristics			
Age	-0.0624	0.0434	-0.010
Education*	-1.4317	0.8961	-0.220
Off farm income (0)**	-1.2201	1.0807	-0.188
Off farm income (0-9.9)***	2.8685	0.9631	0.441
Off farm income (25-49.9)	0.7761	0.7790	0.119
Off farm income (50-99.9)	-1.4425	1.0419	-0.222
Off farm income (100+)	2.0626	1.7949	0.317
Awareness**	2.4529	1.1360	0.378
WQ concern & Mapp improves WQ*	1.8415	2.7573	0.283
Farm Characteristics			
Total Crop Acreage	-0.0008	0.0013	0.000
Farm Sales (0-9.9)*	2.5013	1.5275	0.385
Farm Sales (10-99.9)	-0.6284	1.1180	-0.097
Farm Sales (250-499.9)	-0.0586	1.1414	-0.009
Farm Sales (500+)	-1.0940	1.4282	-0.168
Percent Rented	1.8370	1.2694	0.283
Location***	4.5920	1.3972	0.707
Perceived Characteristics of Manure Use			
Profitability	-0.2973	1.1502	-0.046
Transportation*	-1.5635	0.9133	-0.241
Weeds	-0.3182	0.8598	-0.049
Difficulty	1.0810	0.9617	0.166
Uncertainty	-1.4492	1.2128	-0.223
Smell (self)*	-1.4348	0.9469	-0.221
Smell (neighbors)	-1.4736	1.0804	-0.227

Notes: ***indicates that the variable is significant at the 0.01 level
** indicates that the variable is significant at the 0.05 level
and * indicates that the variable is significant at the 0.10 level.