Correlates of nutrient application rates: the role of socioeconomic factors

Ted L. Napier, Silvana M. Camboni

The Ohio Agricultural Research and Development Center of the Ohio State university,
2120 Fyffe Road, Columbus, Ohio. 43210.

Summary:

Data were collected from 245 land owner- operators in the Darby Creek Hydrologic Unit in central Ohio to examine how socioeconomic factors influence fertilizer application rates at the farm level. A theoretical perspective formulated from components of the farm structure model and social learning theory was developed to guide the investigation. Pounds of fertilizer per bushel of corn, per bushel of soybeans, and per bushel of wheat were treated as dependent variables. Factors used to predict fertilizer application rates were as follows: farm structure variables, perceptions of risk associated with use of farm chemicals, and personal characteristics of the farm operator. The findings revealed that the theoretical perspective had limited utility for predicting nutrient application rates. The findings are discussed in the context of future soil and water conservation initiatives in the study region.

Anotace:

Údaje pro zjišťování role sociálně-ekonomických faktorů na používání výživných látek byly soustředěny z 245 farem (střední Ohio) na jaře 1994. Do modelu bylo zařazeno 12 závisle proměnných, které zahrnovaly množství účinných látek na jednotu výroby a 12 nezávisle proměnných, jako např. poměr dluhů k aktivům.

Regresní nálezy ukazují, že teoretický model měl velmi malou užitečnost pro předvídání používaných dávek hnojiv ve sledované oblasti. Žádná ze sledovaných proměnných se neukázala pro předpovědi dobrá. Výsledky studia naznačují, jak se zaměřit při výběru nových teoretických prostředků pro zkoumání.

Key words:

Socioeconomics Factors, Nutrient Rates, Regression Models

Klíčová slova:

Sociálně-ekonomické faktory, dávky živin, regresní modely

Agricultural chemicals applied to farm land to maintain high levels of crop production are often transported to waterways via soil erosion or to ground water aquifers via percolation through chemical-rich soils. Contamination of water resources by agricultural nutrients often results in destruction of wildlife habitat, loss of recreational use of water resources, increased costs of making degraded water potable, increased threat to human and animal health, and reduced aesthetic beauty of surface water resources (Napier and Sommers, 1994).

Most land owner-operators are aware that production goals designed to maximize output are extremely difficult to achieve without liberal application of inorganic fertilizers. Until farm operators become convinced the economic viability of the farm enterprise will not be negatively affected by reduction of nutrient rates, it is highly likely they will continue to apply nutrients at rates that contribute to environmental degradation.

Some of the variables that have been shown to be significantly related with fertilizer application rates are soil type, climate, yield goals, participation in government commodity programs, farm income, farm specialization, education of primary farm operator, farm size, access to organic fertilizers, tillage systems used, technologies in use, off-farm employment, debt-to-asset ratio, and farming experience.

Building on this limited research base, a study was organized to explore the correlates of nutrient application rates in a selected hydrologic unit in central Ohio. A theoretical perspective developed from selected components of the farm structure model and social learning theory was formulated to guide the investigation.

Theoretical Modeling

The farm structure model basically argues that all farm management decision are influenced by perceived impact of management decisions on the economic viability of the farm enterprise. The model posits that land owner-operators will not voluntarily employ farm production practices they perceive will adversely affect the future viability of the farm firm. Land operators are reluctant to adopt production practices that will increase the risk of failure of the farm enterprise. The farm structure model also suggests farming systems that have produced desirable outcomes in the past will continue to be utilized until alternative production systems are demonstrated to produce greater benefits.

Social learning theory was used to identify psychosocial factors that should theoretically affect fertilizer application rates. The theory asserts that human behaviors enacted in the present are products of past learning experiences. It suggests that human beings assess action options in the context of rewards and costs and choose action options they perceive will generate the highest rewards with the lowest costs.

The model recognizes that altering patterned behavior is very difficult to achieve when existing behaviors produce valued outcomes.

Application of the Social Learning-Farm Structure Model to Fertilizer Use

If land operators perceive that a specific action option will introduce higher levels of risk into their farm enterprise, both theoretical perspectives suggest that farmers will be more reluctant to adopt. Both theoretical orientations posit that past experiences affect willingness to consider adoption of alternative production systems. If experiences demonstrate that production systems in use generate benefits that are highly valued, farmers will be reluctant to consider changing farming practices unless they can secure even higher levels of rewards.

In the context of fertilizer application rates, land operators in the U.S. are aware that technology-intensive production systems require inorganic fertilizers to achieve production goals. Achievement of production goals is a strong motivator for land operators to continue applying large quantities of fertilizers. Changes in application rates would introduce higher levels of risk in the farming operation which is not desirable from the perspective of the farm operator.

The theoretical perspective developed to guide the investigation suggests that a number of farm structure and social learning theory factors should be significantly related to use of fertilizers at the farm level. The farm structure factors chosen for inclusion in the study are as follows: percent grain farmer, off-farm employment, acres cultivated, debt-to-asset ratio, gross farm income, access to technical assistance, and access to financial assistance. The social learning factors selected for study are as follows: years farming, perceived risk associated with chemical use, perceptions of Darby Creek, threat of ground water contamination, and participation in fertilizer education program.

Methodology

Sample selection: Data to assess the merits of the theoretical perspective were collected from 245 land owner-operators within the Darby Creek hydrologic unit in central Ohio during the winter and early spring of 1994. Approximately, 86 percent of the land owner-operators who were asked to participate in the study completed a structured questionnaire.

Study region: The Darby Creek hydrologic unit is located within portions of 6 counties in central Ohio. The watershed is located close to Columbus which is a major metropolitan community. Corn and soybeans are the major agricultural crops produced within the watershed. Pollution of ground water resources within the region is relatively insignificant, however, pollution of surface water from agricultural sources constitutes an environmental issue.

Operationalization of study variables: The dependent variables selected for examination were measured as the number of pounds of nutrients used per unit of output. Pounds of nitrogen per bushel of grain produced, pounds of phosphate per bushel of grain produced, and pounds of potassium per bushel of grain produced were designated as dependent variables for corn, soybeans, and wheat. Total pounds of nutrients per bushel of corn, per bushel of

soybeans, and per bushel of wheat were computed by summing the three nutrient variables for each commodity produced. This independent variables:

- Percent grain farmer
- Off-farm employment
- Acres cultivated
- Debt-to-asset ratio
- Gross farm income
- Access to technical assistance
- Access to financial assistance
- Years farming
- Perceived risk associated with chemical use
- Perception of Darby Creek as a natural resource
- Threat of groundwater contamination
- Participation in fertilizer education program

Statistical analyses: Descriptive statistics were used to explore general trends within the data set, while step-wise multiple regression analysis was used to assess the merits of the theoretical model when all predictive factors were considered simultaneously.

Findings

Average crop yields presented in Table 1 show that grain farmers reported about 127.4 bushels of corn, 42.0 bushels of soybeans, and 59.9 bushels of wheat produced on their farms. These estimates are very similar to state averages for each of the crops assessed.

Computation of average fertilizer application rates by crop produced rations of pounds of nutrient bushel of output (bushels per acre/pounds of nutrient per acre).

Corn requires more pounds of nutrients than any of the other crops assessed. Soybeans required the lowest pounds of nutrients.

Regression analysis was used to assess the nature of the relationships between the predictive factors included in the study and pounds of nutrient per bushel of output for corn, soybeans, and wheat. The regression findings demonstrate that the variables included in the modeling are not good predictors of pounds of nutrients per bushel of output.

The regression findings revealed that only 5 variables were significant in reducing unexplained variance in the 12 dependent variables. Threat of Groundwater Contamination and/or Perceived Risk Associated With Chemical Use entered 7 of the 12 regression models.

The coefficients of determination demonstrate that the theoretical model had very limited utility for predicting nutrient use as it was operationalized in this study. The best explanatory model demonstrated that 2 variables could explain about 10.3 percent of the variance in pounds of nitrogen per bushel of corn.

Conclusions

The role of risk in farm-level decision-making is brought into question in the context of fertilizer application rates in this study. While risk factors entered a number of models, the amount of explained variance demonstrated that measures of risk were not very useful

predictors of fertilizer application rates. Debt-to-asset ratio did not enter any of the statistical models at the .05 level.

The regression findings also failed to support the assertion often made that large-scale agriculturists over-apply fertilizers and that farmers who have internalized favorable attitudes toward the environment will be more conservative in the use of fertilizers. The study data demonstrate that neither of these assertions was supported. Acres under cultivation was not significantly correlated with fertilizer application rates. Favorable conservation attitudes were not significantly related with fertilizer use. This finding strongly suggests that conservation programs designed to enhance positive attitudes toward conservation within the study region will probably have little effect in changing fertilizer application rates among production agriculturalists within the watershed.

Study findings strongly indicate that existing explanations of why farmers apply fertilizers at specific rates are totally inadequate. New theoretical perspectives will have to be developed which place less emphasis on personal characteristics of land operators, farm structure measures, and psychosocial attitudes and perceptions. Climate, soil type, topography, and other physical characteristics of the farmstead may provide insight to differential fertilizer application rates when the modeling is conducted on large geographical regions. However, these factors would have been relatively inconsequential in this study because the watershed is so homogeneous in terms of climate, soil type, and topography.

The data for pounds of nutrient per unit output suggest that fertilizer application rates may not be as problematic as commonly assumed. While it is highly likely that land owner-operators can reduce application rates even more without adversely affecting output, the rates reported by respondents are relatively close to recommendations by the fertilizer industry.

Bibliography:

Baker, David B. and Richards, R. Peter. 1994. Herbicides in Ohio`s Drinking Water: Risk Analysis, Reduction and Communication. In Proceedings of the Fourth National Conference on Pesticides: New Directions in Pesticide Research, Development and Policy Diana Weigmann (ed.). Blacksburg, Virginia: Virginia Water Resources Center at the Virginia Polytechnic Institute and State University

Camboni, Silvana M. and Napier, Ted L. 1993. Factors Affecting Use of Conservation Practices in East Central Ohio. Agriculture, Ecosystems, and Environment 45: 79-94

Clay, D.E., Clay, S.A., Davis, K.B., and Scholes, K.A. 1993. Fertilizer Placement Impact on Nitrate Movement in a Ridge Tillage System. In Agricultural Research to Protect Water Quality. Ankeny, Iowa: Soil and Water Conservation Society Press. pp. 190-194

Table 1: Characteristics of Darby Creek Watershed Respondents (N=245)

Characteristic	Descriptive Data
Age of Primary, Farm Operator	Mean= 50.5 years, S.D.= 12.7 years
Education of Primary, Farm Operator	Mean= 12.0 years, S.D.= 3.1 years
Acres Usually, Cultivated	Mean= 691.1 acres, S.D.= 815.2 acres
Days Primary Farm, Operator Usually, Works Off-Farm for Wages or Salary	Mean= 54.6 days S.D.= 93.2 days
Days Mate Usually Works Off-Farm for Wages or Salary	Mean= 82.6 days S.D.= 105.8 days
Years Operating, Own Farm	Mean= 24.8 years, S.D.= 13.9 years
Debt-to-Asset Ratio	0 to 10 percent= 34.3% 11 to 20 percent= 15.1% 21 to 30 percent= 11.4% 31 to 40 percent= 7.3% 41 to 50 percent= 4.5% 51 to 60 percent= 2.0% 61 to 70 percent= 1.6% 71 to 80 percent= 0.0% 81 to 90 percent= 0.0% 91 to 100 percent= 0.4% missing data= 23.3%
Farm Incomes 1993 Crop Season	Less than $24,999= 22.0% $25,000 to $49,999= 11.5% $50,000 to $74,999= 9.6% $75,000 to $99,999= 3.3% $100,000 to $124,999= 7.2% $125,000 to $149,999= 7.2% $150,000 to $174,999= 4.8% $175,000 to $199,999= 7.1% $200,000 and above = 27.3% missing data= 14.7%
Ethnicity	Mennonite= 23.7 percent Non-Mennonite= 76.3 percent
Acres of Wetland Owned	Mean= 1.1 acres, S.D.= 3.7 acres
Technical Assistance for Conservation	Yes= 22.9 percent, No= 77,1 percent
Financial Assistance for Conservation	Yes= 15.9 percent, No= 84.1 percent
Corn Average Farm Soybeans Output Per Acre * Wheat	Mean= 127.4 bushels, S.D.=24.2 bushels Mean= 42.0 bushels, S.D.= 8.1 bushels Mean= 59.9 bushels, S.D.= 13.2 bushels
Source of Farm Income **	Corn= 31.9 percent Soybeans= 28.5 percent Wheat= 7.1 percent Oats= 0.2 percent Dairy= 9.4 percent Beef= 3.9 percent Swine= 2.7 percent Poultry= 0.1 percent Sheep= 0.1 percent Hay= 1.6 percent Fruits= 0.0 percent Vegetables= 0.1 percent Other Crops= 0,6 percent

* Respondents were asked to estimate the average output per crop during the past 5 years.

** The sum of percentages does not equal 100.0 because some respondents did not know what percentage of rental income should be attributed to each crop. The percentage for each source of farm income was calculated using total sample. This procedure slightly underestimates the percentage of farm income derived from grains, since most rented land in the study region is used for grain production.