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An Economic Evaluation of Beneficial Management Practices for Crop Nutrients in Canadian Agriculture

CAES Selected Paper

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INTRODUCTION

Environmental risk management is the process of measuring and/or assessing environmental risk and developing strategies to manage it. One strategy used in Canadian agriculture to manage environmental risk is the implementation of beneficial management practices (BMPs). Producers realize there is usually some cost involved in adopting BMPs, whether the BMPs take up valuable time or cost money for services such as soil testing. However, in many cases, there are offsetting economic benefits. Producers need to have a solid understanding of the costs and benefits of BMPs when deciding to adopt or continue using them.

This paper provides a summary of a larger research project which explored farm profitability before and after participation in beneficial management practices, specifically those related to crop nutrients.[1]

BACKGROUND

Beneficial Management Practices

While there are many definitions of a beneficial management practice, the Crop Nutrients Council (2005) believes that a beneficial management practice (BMP) considers the balance of nutrients for agricultural production with the goal of protecting environmental resources and ensuring profitable crop production. There are a number of BMPs that are used by agricultural producers in Canada and a detailed list of 30 BMPs has been recognized by national funding programs.[2]

Adoption of BMPs in Canada

Many BMPs in Canada are gaining popularity and are being rapidly adopted by producers. As an example, according to the 2006 Census of Agriculture, the area of cropped land using no-till practices in Canada increased from 29.7% in 2001 to 46.4% in 2006 (Statistics Canada, 2007). In contrast, other BMPs, such as those related to biodiversity and wetlands, continue to experience relatively low adoption rates.

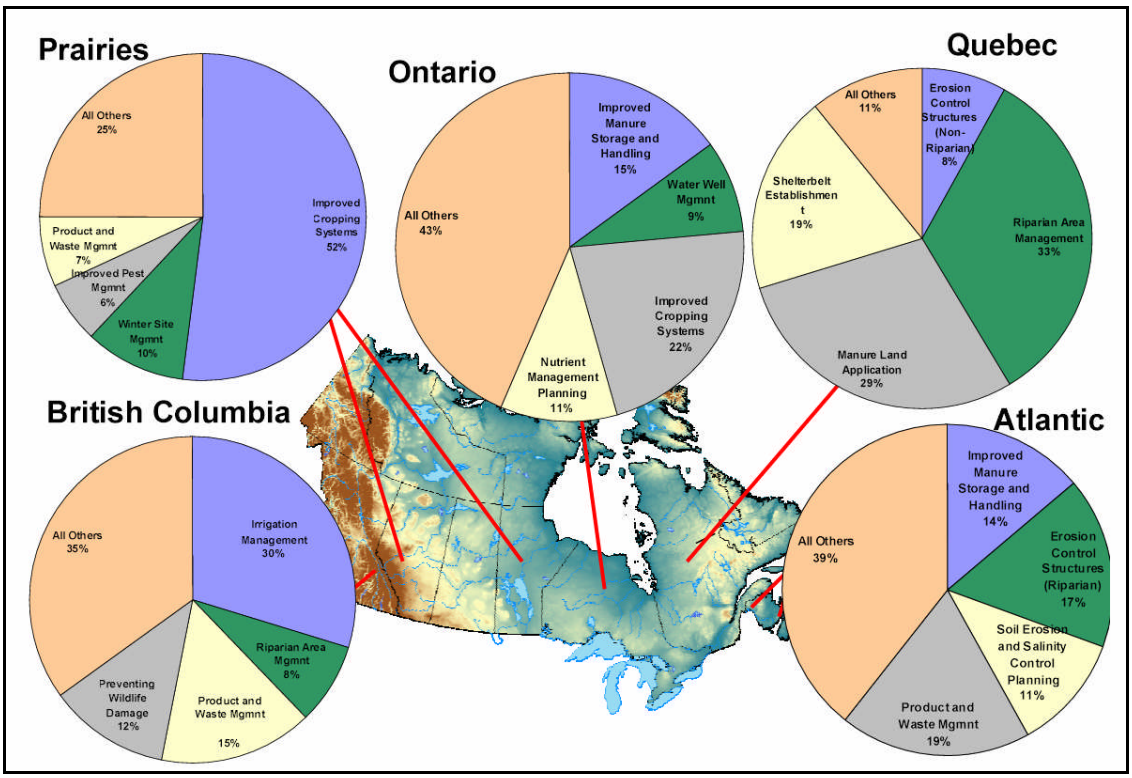
Statistics on the adoption of BMPs suggest that certain BMPs are more commonly used in different agricultural regions of Canada. As indicated by the national funding program data shown in Figure 1 (Snell, 2007), improved cropping systems involving lower soil disturbance (e.g. no-till) or improved application of fertilizers (e.g. GPS controlled

[1] The larger research project was entitled "An Economic Evaluation of Beneficial Management Practices for Crop Nutrients in Canadian Agriculture" and was supported by the Crop Nutrients Council and the Advancing Canadian Agriculture and Agri-Food (ACAAF) Program. For additional information on this research, refer to http://www.georgemorris.org/GMC/Publications/Environment.aspx.

[2] The national funding programs include the National Farm Stewardship Program (NFSP) and Greencover Canada Program. Provincial-specific lists identify which BMPs from the national list are eligible for financial and technical assistance within each province. Please refer to http://www.agr.gc.ca/env/efp-pfa/index_e.php?section=nfsp-pnga&page=intro for more information.

variable rate fertilization) are common in the Prairies and gaining popularity in Ontario. Shelterbelt establishment and riparian area management (e.g. buffers) are BMPs which are commonly adopted in Quebec. In British Columbia, irrigation management to use water and nutrients more efficiently is a BMP commonly funded by national programs. Farmers in Atlantic Canada have focused on improved manure storages, erosion control and improved product and waste management. This data is supported by the Farm Environmental Management Survey (2001) conducted by Statistics Canada, which indicates similar patterns in BMP use by region.

Figure 1 Most Common BMP Categories Funded under the National BMP Programs by Region, as of March 31, 2007



Source: Snell, 2007.

Factors Affecting Adoption

In the literature, a number of characteristics of farms and farm operators were analyzed to determine their influence on the adoption of BMPs. Farmers with higher levels of education, larger farms, farms with higher levels of gross sales, and producers who earned off-farm income were generally more likely to adopt BMPs (Serman and Filson, 1999; Agnew and Filson, 2004). However, these findings were not necessarily consistent across all literature reviewed as some studies did not find significant relationships among these variables.

In assessing why these factors were found to influence BMP adoption, Fulgie (1999) suggested that education increased a producer's ability to learn and adapt new technologies to farm operations. Fulgie (1999) and Deloitte and Touche (1992) also suggested that producers with off-farm income were more likely to use reduced tillage systems because of a higher opportunity cost of labour. Larger farms and farms with higher gross sales were more likely to use BMPs because they generally had more financial resources.

SURVEY DESIGN AND DATA

Design

In 2006, a national survey of producers was conducted by telephone to gain a better understanding of Canadian producers' attitudes toward BMPs and to collect information on the perceived costs and benefits of participation in BMPs. The survey questionnaire was designed by Ipsos Reid and the George Morris Centre in consultation with the Crop Nutrients Council as well as a steering committee representing industry and government. A total of 1,000 respondents completed the survey conducted by Ipsos Reid.[3] Descriptive statistics show that the average age of survey respondents was 54 years. Three quarters of the respondents had completed high school with almost half of the respondents having some university or technical/post secondary education. Almost two-thirds of respondents had incomes of less than $250,000.

A screening question ensured that respondents from Western Canada[4] were involved in farming a minimum of 320 field crop acres and respondents from Central and Eastern Canada[5] had a minimum of 80 acres. Respondents were then asked about crops typically grown and other types of production (e.g. livestock, horticulture/viticulture). Awareness and familiarity with certain BMPs was elicited as well as current use of BMPs. Respondents were also asked to identify barriers to adoption and the importance of financial incentives to encourage adoption.

To solicit detailed responses on the economic costs and benefits of adopting BMPs, the remainder of the survey focused primarily on seven specific crop nutrient BMPs including: soil testing, variable rate fertilization, manure management planning[6], buffer strips, no-till, minimum tillage and nutrient management planning.[7] The survey focused on the impacts of these BMPs on crop production and did not consider the impacts on livestock operations. Note that a block design was used to ensure that each respondent was only asked detailed questions on three beneficial management practices (Ipsos Reid, 2006). Respondents using these BMPs were asked about the specific costs and benefits of

[3] The average margin of error was ± 3.0%. The sample size by province was proportionate to the number of farms per Census Agriculture Region (CAR), based on the 2001 Census of Agriculture.
[4] Includes Saskatchewan, Manitoba, Alberta/BC Peace.
[5] Includes Ontario, Quebec and the Atlantic provinces.
[6] Insufficient survey data was collected for manure management planning to conduct a complete economic analysis.
[7] The BMPs selected for evaluation in the survey were based on the findings in the literature.

each of these BMPs. For example, some of the survey questions surrounding no-till included:

- What would be your approximate net[8] investment in equipment for using no-till?
- Have you experienced a change in yield in your crops as a result of using no-till?
- Have you experienced a change in operating costs, such as fuel, as a result of using no-till?
- Factoring in all cost and benefits (not including financial incentives), do you feel that using no-till creates an economic net gain, a net loss or no change on your farm?

Data

The results of the survey represented the knowledge-based perceptions of farm respondents and were considered to be a valid source of information since actual financial data from farm records was not available.

The majority of farmers surveyed nationally were at least somewhat familiar with most of the BMPs evaluated. Across the country, soil testing and minimum tillage were the most commonly used BMPs. The least used practice was variable rate fertilization. Usage of most of the BMP practices varied by region, with several (soil testing, buffer strips and variable rate technology) being more common in Eastern Canada than in the west. Beneficial management practice usage also differed by farm size. Typically, larger farm operations within each region had the highest levels of BMP adoption (Ipsos Reid, 2006).

Almost all producers surveyed used at least one beneficial management practice. Further, half of respondents used two or more BMPs. The main reason in most cases for not using a specific BMP was "not seeing the need/not effective", followed by concerns about the costs of adoption. Among those who considered cost as a barrier to adoption, a large majority thought it is important for the government to provide financial incentives and would consider using these practices if cost was not an issue (Ipsos Reid, 2006).

Typically, respondents who used beneficial management practices witnessed a yield increase (Ipsos Reid, 2006):

- Generally about half or more users thought that they experienced a yield increase as a result of soil testing.
- About four in ten who used min-till experienced a yield increase to crops.
- About half or slightly more of those using no-till experienced a yield increase to their cereals and canola versus only about a fifth for soybeans or corn.
- The impact of variable rate technology on yield varied considerably by crop, with a high percentage of cereal and canola growers seeing a yield increase.
- The impact of a nutrient management plan on yield also depended on the crop, with the majority who grew cereals and canola or potatoes having seen an increase in yield, versus less than half for those growing corn or soybeans.

[8] Factoring in any costs for trading in any equipment as well as purchasing new equipment.

The impacts on cost varied by BMP (Ipsos Reid, 2006):

- Over half of those who used soil testing or variable rate fertilization or a nutrient management plan experienced an increase in operating costs.
- The majority of those using minimum tillage or no-till experienced a decrease in costs.

It is important to note that the survey results, such as changes in yield due to a particular BMP, should be interpreted as knowledge-based perceptions of values by farmers rather than actual values obtained from farm records.

MODELLING AND RESULTS

Representative Farm Models

Cost and benefit data from the survey responses was incorporated into representative farm models to estimate the economic impact of the BMPs on farm profitability. Farm models were developed for Alberta, Saskatchewan, Manitoba, Ontario, Quebec and Prince Edward Island using 2006 crop enterprise budgets obtained from the respective provincial governments.[9] The enterprise budgets provided an estimate for revenue, variable costs, fixed costs[10] and expected net revenue for individual crops on a per acre basis. Using the per acre profitability estimates for the individual crops, representative farm models were developed based on typical crop rotations for each region and mean farm sizes from the survey data. In Western Canada, crop rotations were based on soil zone and were assumed to include some combination of spring wheat, canola, barley, peas and lentils. In Ontario and Quebec, the crop rotation consisted of corn, soybeans and wheat.[11] Due to a lack of data for PEI, the crop rotation was based solely on potatoes. The average farm size varied by region. In Western Canada, respondents had an average of 1,355 cropped acres. In Ontario and Quebec, the average farm size was 396 acres, while in PEI, the average size of a potato farm was 563 acres.

Given time and budget constraints, models could not be created for all of the BMPs in all of the provinces. As such, certain BMPs were selected for analysis in each province.

[9] Crop enterprise budgets for Ontario were obtained from the Ontario Ministry of Agriculture, Food and Rural Affairs. Crop enterprise budgets for Quebec were obtained from the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ). Crop enterprise budgets for the Prairie provinces were obtained from Alberta Agriculture, Food and Rural Development, Saskatchewan Agriculture and Food, and Manitoba Agriculture, Food and Rural Initiatives. Crop enterprise budgets were obtained from Prince Edward Island Agriculture, Fisheries and Aquaculture and updated by Meyers Norris Penny. Provinces where enterprise data was unavailable or outdated were left out of the analysis (i.e. remaining Atlantic provinces and British Columbia).

[10] Although fixed costs do not change with changes in acreage, overall fixed costs, including depreciation, must be covered to maintain long-term profitability.

[11] Winter wheat in Ontario and spring wheat in Quebec.

A BMP was selected for evaluation if:

- The BMP was not currently in use in a region and it was felt that having information about the economic costs and benefits of the BMP could improve adoption.
- Producer interest in the BMP was evident when cost was not an issue.
- Sufficient data from the survey was available for evaluation.

A BMP was not selected for evaluation if:

- The BMP was currently in use in the area and provincial enterprise budgets suitable for determining the cost of implementing the BMP was readily available.

The following table (Table 1) outlines the BMPs selected for evaluation by province.

Table 1 Beneficial Management Practices Selected for Evaluation

Province	Soil Testing	VRF	Min-Till	No-till	NMP	Buffers
Alberta - Black Soil		X			X	X
Alberta - Brown Soil	X		X		X	
Saskatchewan - Black Soil	X	X			X	
Saskatchewan - Brown Soil	X		X		X	
Manitoba	X	X	X	X	X	X
Ontario	X	X	X	X	X	X
Quebec	X	X	X	X	X	X
Prince Edward Island						X

VRF – variable rate fertilization
Min-Till – minimum tillage
NMP – nutrient management planning

Given the selection of BMPs for evaluation, a total of 39 models were developed (8 base models of representative farms prior to the implementation of BMPs and 31 iterations of the models after the implementation of BMPs). Farm profitability (given by expected net revenue) was simulated with and without implementation of each BMP on a per acre and whole farm basis using the representative farm models.[12] The results of the simulation were used to assess whether participation in the BMP was economically justifiable.

The models were also run with the estimated financial assistance available from federal and provincial programs in Canada. Financial assistance was determined to be available

[12] Note that four BMPs (minimum tillage, no-till, buffer strips and variable rate fertilization) required producers to commit to large capital outlays when initially adopting the technology. The equipment and buffer establishment cost estimates provided by respondents were therefore adjusted to an annualized basis before they were incorporated into the models. Equipment costs were annualized using estimates of the purchase price, salvage value and useful life of the equipment, as well as market interest rates to reflect the opportunity cost of capital. The useful life of the equipment was assumed to be 10 years for conservation tillage equipment and 5 years for variable rate fertilization equipment. The market interest rate was estimated at 7%. For buffer strips, the useful life was assumed to be 10 years with a salvage value of zero.

for all of the BMPs evaluated, with the exception of soil testing.[13] All the funding programs across Canada have a percentage cost share and maximum funding limit. Cost share portions were applied to the eligible costs required to establish the BMP in order to determine the amount of financial assistance and the remaining producer cost.[14]

Results

The results of the model analysis suggested that soil testing, nutrient management planning, minimum tillage and no-till were the top-performing BMPs. These practices generally produced increased yields that offset any increases in operating costs. Producers using minimum tillage and no-till identified fewer increases in yields. However, these BMPs typically showed improvements in expected net revenue due to reductions in operating costs despite equipment costs.

In general, variable rate fertilization and buffer strips were not as profitable. Typically these practices reduced profitability because of increased costs. In all cases, buffer strips reduced expected net revenue due to the higher costs for the establishment of the buffers and the lost crop production in the area of the buffer. It is important to note that the models do not capture the environmental benefits related to buffer strips. For example, buffer strips may reduce erosion, reduce drain and ditch maintenance, and reduce the risk of impairment to watercourses over time. However, due to the difficulties associated with placing a value on these types of benefits and the terms of reference for this research, these benefits were not included in the models. As a result, the benefits of buffer strips may be underestimated in this analysis. Other BMPs, such as variable rate fertilization, may have similar environmental benefits which are not captured in the models.

Table 2 and Table 3 present the whole farm results for all the provinces evaluated without and with financial assistance, respectively. What is shown in the tables is the percent change of expected net revenue over the base model when the various BMPs are implemented.[15] For example, in Quebec, the adoption of no-till practices led to an 8% increase in expected net revenue over the base model, assuming that financial assistance was not received for the conservation equipment purchase.

[13] Note that financial assistance is available for soil testing during the development of a nutrient management plan.
[14] Financial assistance was amortized using the same period and interest rate as the estimated BMP implementation costs.
[15] Note that the crop rotations vary by province.

Table 2 Provincial Whole Farm Results: % Change in Expected Net Revenue from Base Model with BMP, WITHOUT Financial Assistance

	Soil Testing	VRF	Min-Till	No-Till	NMP	Buffers
Alberta – Black Soil		53%			78%	-10%
Alberta – Brown Soil	19%		34%		33%	
Saskatchewan – Black Soil	24%	25%			38%	
Saskatchewan – Brown Soil	15%		17%		30%	
Manitoba	12%	-7%	12%	12%	20%	-1%
Ontario	59%	-9%	23%	23%	42%	-3%
Quebec	1%	-6%	12%	8%	13%	-2%
PEI						-0.6%

VRF – variable rate fertilization
Min-Till – minimum tillage
NMP – nutrient management planning

Table 3 Provincial Whole Farm Results: % Change in Expected Net Revenue from Base Model with BMP, WITH Financial Assistance

	Soil Testing	VRF	Min-Till	No-Till	NMP	Buffers
Alberta – Black Soil		57%			79%	-8%
Alberta – Brown Soil	19%		35%		33%	
Saskatchewan – Black Soil	24%	28%			39%	
Saskatchewan – Brown Soil	15%		20%		31%	
Manitoba	12%	-3%	12%	13%	20%	-1%
Ontario	59%	-9%	26%	27%	44%	-2%
Quebec	1%	-6%	13%	9%	14%	-1%
PEI						-0.5%

VRF – variable rate fertilization
Min-Till – minimum tillage
NMP – nutrient management planning

In all cases, the inclusion of financial assistance resulted in greater expected net revenue than the models without financial assistance. However, the magnitude of improvement depended highly on the cost share percentages of available funding and the number of years over which the funding was amortized. In the case of buffer strips, with an assumed life of 10 years, the funding in all provinces evaluated was not sufficient to generate a positive change in expected net revenue over the base model when financial assistance was included. This may suggest that funding for buffer strips under Canadian programs is not sufficient, given the assumptions in the representative models.

Variable rate fertilization was another BMP that demonstrated negative changes in expected net revenue when compared to the base model for many of the provinces.[16] However, the majority of producers in Ontario and Quebec indicated that they used

[16] Note that the data for variable rate fertilization was based on small sample sizes and therefore the results may be limited.

custom application services which are ineligible for financial assistance. For the Saskatchewan and Alberta black soil models, the change in expected net revenue for variable rate fertilization improved, although it was positive to begin with. Finally, in Manitoba, the financial assistance for variable rate fertilization was not sufficient to improve the change in expected net revenue to the point where it was no longer negative.

At the individual crop level, spring wheat in western Canada and Quebec and winter wheat in Ontario were the crops that were most responsive to the introduction of crop nutrient BMPs, showing an increase in expected net revenue for all BMPs analyzed (with the exception of buffers in all provinces and VRF in Manitoba) regardless of the province. The results at the individual crop level were the same with the inclusion of financial assistance.

It is important to note that changes in farm profitability due to the adoption of BMPs for individual farms may vary from the results of this study. This is because the research is based on producer perceptions, representative farm models, and additional assumptions for modelling purposes. Therefore, individual producers may experience different effects on farm profitability from the adoption of BMPs due to factors such as the site specific nature of their property (resulting in varying yield changes from BMPs), as well as revenues and expenses which are different from those used in provincial budgets.

CONCLUSIONS

Canadian producers have lacked information on the economic viability of BMPs. The goal of this study was to provide a framework for producers to assess the benefits and costs of BMPs for their farm operations.

Based on producer perceptions and the assumptions used in this analysis, the results of this study indicated that the majority of the selected BMPs, including soil testing, minimum tillage, no-till and nutrient management planning, improved profitability for the representative farms. The profitability of farms using variable rate fertilization depended on the crop grown and the province in which the BMP was practiced. In all cases, the models suggested that buffer strips reduced expected net revenue. Although many of the BMPs evaluated in this study were found to be profitable, these results are not meant to suggest that financial assistance programs are not required. As stated above, results will vary by farm, thereby impacting profitability and the need for financial assistance.

Another goal of this research was to assess the incentives currently available for producers to adopt BMPs. The study found that funding was available for all the BMPs evaluated except soil testing.[17] Despite this, respondents from the survey indicated they were not taking advantage of the funding programs. Only 1-7% of respondents received financial incentives, depending on the BMPs adopted on their farms. In order to verify this information, the National Farm Stewardship Program administrators were contacted to understand current uptake levels in the national programs. As of September 30, 2006,

[17] Financial assistance is available for soil testing during the development of a nutrient management plan.

approximately 6,000 producers had applied and received funding for 9,623 BMPs (Snell, 2006). This represented 3% of all Canadian producers (6,000 of approximately 200,000 producers). As of March 31, 2007, the number of projects funded increased to 16,850 (Snell, 2007). Overall, it would seem that there are additional barriers to adoption that need to be addressed.

The results of the survey suggested that the greatest barriers to adoption were cost and not understanding the need for the BMP. One observation made while doing this analysis was that many producers did not recognize that the BMP could have an economic net gain for their farm. While financial assistance deals with the cost barrier, not understanding the need for the BMP or recognizing the economic viability of the practice implies that future work needs to include communication and education regarding the environmental and economic benefits of the BMPs.

Transition costs, real or perceived, may also be barriers preventing further adoption by producers. The capital costs (e.g. equipment) required for no-till and variable rate fertilization may prevent producers from establishing these practices. Transition costs may also include costs dedicated to learning about BMPs (e.g. time, education) and perceived risks of adopting new practices versus continuing reliable methods. There may also be transition costs involved in accessing financial assistance for BMPs such as costs of paperwork and meeting program requirements (e.g. completion of an Environmental Farm Plan). Overall, transition costs may hinder producers from adopting BMPs despite the economics of the practices after adoption is established.

According to the survey, the following types of resources would assist producers in adopting and using beneficial management practices:

- Written material on how to adopt/implement the practice
- Workshops or seminars
- More financial assistance
- Agricultural extension assistance
- More information

One final conclusion that can be drawn from this research is that at least some types of BMPs (e.g. variable rate fertilization and buffer strips) were not affordable to many farms without incentives, regardless of the environmental benefits gained from the practice. Even though some incentive programs already exist to address these BMPs, it is key that governments ensure that:

- producers are aware of the programs;
- there is sufficient compensation from the programs; and
- the application processes are simple.

In closing, to maximize profitability, a producer needs to consider all aspects of their farm. Prosperity will depend not only on applying ‘best practices’ to their operation, but to the environment as well. Enhancing environmental sustainability on the farm over the long term will improve its economic sustainability.

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