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An Analysis of the Effects of Beneficial Management Practices on Crop Yields in the South Tobacco Creek

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Introduction

Beneficial Management Practices (BMPs), are new generation agricultural management practices. Whether BMPs are a feasible way to achieve sustainable agriculture in the long run is a complex issue. Both benefits and costs of BMPs need to be considered. The benefits of BMPs involve not only enhancing productivity growth, but also decreasing greenhouse gas emission, protecting land from wind and water erosion, preserving water quality and so on (Knopf, 2006). This study only covers a small part of this big issue by focusing on the influences of BMPs on agricultural productivity in terms of crop yields in the South Tobacco Creek (STC) in South Manitoba (Figure 1).

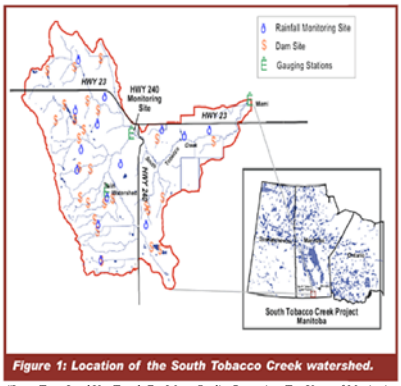


Figure 1: Location of the South Tobacco Creek watershed.

"Long Term Land Use Trends For Water Quality Protection: Ten Years of Monitoring in the South Tobacco Creek Watershed", AAFC, 2002, p. 1.

Objective

The objective of this study was to analyze the effects of some BMPs on crop yields. The Beneficial Management Practices evaluated in the study refers to the crop rotation, zero tillage, and nutrition management. Explanations of the BMPs are presented in Table 1.

Table 1 : Explanations of BMPs under Evaluation

BMPs	Explanations
Crop Rotation	A rotation, such as oilseed-cereal-legume-cereal, can increase soil organic matter, and then decrease the use of commercial fertilizer. Following biologically fixating crops with high N-use crops is condersidered both economically and environmentally friendly.
Zero Tillage	Zero tillage or reduced tillage can reduce soil distrurbance and maintain crop residual cover. It can reduce fossil fuel consumption.
Nutrition Management	The time and methods of fertilizer application are crucial for agricultural production. For example, N application in spring is preferred. Residual nitrogen cover crops, legume, and manure need to be considered when calculating nitrogen requirements to avoid overapplication.

Source: "Global Warming and Agriculture: Best Management Practices", Soil Conservation Council of Canada.
"Assessing the Water Quality Benefit of BMPs: At Watershed Scale across Canada", AAFC.
"Steppler WEBs Project: South Tobacco Creek", AAFC.

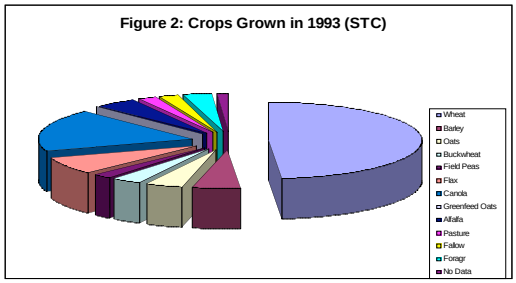
Methodology

The STC area is a sub-watershed in rural municipality of Thompson, Manitoba. The average farm size is 125.79 hectares (Deng, 2006). About 40% of the farms are mixed farms producing both grains and livestock. The crop composition of the STC in 1993 is presented in Figure 2. The primary soil type is clay-loam. The study is from 1992 to 2004 by AAFC and PFRA. Ordinary Least Squares are employed to estimate the yield response functions of wheat, barley, oats, flax, and canola respectively. The model used in this study for the five crops respectively is based on Deng Yu's work (2006) and presented as follows:

$$Log(YIELD) = \beta_0 + \beta_1 CEREAL + \beta_2 OILSEED + \beta_3 LEGUME + \beta_4 ZEROTILL + \beta_5 SPRINGN + \beta_6 SPRINGP + \beta_7 FALLN + \beta_8 FALLP + \beta_9 (GS/GDD) + \beta_{10} (GS/GDD)^2 + \beta_{11} T + e$$

where YIELD is the crop yield in tonne/ha; CEREAL, OILSEED, and LEGUME are binary variables for certain crop grown in the previous year (i.e., Cereal = 1 for cereal crop grown in the previous year, and 0 otherwise); ZEROTILL is a binary variable indicating whether zero tillage is employed; SPRINGN, SPRINGP, FALLN, and FALLP indicate the accumulated amount of N or P applied in spring or fall respectively in tonne/ha; (GS/GDD) is the ratio between GS (gross precipitation) and GDD (growing degree days), constituting a proxy for "water use to water demand" ratio that determines the growing condition for crops (Cortus, 2005); T is the time trend (T=year-1991); e is error term.

Figure 2: Crops Grown in 1993 (STC)



Source: "Farm Demographics", STC Project, Deerwood Soil and Water Management Association, 1993.

Results

Oilseed and legume crop in the previous year have an approximately 6.14% and 11.8% effect on wheat yields respectively (Table 2). But other rotation variables are either statistically insignificant or having negative signs on coefficients. Zero tillage has a small positive effect on wheat yield at 10% level, and has negative signs or statistical insignificance in other crops. When examining the effects of the accumulated amount of N or P applied in spring or fall, the measurement units should be considered as well as statistical significance and economic significance. For example, adding 100 kilograms of P per hectare in fall increases wheat yields by 19.442% although it is not statistically significant. The ratio between GS and GDD and its square form are jointly significant in wheat, flax, and canola functions. But the signs on the two variables in canola function are not what we expected. Except for oats, time has a positive statistically significant influence in other crops.

Table 2: Estimation Results of Crop Yield Response Functions

	Wheat	Barley	Oats	Flax	Canola
CEREAL	-0.0069	-0.0279	-0.0477	-0.2119**	-0.0069
OILSEED	0.0614*	0.0416	-0.0099	-0.2812***	-0.0360
LEGUME	0.1180***	-0.0422	-0.1344	-0.1724	0.0643
ZEROTILL	0.0453*	0.0593	-0.1076	-0.0169	-0.0002
SPRINGN	1.8205***	0.4425	1.5036	0.1617	1.3621***
SPRINGP	0.0298	-0.2230	4.6516**	-0.3118	0.9640
FALLN	0.8454**	0.6666	5.3700**	-0.9795	1.3999***
FALLP	1.9442	7.5619	-12.9190*	4.4552	-2.6862
GS/GDD	14.0290***	1.3302	8.2726	6.3954***	-1.6123
(GS/GDD)^2	-30.2660***	-3.9384	-17.2440	-13.390**	1.8764
T	0.0203***	0.0268***	0.0061	0.0145***	0.0309***
Constant	-0.9072***	0.9237***	-0.1172	-0.2258	0.4673**
R^2	0.271	0.141	0.100	0.118	0.182
N	1099	292	228	310	646

Note: Dependent variable in each function is Log(YIELD).
* represents significance at the 10% level, ** at the 5% level, and *** at the 1% level.

Conclusion

This preliminary study on BMPs reveals positive effects of some BMPs on crop yields. Because of the limitation of data and functional form, the effects of some other BMPs on crop yields are ambiguous or contradict with our expectation. The model is not able to capture the overall system impact. In the future work, combining livestock section and crop section and taking into account costs will improve the BMP analysis.

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