Decision Making among Canola Growers in the Prairie Provinces: The Impact of Farm and Grower Characteristics

By

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INTRODUCTION

The production of canola (*Brassica napus*, an annual oilseed crop) in western Canada has expanded in recent years, as has crushing capacity. The industry requires an increasing supply of harvested seed for crush and export that can only be met by increasing area, yield, or both. Improving the profitability of canola relative to other crops will help to ensure an adequate supply of canola. One option to increase profitability across the industry is to assist those producers identified as not using best management practices for canola production to adopt better production practices. Canola yield on adjacent farms can be very different, although climatic and soil conditions are similar. The application of inputs, such as fertilizer, herbicides and fungicides, can explain some, but not all of the yield differences observed across farms. Management practices such as timing of field operations and keeping of records to better manage the uniqueness of fields differ among farms, and good management practices can bolster crop yield and productivity.

An industry goal to achieve production targets would be to improve the management skills of all growers, especially for growers who currently are not using the best management practices. Given that crop yield is highly variable and there are yield differences across farms, identification of farm and grower characteristics that contribute to better decision making could be used to focus extension activities to improve yield and profits for farms constrained by lower yield. Some management decisions that growers make are easily identified (fertilizer application rates), while others are less obvious and their impact is only apparent when combined with numerous other decisions. These decisions could make a difference in crop yield and productivity. For example, decisions about the tillage system to use, when to swath canola at harvest, how to determine fertilizer and fungicide application rates, and consistency of field record keeping could all affect canola yield and productivity.

A few studies have estimated the adoption of a specific technology, such as zero tillage (Rahm and Huffman 1984; Davey and Furtan 2008; D'Emden et al 2008). There have been no studies which have evaluated the adoption of a suite of management practices that can contribute to higher production efficiency. Factors that have been considered in the past to explain technology adoption have included age, education, location/region, farm operating structure, investment, farm size, soil erodibility, rainfall, and use of extension information. Lin (1991) focused on farmer education level in adopting hybrid rice, while Huffman and Mercier (1991) showed record keeping was an important factor to efficient dairy production in Iowa. Paudel et al (2008) included continuation in farming, environmental attitudes, debt-to-asset ratio and the nearby presence of urban development to explain the adoption of best management practices by dairy farmers.

The objective of this study was to determine the principal farm and grower characteristics determining canola growers' decisions to use best management practices to enhance crop yield and productivity. Grower decisions selected for analyses include tillage system, timing of harvest, chemical applications including fertilizers and herbicides, and record keeping for farm planning. Knowing how farm and grower characteristics contribute to improved decision making, extension efforts could be targeted to those producers with the greatest need.

MODEL SPECIFICATION

Producers will adopt improved or best management practices if they perceive the utility from the new practices to be higher than that of the old practices. The practices could be field activities (tillage system) or a management practice that requires a change in the methods used to produce a crop (e.g., timing and rate of input use). The management practice could alter production costs, or require improved decision making skills and time committed to keeping and using field records. Characteristics of farms and growers have been used to explain why some growers adopt new systems and management practices while others stay with their current system. The farm and grower characteristics are the underlying factors driving grower choices.

In general, determination of the contributing factors which explain the behaviour of a decision maker is constrained by the finite number of choices and outcomes. The outcomes typically either occur or do not occur. Numerous methodologies have been used to evaluate the factors influencing farm management decisions. A qualitative or limited dependent variable model is the appropriate model to use when categorical and continuous data are employed to estimate grower decision responses. The limited dependent variable model predicts the probability of the desired outcome occurring and depends on the explanatory variables. The explanatory variables can be categorical variables with limited choices, or continuous variables such as age, education or farm size.

Probit and logit models are the most common models used to estimate limited dependent variable models. The adoption of zero tillage used probit (Rahm and Huffman 1984; Davey and Furtan 2008) and logit (D'Emden et al 2008) regression models to explain adoption. The dependent variable is defined as 1 if the event occurs, 0 otherwise. The limited dependent variable model estimates the probability of the dependent variable being equal to 1, and is a function of farm and grower characteristics. The logit model has several advantages: (a) it is more appropriate for handling the relationship between a categorical response variable and a set of independent continuous and categorical variables, (b) it can accommodate explicit interaction and power terms, and (c) the error terms are not assumed to be normally distributed.

The following notation follows that of Maddala (1983, p.22). The logit model can be specified as:

$$y_i^* = \beta' x_i + u_i$$

where y_i^* is a binary variable, β' is a vector of regression coefficients, and u_i is a vector of error terms. What we observe is a dummy variable y defined by:

$$y = 1 \quad if\ y_i^* > 0$$

$$y = 0 \quad otherwise$$

As indicated by Maddala in this formulation, $\beta' x_i$ is not $E(y_i|\chi_i)$ as in the linear probability model; but rather it is $E(y_i^*|\chi_i)$. The decision can be modeled as

$$Prob(y_i = 1) = Prob(u_i > -\beta' x_i)$$

$$= 1 - \mathrm{F}(-\beta' x_i)$$

where F(.) is the cumulative distribution for u. The functional form for F(.) depends on the distribution of u_i. When the cumulative distribution of u_i is logisitic, the logit model is appropriate:

$$\mathrm{F}(-\beta' x_i) = \frac{\exp(-\beta' x_i)}{1 + \exp(-\beta' x_i)} = \frac{1}{1 + \exp(\beta' x_i)}$$

Therefore:

$$Prob(y_i = 1) = \frac{\exp(\beta' x_i)}{1 + \exp(\beta' x_i)}$$

Two measures (odds ratio, derivatives for the probabilities) can capture the marginal effects of the categorical variables on the probability of the operator making or adopting a given decision. Because many of the explanatory variables are discrete or binary it is easier to interpret the odds ratio (Paudel et al 2008). The odds ratio provides the change in the odds for a one unit increase in the corresponding explanatory variable. The derivative of a linear probability model predicts the effects of a change to one of the independent variables on the probability of belonging to the group. This is given as:

$$\frac{\partial \mathrm{P}}{\partial x_j} = \frac{\beta_j \cdot \exp(x' \beta)}{[1 + \exp(x' \beta)]^2}$$

DATA

A questionnaire survey of 996 canola growers was undertaken in the Prairie Provinces (Alberta, Saskatchewan, Manitoba) to solicit farm and growers characteristics and factors motivating their production decisions, such as no-till practices for the 2011 crop year (Blacksheep Stategies Inc. 2012). The primary purpose of the survey was to determine the production practices and inputs employed by canola growers, and to gain a better understanding of the farm/farmer characteristics that contribute to higher canola yield and influence producer decisions. Knowledge of the factors that contribute to improvements in canola yield can lead to the development of extension strategies to assist operators in addressing constraints limiting their crop productivity. The survey included socio-economic and agronomic information about farm and grower characteristics including age, education, income and soil type, to list a few. While the bulk of survey respondents completed the survey, it should be noted that some segments of the survey were not applicable to many of the growers.

Selected grower decisions and farm/grower characteristics were first tested to determine their influence on decisions made by canola growers. The decision variables included tillage system, the criteria of when to seed, applying herbicides, swath and combine, how fertilizer application rate was determined, consideration of environmental conditions when applying fungicide, and keeping field records. The farm/grower characteristics included: age, education, farm goals, farm structure, debt-asset ratio, farm size, soil zone, farm-related income, record-keeping, and years growing canola (experience). Prior to the initial testing, the number of categories for each characteristic was reduced by combining similar categories or eliminating categories with fewer occurrences. A log-linear analysis was performed on the survey count data. The counts were the number of grower responses in the survey that were in each of the category combination cells (for example tillage by education had 4 by 4 = 16 cells). The analysis was undertaken with the SAS Proc Glimmix procedure (SAS 2013), and the output was interpreted in a similar manner to analysis of variance.

Most of the farm/grower characteristics had a significant relationship to the decision variables (Table 1). Grower decisions with limited significant relationships included seeding, herbicide application and combining. These three decision variables were deleted from further analyses. The continuous characteristic variables of interest included age, farm size and years growing canola, while the remaining were categorical variables. The relationship between the characteristics was estimated using count data. The three continuous variables were transformed to categorical variables for the relationship analysis.

Table 1. The Probability of farm/grower characteristics affecting decisions.

Characteristics / *Decisions*	**Age**	**Education**	**Farm Goals**	**Farm Structure**	**Debt-Asset Ratio**	**Farm Size**	**Soil Zone**	**Farm Income**	**Record-Keeping**
Tillage System	0.168	**0.004**	0.101	**0.001**	**0.009**	**<0.001**	**<0.001**	**0.002**	**0.041**
Seeding	0.370	0.333	0.722	0.127	0.710	0.322	**0.001**	0.394	**0.056**
Swathing	**<0.001**	**<0.001**	**0.034**	**0.067**	0.163	**0.001**	0.134	**0.002**	**0.014**
Fungicide	0.374	**0.013**	**0.015**	**<0.001**	0.535	**0.010**	**<0.001**	**0.002**	**0.094**
Herbicide	0.374	0.552	0.124	0.738	0.723	0.841	**0.004**	0.609	0.266
Combine	**0.024**	0.812	0.284	0.784	0.813	0.123	0.957	0.992	0.397
Fertilizer	**0.012**	**0.064**	**0.064**	0.222	**0.008**	0.114	**0.001**	**0.096**	**<0.001**
Record Keeping	0.691	**<0.001**	0.253	**0.001**	0.756	**0.005**	**0.065**	**0.001**	

Testing of the different characteristic variables was undertaken to determine if there was a high degree of relationship among the characteristic variables. A significant relationship among some of these variables would indicate fewer variables would be required to explain decisions (Table 2). Six of the farmer/grower characteristics were considered adequate to explain the remaining characteristics. The criterion employed to select the important farm/grower characteristics was based on a significant relationship of P≤0.10 (Table 2).

Table 2. The probability of relationships among farm/grower characteristics

	Age	**Education**	**Farm Goals**	**Farm Structure**	**Debt-Asset Ratio**	**Farm Size**	**Soil Zone**	**Farm Income**	**Record-Keeping**
Age		**<0.001**	**<0.001**	**0.001**	**<0.001**	**<0.001**	0.181	**0.003**	0.691
Education	**<0.001**		**0.001**	**0.003**	0.116	**0.005**	**<0.001**	0.945	**0.001**
Farm Goals	**<0.001**	**0.001**		**<0.001**	**<0.001**	**<0.001**	0.928	**<0.001**	0.291
Farm Structure	**0.001**	**0.003**	**<0.001**		0.225	**<0.001**	**0.077**	**<0.001**	**0.009**
D/A Ratio	**<0.001**	0.116	**<0.001**	0.225		**<0.001**	0.268	0.797	0.654
Farm Size	**<0.001**	**0.005**	**<0.001**	**<0.001**	**<0.001**		**0.001**	**<0.001**	**0.025**
Soil Zone	0.182	**<0.001**	0.928	**0.077**	0.268	**0.001**		0.374	**0.060**
Farm Income	**0.003**	0.945	**<0.001**	**<0.001**	0.797	**<0.001**	0.374		**0.002**
Record-Keeping	0.691	**0.001**	0.291	**0.009**	0.654	**0.025**	**0.060**	**0.002**	

The questionnaire responses of the decisions and the farm/grower characteristics variables are as follows:

Decision Variables (best management practices underlined): Tillage systems included conventional (12%), conservation tillage (minimum or reduced till) (31%), conservation tillage (direct seeding) (17%), conservation tillage (no-till or zero-till) (40%). Seeding included soil temperature (40%), date (20%), once dry enough (22%), and other (18%). When to swath canola for harvest included seed colour change (73%), pod colour change (11%), field colour change (9%), and other (7%). The criteria that growers considered in applying fungicide included environmental conditions (37%), past disease history (14%), scouting (26%), advice of crop consultant (15%), and other (8%). Herbicide application decisions considered factors such as scouting (48%), crop stage (35%) and other (17%). The decision when to combine canola included moisture content (50%), green seed count (39%), and other (11%). Fertilizer rate determination decision included: soil test recommendations (29%), general fertilizer use guidelines (13%), past yields (12%), own experience (30%), price/cost limitations (8%), and advice of a crop consultant (8%).

Farm/Grower Characteristics: Education included up to some high school (13%), completed high school (26%), some college or university or completed trade school (40%), and completed university or graduate degree (21%). Farm goals included acquire assets/increase income (26%), expand to include family members (15%), maintain current farm and lifestyle (33%), implement a succession plan to transfer the farm untouched (10%), and other (16%). Farm structure was categorized as sole proprietorship (39%), family corporation (34%) and other (27%). Debt-asset ratio was categorized into three groups: 0 to 0.25 (59%), 0.26 to 0.50 (30%) and >0.51 (11%). The soil zones where operators were located were Black (40%), Gray (19%) and Brown plus Dark Brown (41%). Income categories consisted of 0 to $99,999 (45%), $100,000 to $249,999 (27%), and ≥$250,000 (28%). The 30+ options in the survey for farm records were categorized into the following seven records based on the most commonly recorded and considered important: each herbicide used by product name, swathing date, a physical sample of each load prior to binning, the nutrient program applied to each field, results from soil tests, details of any weed problems in each field, and details of any disease problems in each field. Counts of these records were obtained and were classified into four groups: zero (10%), 1 to 2 (26%), 3 to 5 (50%), and 6 to 7 (13%).

Analytical Procedure

The logistic regression model employed the decision variables as the dependent variable and the farm/grower characteristics as the independent variables. The best management practices considered to be optimal included no-till, seeding based on soil temperature, swathing when seed colour changes, employing environmental conditions to decide whether to apply fungicide, scouting for weed control, using seed moisture to determine when to combine, and employing soil test for fertilizer determination. Farm goals, farm-related income, and debt-asset ratio were eliminated from the models because they were highly related with the remaining farm/grower characteristics. Farm size was a good predictor of farm income, and age was a good predictor of canola experience (years growing canola), farm goals and debt-asset ratio. Given the information presented in Tables 1 and 2, five decision variables were retained for analyses: tillage system, record-keeping, fertilizer application, swathing, and fungicide application. The independent variables included: age, education, farm structure, farm size, soil zone, years growing canola, and record-keeping. The categorical independent variables were specified as binary (0/1) variables for the logistic regression analysis. The logit model was estimated for each of the five production decisions, and for growers who met at least four of the decision criteria (multiple). The initial model included all of the possible explanatory variables with variables deleted if they were not significant using the Wald Chi-squared test. For most decisions, three variables were retained in the final estimates (Table 3).

RESULTS and DISCUSSION

The results of the logit regression model showed that farm size, education and soil zone were significant variables influencing the probability of canola growers adopting or using no-till

(Table 3). The results were consistent with results reported by Davey and Furtan (2008) for the Canadian prairies. In Australia, there was grower perception that no-till led to crop production benefits associated with the effectiveness of pre-emergent herbicides (D'Emden et al. 2008). The probability of using no-till was higher for larger farms, growers with higher formal education, and for growers in the Dark Brown or Brown soil zones.

For the remaining decision models, the probability of using the best management practice was greater for larger farms and for growers with higher formal education. The age of the operator had a positive impact on record keeping and on the decision criteria for swathing canola, but a negative effect for applying fungicides. Years of experience in growing canola had a positive impact on both swathing and fungicide application. Producers in the Black soil zone were more likely to use the best management decision criteria for making production decisions regarding fertilizer and fungicide use. Farm families with a corporate farm structure use the fungicide criteria moreso than sole owners/proprietors. The column "Multiple" in Tables 3 and 4 was for producers who adopted best management practices for at least four of the practices (tillage, records, fertilizer, swathing, and fungicide). Growers with larger farms and more formal education were more likely to use best management practices for their decisions.

The percent of the observations that were concordant ranged from 62 to 66. While the models were able to correctly predict over 60% of observations, there were still a high number of growers not accurately assigned. Other models and forms had similar predictive efficacy with these data. Explaining the adoption of best management practices of growers was difficult based on the observed variables considered in the analysis, including farm size, age, experience, education, and farm location. These variables are proxies for decision making abilities and expertise of growers, and likely do not fully explain growers' abilities.

The odds ratios of the variables provide an easier interpretation of the results than the model coefficient estimates. For tillage, the value of 1.43 for acres ('000) indicates the odds of using no-till will increase by 43 percent for each additional 1,000 acres of land. The odds of using no-till were nearly twice (91% higher) as high for growers with a university education than growers with some high school. The odds of using no-till were 30% lower in the Black and 69% higher in the Dark Brown and Brown soil zones relative to growers located in the Gray soil zone.

For all of the production decisions, the odds ratio was higher for larger farms and for growers with college or university education (Table 4). The high school versus some high school had mixed results across canola grower decisions. The soil zone factors were important, with the impact depending on the decision. The Brown and Dark Brown soil zones were more likely to use no-till, but were less likely to use the recommended fertilizer and fungicide criteria. Growers in these two soil zones have less experience growing canola.

The impact of farm size on using no-till was consistent with that of Davey and Furtan (2008). No-till is a more common conservation practice in the drier Brown and Dark Brown soil zones.

Table 3. Regression estimates for five production decisions and at least three of the decisions (Chi-Square P-values are in parenthesis).

Variables	Tillage	Records	Fertilizer	Swathing	Fungicide	Multiple
Intercept	-1.122 (<.01)	-1.246 (<.01)	-0.5578 (<.01)	-1.271 (<.01)	-0.023 (0.95)	-2.162 (<.01)
Acres (‘000)	0.3540 (<.01)	0.1660 (<.01)	0.1002 (<.01)			0.0804 (0.05)
Acres (‘000)^2	-0.0187 (<.01)					
Age (yr)		0.0124 (0.07)		0.1042 (<.01)	-0.0222 (<.01)	
Age^2				-0.0013 (<.01)		
Experience (yr)				0.0200 (<.01)	0.0260 (<.01)	
Education	(0.02)	(<.01)	(<.01)	(<.01)		<.01
High school (HS)	-0.0708 (0.56)	-0.076 (0.43)	-0.3154 (0.03)	-0.148 (0.25)		-0.3871 (0.04)
College	0.1795 (0.09)	0.1284 (0.40)	0.0063 (0.96)	0.1801 (0.14)		0.0671 (0.61)
University	0.2683 (0.04)	0.4749 (<.01)	0.4811 (<.01)	0.4604 (<.01)		0.5294 (<.01)
Some high school	Base	Base	Base	Base		Base
Soil Zone	(<.01)		(0.01)		(<.01)	0.105
Black	-0.4000 (<.01)		0.2791 (0.01)		0.4363 (<.01)	0.2781 (0.04)
Brown+Dk						
Brown	0.4620 (<.01)		-0.2679 (0.02)		-0.3230 (<.01)	-0.100 (0.48)
Gray	Base		Base		Base	Base
Farm Structure					(<.01)	
Family corp.					0.2445 (0.01)	
Other					0.0561 (0.58)	
Sole owner					Base	
Percent Concordant	66.1	62.1	62.3	62.7	64.7	66.2

Table 4. Odds ratios by production decision

Variables	Tillage	Records	Fertilizer	Swathing	Fungicide	Multiple
Acres ('000)	1.43	1.18	1.11			1.08
Age (yr)		1.01		1.11	0.98	
Experience (yr)				1.02	1.03	
High school (HS) vs. some HS	1.36	1.57	0.87	1.41		0.85
College vs. some HS	1.75	1.93	1.20	1.96		1.34
University vs. some HS	1.91	2.72	1.92	2.59		2.11
Black vs. Gray	0.71		1.34		1.73	1.58
Brown + Dk. Brown vs. Gray	1.69		0.77		0.81	1.08
Family corp. vs. sole owner					1.73	1.65
Other vs. sole owner					1.43	0.86

The lower odds of using no-till in the Black, compared to the Gray, soil zone was contrary to expectations because the more northern Gray soil zone have cooler soil conditions in the spring, especially with no-till.

About less than 30% of growers used soil testing to determine fertilizer rates. The probability of growers using soil testing was higher for growers with university education and for growers located in the Black soil zone (Table 4). Nitrogen fertilizer is a critical input for optimizing canola yield. Growers using the best management practice to determine when to swath canola had higher odds for older growers, and those with more formal education. The best management practice of applying fungicide had higher odds for growers in the Black soil zone, and for operators with a family corporation. The latter could have been capturing other management skills not accounted for by the other variables. Forty-seven percent of growers in the survey kept four or more production records. The odds of recording these many records were higher for growers with larger farms and with higher formal education.

CONCLUSIONS

Over time farm numbers have declined and there has been a trend towards greater consolidation of operations. This study analyzes the factors influencing the adoption and use of best management practices by canola growers. A logit regression model was estimated from the survey responses of 996 canola producers in the prairies. The survey included information on farm/grower characteristics and principal operator decisions. The management practices canola growers used were explained in large part by the characteristics of farms and growers. Larger farms and growers with higher formal education were more likely to use the best management practices for canola production. Grower decisions were also influenced by the soil zone, while age and experience had a relatively small impact on decisions. Efforts to encourage producers to use the best management practices to improve canola production can be targeted to specific groups of growers, specifically operators with smaller farms and less formal education. The information supplied to producers by extension programs could also be tailored in terms of message and format for the client.

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