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Agricultural Biotechnology and Canola Meal: An Application of Real Options to Canadian Research Policy

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1.0 Objectives and Background

1.1 Canola

Canola is a major oilseed crop in Western Canada and is produced mainly for its high quality oil. Canola oil is used as an ingredient in many foods and is sold both commercially and by retailers. In the 2005/06 marketing year, Canada produced 9.7 million tonnes of canola on 5.4 million hectares of land and exported 1.5 million tonnes of canola meal (United States Department of Agriculture, 2007), the by-product of canola oil extraction*.* Canola meal is relatively high in protein. However, canola meal is low in protein (35%) (Canola Council, 2007) compared to soybean meal (48%) (National Grain and Feed Association, 2007). Canola meal is generally used in animal feed as a protein supplement.

Canola meal contains two naturally occurring compounds, sinapine and phytate, which have anti-nutritional factors (ANF). These compounds reduce the nutritional quality of the meal, as they cause poor uptake of essential nutrients. Sinapine, the most abundant small phenolic compound in canola, gives canola meal a bitter or astringent taste, usually reducing palatability. Sinapine also gives a 'fishy' odour to eggs (Selvarage, 2002), rendering them unacceptable. Phytate binds to minerals in the digestive tract, removing nutrients such as zinc, phosphorus, calcium and iron from food in the digestive tract. These minerals are generally excreted in the feces, resulting not only in compromised mineral absorption, but environmental consequences associated with an excess of phosphorus leaching into the waterways. The presence of ANF reduces the price of canola meal relative to soybean meal. Reducing ANF in canola meal should increase the value of canola meal protein relative to soybean meal protein.

1.2 Biotechnology and economics: reducing ANF in canola

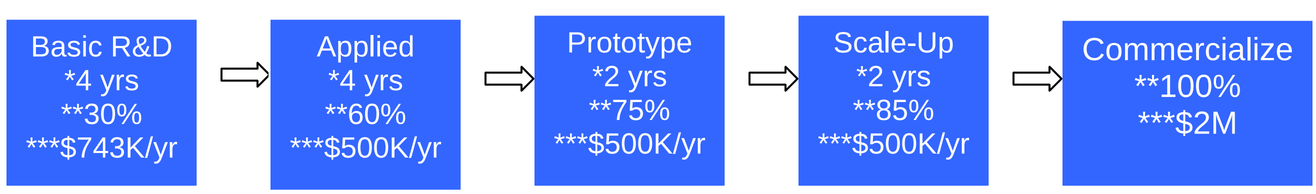
New biotechnology product development and commercialization requires investment decision-making, based on the analysis of the project and future cash flows. The Plant Biotechnology Institute (PBI) in Saskatoon, Saskatchewan is equipped with advanced technology for genomics research. PBI is a part of the government of Canada National Research Council (NRC). PBI engaged in research to develop canola seed producing canola meal with reduced ANF. The objective of our project was to evaluate *ex ante* the dollar value of the ANF canola research program and compare two different investment analysis approaches. A separate issue identified at the completion of the project was challenges with the NRC-PBI research funding model which required industry funds at later research stages before the PBI R&D program could continue.

2.0 NPV and RO Analysis in the Canola Meal Study

Two approaches - RO (real options) and NPV (net present value) were used to evaluate the reduced ANF R&D research project at PBI. The RO approach is a relatively new concept in which investment decisions are regarded as a series of opportunities or investment options. The RO framework is based on the realization that future investment opportunities are contingent on those in the past. Rather than adhering to a strict decision timeline, decision-makers are allowed to keep investment options open until new information arrives. In the case of R&D, ROs assist in valuing the flexibility of continuing or abandoning the R&D program at each stage in the research program (Figure 1).

NPV is the present value of net cash flows from the R&D program combined with the discounted future industry related profits. It is a standard method for determining the present value of a long term project. The standard NPV approach assumes the project must begin now or never. It further assumes that if the project commences, it is carried through to completion. Standard NPV models may have difficulties valuing projects where managers can be flexible in making decisions at later stages in the project.

PBI identified the various stages of the ANF project, the length of time to complete each stage, the estimated costs for each stage (i.e. dollars/year) and the probability of a successful research outcome in each stage. These research stages are illustrated in Figure 1. For example, if the applied research stage was completed and the research outcome was successful (e.g. move to prototype stage) the cost of the next stage, prototype, would be $500,000/year for two years and the probability of a successful research outcome (i.e. move to scale-up) is 75%. The end of each stage in Figure 1 represents a logical decision point to either continue or discontinue the research program. Hence, RO may have a useful role in evaluating this research program where managerial flexibility can be modeled at the end of each research stage. PBI can undertake Basic R&D using government funds but in general, industry/business co-funding is required before PBI can move to applied and the later research stages identified in Figure 1.



* Time to complete stage
** Probability of Completing Stage with successful research outcome suggesting continue to next research stage
*** Estimated cost to complete stage

Figure 1. PBI Research Model – Time, Success and Probability of Completing Each Stage and Associated Estimated Costs.

The following assumptions were used to apply the RO and NPV models to the reduced ANF project.
1. Technology risk and market risk are independent
2. Sequential investment decisions are made at the end of each R&D stage for RO analysis. At the end of each stage, the project is re-evaluated with the decision to continue to the next stage or abandon the research project.
3. The reduced ANF canola meal protein is directly substitutable with soybean meal protein. The value of the project is based on the price difference between improved canola meal and regular canola meal.
4. The private firm is able to design and enforce contracts that allow it to capture the benefits from canola, producing reduced ANF canola meal.

2.1 The RO approach in the canola meal study

Two scenarios were evaluated. Potentially, reduced ANF genetics could be incorporated into most of the canola grown in western Canada. The entire canola industry would potentially benefit from this outcome (scenario 1) and there would be no requirement for separate identity preserved supply chains for reduced ANF canola. Scenario 2 assumes a single firm co-funds the PBI research and if the R&D program is successful, the firm has the ability to profitability manage the supply chain for reduced ANF canola. Under scenario 2, the single firm manages the supply chain using contracts and produces about 225,000 tonnes of reduced ANF canola meal/year.

Table 1 summarizes key assumptions used to compare the two scenarios. The key differences are the increased tonnage of reduced ANF canola meal produced under Scenario1.

Table 1. Base Assumptions of the Canola Meal R&D Investment Analysis

Variable	Scenario 1: Industry	Scenario 2: Private
Reduced ANF meal tonnes/year	3.9 Million	225,000
Price Improved ANF Meal	$208/tonne	$208/tonne
Price Regular Meal	$160	$160
Volatility Meal Price	9%	9%
Risk Free Interest Rate	3.5%	3.5%

Table 2 and table 3 summarize the results from NPV and RO analysis of the R&D program assuming the analysis starts at the beginning of the Basic R&D stage or the Applied R&D stage (Figure 1). NPV showed a positive investment result under Scenario 1 (Table 2) at the basic and the applied stage. NPV analysis shows that the industry would benefit by undertaking this research. The RO analysis reached a similar conclusion for Scenario 1 but showed that the benefits of flexibility at each research stage increased the value of the project relative to NPV. Scenario 1 shows high benefits to the canola industry in western Canada if the project were successfully continued through each stage[1].

Under Scenario 2, the private firm, NPV analysis showed a negative investment return at the basic research stage (Table 3). This suggests the private firm should not begin the research project. Hence, a commercial firm may not be interested in undertaking the project at the basic R&D stage. However if the basic research stage has been completed successfully by other groups such as PBI, the NPV analysis is positive and indicates the firm should undertake

[1] This also assumes there are minimal negative issues associated with the genetic modification of the canola seed.

research starting at the applied stage. In contrast the RO analysis suggests that the project should be undertaken by the private firm at the basic or the applied stage. Valuing the flexibility of the R&D process increases the value of the project to the private firm.

Table 2. Scenario 1 Public (Industry) Benefits Analysis. Market Size = 3.9 M tonnes of meal

Approach	Basic R&D	Applied R&D
NPV	$104M*	$363M*
RO	$130M*	$378M*

* Million

Table 3. Scenario 2 Private (Firm) Benefits Analysis. Market Size = 225,000 tonnes of meal

Approach	Basic R&D	Applied R&D
NPV	$(0.7M)*	$15.9M*
RO Stage	$2.8M*	$17.3M*

*Million

At the applied R&D stage, the project is less risky (i.e. there is a higher probability of success) than at the basic R&D stage. Both NPV and RO under scenario 2 show potential benefits greater than $15M at the beginning of the applied R&D stage. The NPV and RO differ in their conclusions about the value of the research program for the private firm at the basic R&D stage. The NPV approach, on the other hand, may be favoured over the RO approach when valuing R&D type of investments at later research stages as there is less risk or flexibility involved in the research project.

3.0 Policy Implications

Analysis of R&D

A comparison of the RO and the NPV options shows the different results when flexibility is added to valuation approach. The RO approach may provide a better valuation model in the early stages of R&D research on a particular research project. RO can capture more of the flexibility inherent in the R&D process. Standard NPV analysis may reject starting R&D projects that would be accepted using RO analysis.

Co-funding Research Model

Despite the potentially high benefits identified by the investment analysis, the PBI reduced ANF canola research project has experienced difficulty finding commercial investors to move the R&D to the applied research stage. This may be due to factors such as:

1. commercial firms are undervaluing the economic benefits of the reduced ANF canola meal,
2. commercial firms are unable to identify profitable ways to capture the economic benefits from developing canola seed with reduced ANF meal,
3. The PBI basic research results thus far suggest the technology may not reach successful completion or
4. Commercial firms have alternative research investment opportunities that provide a superior expected return to the PBI reduced ANF project.

The analysis with both RO and NPV investment models suggest there may be a very large benefit to the canola industry to develop reduced ANF canola seed. The lack of private sector funding for the PBI project may be the result of point 2 above: commercial firms are unable to identify ways to commercially and profitably manage a reduced ANF canola seed. If this is the case, it suggests that the PBI co-funding model may be missing R&D investment opportunities that would be of great benefit to the industry yet are not pursued due to the co-funding model. The reduced ANF canola meal R&D program analysis suggests that the research should go forward even if industry/firm co-funding is not available.

A NRC- PBI research funding model should be developed that evaluates the benefits and costs to the industry as well as to a private firm. The *ex ante* analysis of the society benefits-costs of the R&D program should be used to guide the PBI funding model and if the public benefits are sufficiently high, industry co-funding should be not be required before PBI can undertake the applied and later stages of research. The RO model approach may be helpful in *ex ante* analysis of R&D projects and directing public support to appropriate R&D projects.

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