Annual Status Report, 2019-2020

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Western Grains Research Foundation and partners Alberta Pulse Growers Commission (APG), Alberta Wheat Commission (AWC), Brewing and Malting Barley Research Institute (BMBRI), Manitoba Pulse & Soybean Growers (MPSG), Prairie Oat Growers Association (POGA), and Saskatchewan Wheat Development Commission (SWDC)

PART I – Annual Status Report

Progress on Objectives

Objective 1: Determine the profitability and quantify the risk associated with cropping systems of different rotation length and diversity of crops. This will be for each of three ecosystems in the Canadian prairies. Leads are assigned, but Smith, Jeffrey, Le Roy and Brewin will collaborate on all of the modelling and analyses.

Year 1 (2019-2020)

- Model development for the Black – Gray soil zones of the prairies. Specify crop rotations, develop the cropping budgets for the rotations, and source agronomic relationships related to pests and productivity. (Jeffrey)
- Develop model for the southern Manitoba region of the prairies. Recruit a graduate student. Specify crop rotations, develop the cropping budgets for the rotations, and source agronomic relationships related to pests and productivity. (Brewin)

Progress on Objective 1:

Master's students at both the Universities of Alberta and Manitoba initiated work on the project. Cropping data were gathered to develop representative farms for the analysis, and to develop crop budgets for the crops to be included in the analysis. Crops included: wheat, canola, flax, barley, oats, soybean, corn, lentil, field pea, forage, and for the two regions there were some differences (for example, corn and soybean were in Manitoba only); (2) crop insurance data of crop yields by cropping sequence were analyzed to determine likely sequencing effects on yield, in addition to the disease influence on crop yield; and (3) an element of uncertainty was incorporated into models to account for the variability that is observed in crop production.

(1) Parkland of Alberta-Saskatchewan

At the University of Alberta, a farm-level simulation modelling approach has been specified; both yield and price risk will be incorporated into the multi-year simulation analysis, with farm wealth as the economic performance measure of interest. Distributions of wealth for alternative rotations will be compared using risk efficiency methods.

Data have been sourced concerning crop yields, crop prices, input use, input prices, and other production costs. Three representative farms have been defined (for the Dark Grey and Black soil zones in Alberta, and the Black soil zone in Saskatchewan). Alternative crop rotations to be modeled have been identified for each farm, based on previous studies and expert opinion. The simulation models are still in development; to date, yield and price models have been estimated and validated. Currently, modeling of business risk management programs (crop insurance, AgriStability) is underway.

(2) Manitoba

At the University of Manitoba, the student has sourced data, completed initial estimates, and prepared a detailed proposal as part of the degree requirements. The effect of crop sequencing of crop yield and net returns will be estimated using Manitoba crop insurance yield data. The cropping sequence effect on crop yield will be separated from: previous crop, soil quality, seeding date, precipitation, heat units, location (Risk Area), and climatic (year) effects using econometric techniques. Monte-Carlo simulation techniques will be used to assess the risks of different systems.

The model to estimated crop yield, dependent on previous crop, can be expressed as

$$Y_{i,t} = \alpha_0 + \sum_j \beta_j \, CF_j + \sum_m \sum_n \gamma_{mn} \, R_m S_n + \sum_k \alpha_k C_k + \sum_l \theta_l \, D_l + \sum_t \delta_t T_t$$

where Y is yield, CF are climatic factors (precipitation and heat units), R is risk area, S is soil classification, C is previous crop, D is seeding date (week), and T is year. The model will be estimated for each of the crops (spring wheat, canola, soybean, oats, barley, and grain corn). Estimated yields are then used in a crop budgeting model framework to determine the expected returns from specified crop rotations.

(3) Prairie of Saskatchewan and Alberta

Recruiting a Master's student for the work at the University of Lethbridge was initiated, but none have yet to be identified, A graduate student might not be in place until the fall of 2020. The option of having an undergraduate student during the summer months of 2020 to collect and summarize some of the required data will be explored, but is on hold because of self-isolating COVID-19 issues.

Objective 2: Determine the marginal user costs and benefits associated with cropping systems of different lengths and complexity. Quantify the expected long-term benefits to producers from diversified crop rotations.

Year 1 (2019-2020)

- Develop the model framework for the long-term costs and benefits analysis. Analyze Black soil zone long-term costs and benefits analysis.

Progress on Objective 2:

A model framework, with similarities to evaluating soil quality, was developed. For the analysis, a macro was written to incorporate uncertainty of disease and yield impact of disease within an optimization model simulation model. The simulation will provide direction as to the variability in the disease effects on the optimal system and on the variability of expected net returns. The model will be populated with data from the Universities of Alberta and Manitoba, as well as there is a need to obtain input from plant and crop disease pathologists.

Objective 3: Determine whether business risk management programs impact on the choice of cropping system. The business risk management programs will be included in the modelling of objectives 1 and 2.

Progress on Objective 3:

Business risk management options are included in the farm-level models as options. There is the flexibility to include or exclude the programs to facilitate determining their influence on cropping systems.

Deviations to report

There are no deviations in objectives 1 and 3 and their milestones to report for 2019-2020. For objective 2, the planned analysis will be moved to 2020-2021.

Project public information

There were three public presentations about the project in 2019 to report, one at a producer meeting and two at professional meetings. Details are provided below in the Annual Extension Report.

Financial Statement

Budget variances for 2019-2020:

There were no significant variances to budget expenditures for 2019-2020. A minor note would be that some funds budgeted for software in 2018-2019 were utilized to provide about one-half of the funds required for a computer at the University of Alberta.

Elwin Smith: Travel funds form 2018-2019 were used in 2019-2020 to attend the Canadian Agricultural Economics Society annual meeting, at which there was a presentation on this project.

Danny LeRoy: travel funds for 2018-2019 were utilized to attend two professional meetings in 2019-2020 at which presentations were made on this project.

Scott Jeffrey: Some software funds form 2018-2019 were used to help with the purchase of a computer that is dedicated to this project. Funds for 2018-2019 to purchase the software @RISK were spent in 2019-2020 to purchase the program software.

Derek Brewin: no variances to report.

Financial statements will be submitted by the University of Lethbridge, Finance Section.

Invoices will be issued by the University of Lethbridge, Finance Section.

PART II – Annual Extension Report

There were three public presentations in the summer of 2019 about the project (Appended pdf files). Kieran Brett, of Boot Print Marketing, contacted the project leaders and wrote an overview of the project objectives for the Western Grains Research Foundation.

Presentations:

1. Derek Brewin, Hazel Sakulanda, Liting Yi, Rally Yang, and Sabrina Reza. 2019 Optimal Rotations with Consideration for Corn in Southern Manitoba. CropConect. Winnipeg, MB, Feb. 13. Department of Agribusiness and Agricultural Economics, University of Manitoba.

This presentation, while primarily about corn, contained relevant background material for this study, and was a joint output of this and a study funded by Manitoba Cron Growers. Relative crop yields by crop sequences were estimated. These yield impacts were used to determine the net effect on net returns for selected crop rotations. This work is the base from which much of the research component at the University of Manitoba has been developed. See file submitted with the report: CropConectBrewin.pdf

2. Danny G. Le Roy, Elwin G. Smith, Scott Jeffrey, and Derek Brewin. 2019. Economic Analysis of Crop Rotations in the Canadian Prairies. Selected Paper in Session “Agricultural Economics” at the 2019 CEA Annual Meeting. Banff, AB. Friday, May 31.

This presentation to an audience of general economists. It was a detailed overview of the research problem to be addressed by this study. The grower’s dilemma: higher short-term returns from some intensive production systems of only a few crops (canola, pulse crops) versus long-term higher returns from cropping systems with more diverse systems, with a longer break between crops of canola or pulses. Model specifications were provided to obtain feedback from the audience. See file submitted with the report: CEA 2019 – 20190530.pdf

3. Danny G. Le Roy, Elwin G. Smith, Scott Jeffrey, and Derek Brewin. 2019 Economic Analysis of Crop Rotations in the Canadian Prairies. Selected Paper Session 15 “Economics of Agricultural Production Practices” at the 2019 CEA Annual Meeting. Ottawa, ON. Thursday, July 11.

This presentation was to an audience of agricultural economists. It provided an overview of the study, and of the methods and models proposed to address the objectives of the study. See file submitted with the report: CAES Cropping Presentation - 06062019-2.pdf

Model Overviews for Objective 2:

Two models will be utilized to examine the long-term effects of cropping systems on the long-term returns, under conditions of uncertainty. The stochastic dynamic models will be used to determine the optimal cropping interval years between the crop of interest (canola, pulse crops). Three crop rotations will be considered, 1, 2, and 3-yr intervals between the crop of interest. With canola, growing hybrids with and without resistance will be included. The interval crop will be HRS wheat, but could be a specified as a composite of crops (barley, oats, field pea, etc.) to better reflect the returns from the interval crop possibilities.

(1) Stochastic dynamic programming model

The stochastic dynamic programming (SDP) model will be used to determine the optimal cropping interval years between the crop of interest (canola, pulse crops), given the disease level in the field. The returns will be the net present value of expected returns, if an optimal production path is followed over time. The SDP model can be specified as

$$V_t(i,k) = \max_{a_t}\left[R(i,a_t) + d\sum_{j}^{J} P_{ij}(a)V_t(j,k-1)\right]$$

where V_t is the value of the objective function during the remainder of the planning horizon with optimal *a* given state *i*, *k* is the periods remaining, *R(.)* is the net return function with management action *a* and disease state *i*, *d* is the discount factor $(1+r)^{-1}$, and the disease transitions from period to period by the probability transition matrix $P_{ij}(a)$. The probability transition matrix contains the probability the system currently in state *i* will be in state *j* at period *t+1*, given the action at *t* is a_t. The sum of the probabilities of going from state *i* to all *j* states will sum to 1.0; $\sum_j P_{ij} = 1 \; and \; 0 \le P_{ij} \le 1$. The use of a Markov process in a SDP model will determine the maximum expected discounted returns for *k* periods given the process starts in state *i*. The boundary condition is $V_t(i,0) = CP * Y_i - CX$, where *CP* is the crop price, Y_i is crop yield with disease state *i*, and *CX* is production costs of all inputs that have no impact on the end process. A producer will take actions to maximize the expected current net return plus expected discounted future net returns. The payoff function will be an expected value because the future disease state is unknown and can only be described by probabilities.

The critical data required for this model, and the data that is most uncertain, is how the disease transitions over time. The are some publications reporting yield effects of disease levels. Disease transition is difficult to measure, and will vary depending on growing conditions. The probability transition matrix will facilitate the inclusion of this aspect of uncertainty. Consultation with plant pathologists on disease progression under different management practices will be essential to having a system that reflects reality.

(2) Stochastic optimization model

The stochastic optimization model uses a 'conventional' linear, or non-linear, programming model to solve a multi-year cropping system problem. The stochastic component of the model introduces probability distributions as to how the disease level in the model transitions from one period to the next. The problem is solved with disease transition coefficients generated from the probability distributions, then moves on to the next iteration with a new set of coefficients generated from the probability distributions. The distributions will be a function of the cropping system (fewer interval years will have higher probabilities of increased disease). The model flow is illustrated below in Figure 1. The model uses the optimization with Excel, so the model size is limited. The add-in program SIMETAR is use to generate the coefficients from the probability distributions, and to analyze the model output that is written to a worksheet. An Excel Macro is used to control the loop, the insertion of the updated coefficients in the model, re-solving of the model, and outputting results to a worksheet. The model can be specified as

$$MAX(NR) = \sum_{0}^{T}(1+r)^{-t}\left[P_t \cdot Y_t(X_t, S_t, U_t, t) - C[X_t, S_t, U_t, t]\right]dt - TV[S(T)]$$

$$\text{Subject to: } S_t = S_{t-1} + g(X_t, S_t, U_t, t)$$

where NR is net return, P is crop price, Y is yield that depends on inputs X, disease level S, and disease control measures U, and C(.) are costs. TV is a terminal value function at the end of the time horizon to penalize decisions that result in lower yield because of increased disease. Both of these models will have a yield damage function, to compute yield for the level of plant disease and cropping system.

As with the stochastic dynamic programming model, the disease probability distributions are the model coefficients that have the greatest uncertainty. This model formulation will facilitate determining the marginal user cost of the plant disease level, or put a cost on the plant disease. The marginal user cost will have a distribution around it, rather than a fixed value. The dispersion of the marginal user cost will provide the industry with the possible cost range of plant disease that is faced by producers.

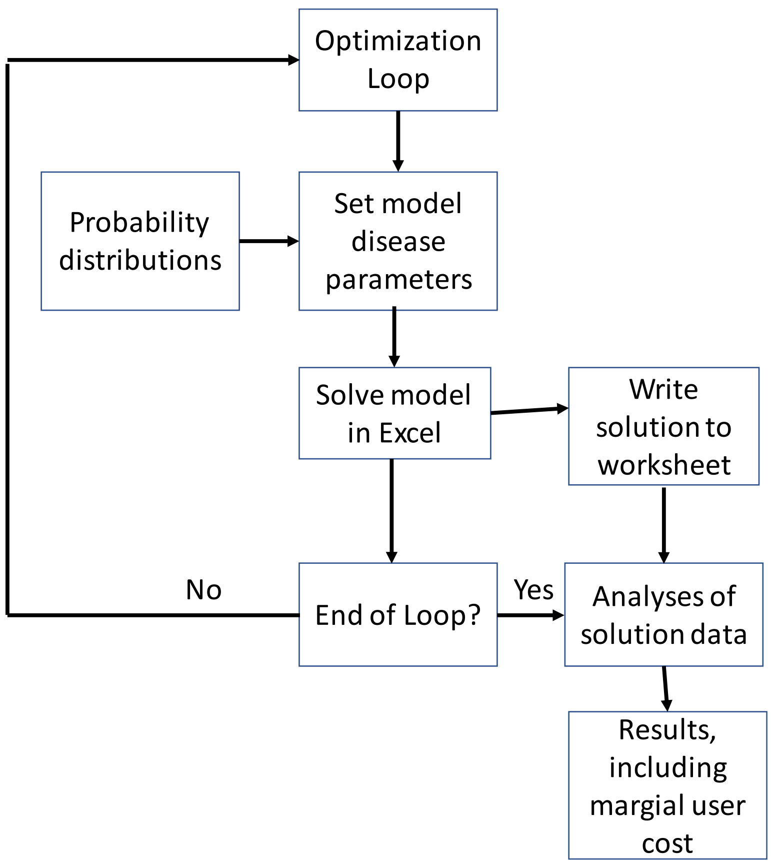

Figure 1. Diagram of flows for the dynamic optimization model

Deora, A., Gossen, B.D., McDonald, M.R. 2012. Infection and development of *Plasmodiophora brassicae* in resistant and susceptible canola cultivars. Can. J. Plant Pathol. 34: 239-247.

Gossen, B.D., Adhikari, K.K.C., McDonald, M.R. 2012. Effect of seeding date on development of clubroot in short-season Brassica crops. Can. J. Platn Pathol. 34: 516-523.

Peng, G,, Pageau, E., Strelkov, S.E., Gossen, B.D., Hwang, S-F., Lahlali, R. 2015. A > 2-year crop rotation reduces resting spores of *Plasmodiophora brassicai* in soil and the impact of clubroot on canola. European Journal of Agronomy. 70: 78-84.