PROJECT DETAILS

- **Funders:** Agriculture and Agri-Food Canada, Canola Council of Canada, Alberta Canola, SaskCanola and Manitoba Canola Growers
- **Research program:** Growing Forward 2
- **Principal investigator:** Alan Moulin
- **Collaborators/additional investigators:** Mohammad Khakbazan, Rejean Picard, Steve Sager, Don Cruickshank, Ken Coles and Stu Brandt
- **Year completed:** 2018

Final report

This research identifies potential improvements to contemporary practices for precision agriculture. Prescription maps developed by agricultural consultants in precision agriculture are commonly based on combinations of NDVI data from remote sensing, and soil analysis. This research provides an alternative based on analysis of yield maps to develop management zones for variable application of N fertilizer, and additional sources of information from analysis of terrain attributes. The viability of using precision agriculture to improve N use efficiency and profitability at the farm field was evaluated. The project also provides information on fertilizer response in the context of historical trends for canola yield at the field scale. In this study, canola yield varied considerably between farms, terrain attributes accounted for a significant proportion of variability, showing the importance of field specific analysis in precision agriculture.

Statistical analysis for the study included a range of methods from plot based analysis of variance with contrasts and covariates related to soil properties and terrain analysis, economic model evaluating canola yield and net revenue estimations using panel field data, to machine learning methods such as boosted tree analysis commonly used in Big Data. Boosted tree analysis showed the relative importance of fertilizer management, yield zones and terrain attributes, in the context of variability between farms. The application of machine learning methods to development of prescription maps may have promise, as the analyses relate a wide number of variables to potential canola yield.

Results of the research showed statistically significant increases in canola yield for several fields in the study, when N fertilizer was applied compared to no N fertilizer. Yield zones and fertilizer rates significantly affected canola yield, when farms were included as a factor in combined analysis.

However the yield response to N fertilizer and related economic return varied considerably between fields, with significant differences in analysis of comparisons between the control (0% of recommended N fertilizer)

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and higher rates. Few significant differences were observed between 50, 100 and 150% of soil test recommendations (Figures 1, 2, 3, 4), Tables 1, 2 and 3>.

Field scale analysis of fertilizer management with producer's equipment and agronomic management, is relevant, and merits research. However the variability related to differences in management between farms, such as canola variety, soil properties, terrain attributes, types of fertilizer, and agronomic practices significantly the results of the study and must be identified. Multivariate methods, referred to as Big Data, have been used to analyse data from this study, and identify significant sources of variability such as elevation.

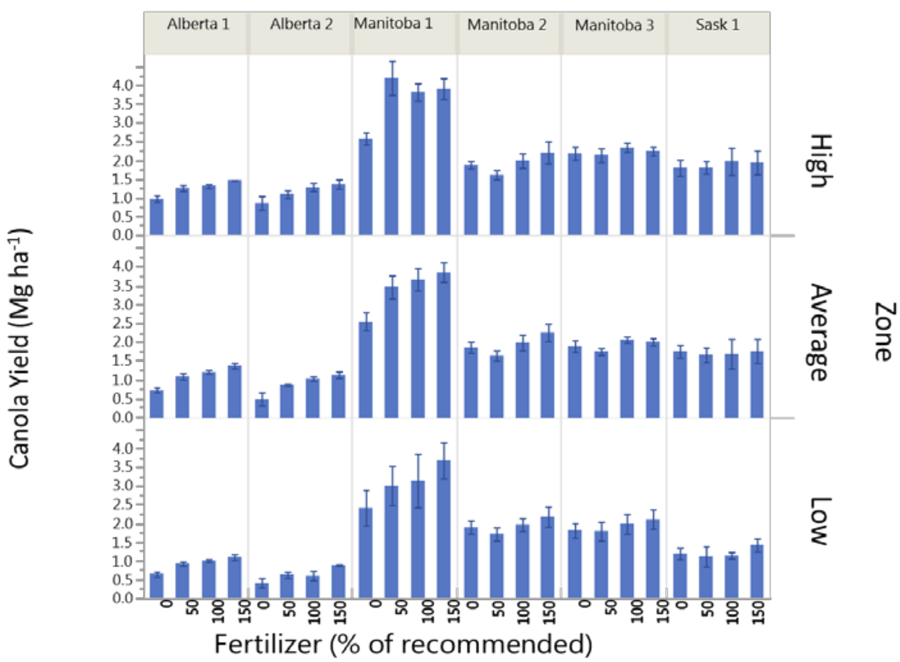

Figure 1. Canola yield response to management zones and fertilizer rates by farm in 2014

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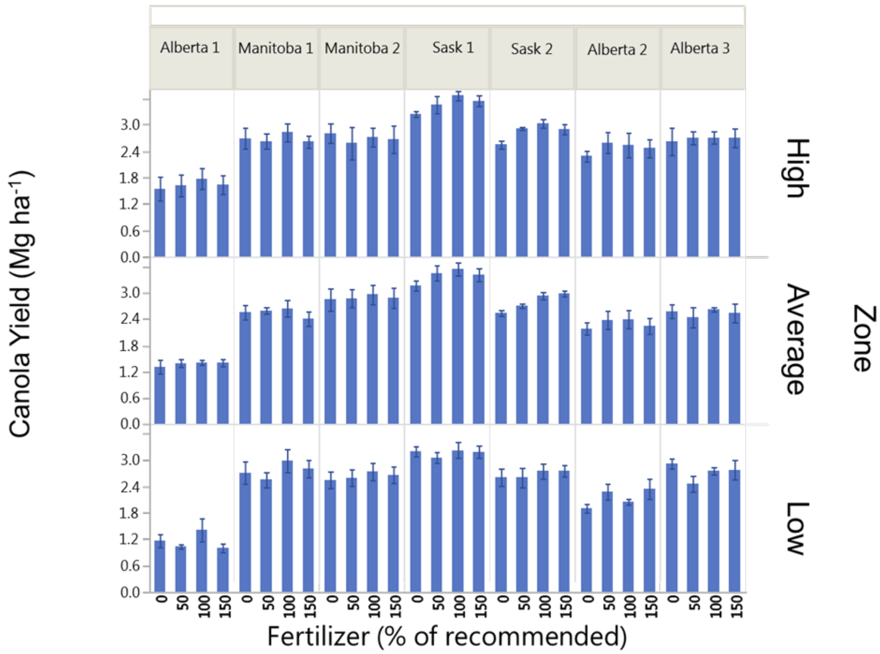

Figure 2. Canola yield response to management zones and fertilizer rates by farm in 2015

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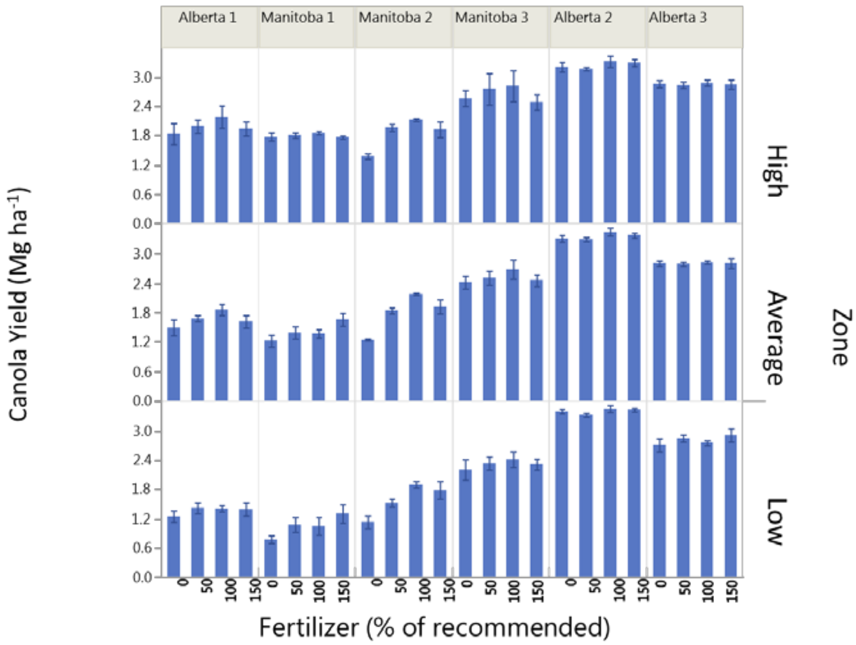

Figure 3. Canola yield response to management zones and fertilizer rates by farm in 2016

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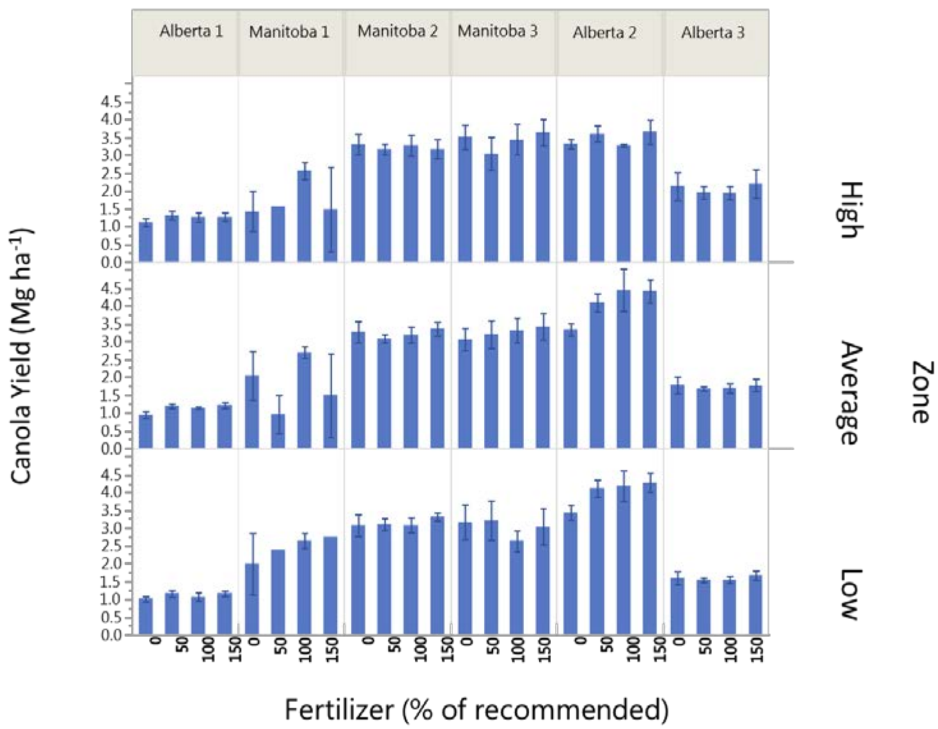

Figure 4. Canola yield response to management zones and fertilizer rates by farm in 2017

In economic analyses of yield response to the mass of fertilizer applied, the canola production and net revenue functions generally followed conventional response curves, the results were mixed in terms of effects of zones and N rates at each individual site. Overall, when all data combined, N and zones were significant. The high zones, on average, generated \$67 more and the low zones \$61 less net revenue ha^{-1} as compared to average zones. Farm location had significant effects on canola yield and profitability ranging from -\$490 to \$530 ha^{-1}. These results identify the need to revisit current soil test recommendations, to account for potentially mineralizable N not accounted for in current soil test analyses. We anticipate that cereal-canola rotations may accumulate N in mineralizable form, which is not measured with current soil extractions in commercial labs. Additional research is required to confirm this hypothesis.

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A series of statistical analyses, beginning with analysis of variance for zones and treatments (replicates were included in the analysis but not shown), was used to address the variability in the data set. The initial analysis of zones and treatments varied between years, with significant effects in 2015 but not in 2016. Addition of fields as a factor to the statistical model, resulted in significant effects due to zone and fertilizer in both 2015 and 2016 (Table 2). Boosted tree analysis, a form of Big Data analytics, showed the relative importance of elevation with respect to canola yield (Table 3). However elevation was not significant when included as a factor in the analysis of variance (Table 4). Comparisons of means for the significant interaction of fertilizer treatment within zones in 2016 indicated that the majority of significant differences were between the controls, without N fertilizer, and higher rates. Few significant differences occurred between the 50, 100 and 150% rates of fertilizer.

Table 1. Analysis of variance for canola yield response to yield zone and treatments within zones for 2015 and 2016.

Variable	Significance
2015	
Zone	0.6811
Treatment within Zone	0.8763
2016	
Zone	0.0019
Treatment within Zone	0.0025

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Table 2. Analysis of variance for canola yield response to yield zone, treatments within zones and fields for 2015 and 2016.

Variable	Significance
2015	
Zone	0.0218
Treatment within Zone	0.0295
Field	0.0001
2016	
Zone	0.0001
Treatment within Zone	0.0001
Field	0.0001

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Table 3. Boosted tree analysis of canola yield as affected by terrain attributes for 2015 and 2016

Terrain Attribute	Portion of variance
2015	
Elevation (m)	0.8817
Channel Network Base Level	0.033
2016	
Flow Accumulation	0.1991
Valley Depth (m)	0.114
Elevation (m)	0.1055
z2pit (m)	0.0597
Diffuse Insolation-April	0.0557
Topographic Wetness Index	0.0494
Diffuse Insolation-June	0.0484
Channel Network Base Level	0.0453
%2pit (m)	0.0404

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Table 4. Analysis of variance for canola yield response to yield zone, treatments within zones, fields and elevation for 2015 and 2016.

Variable	Significance
2015	
Zone	0.0225
Treatment within Zone	0.0302
Field	0.0001
Elevation	0.1955
2016	
Zone	0.0001
Treatment within Zone	0.0001
Field	0.0001
Elevation	0.3429

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Table 5. Mean comparisons (Tukey HSD) between combinations of yield zones and fertilizer treatments for all fields in 2016.

Variable	Significance
2016	
Average 0 vs Average 100%	0.0039
Average 0 vs Average 150%	0.0197
Average 0 vs High 50%	0.0098
Average 0 vs High 100%	0.0001
Average 0 vs High 100%	0.0007
Average 0 vs Low 0%	0.0001
Average 150 vs Low 0%	0.0001
High 0 vs High 100	0.0001
High 50 vs Low 0%	0.0001
High 100 vs Low 0%	0.0001
High 50% vs Low 50	0.0121
High 150 vs Low 0	0.0001
Low 0 vs Low 50%	0.0349
Low 0 vs Low 150%	0.0027

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Summary

Yield zones significantly influenced canola production, in conjunction with fertilizer rates when fields were included in the analysis. The importance of field by field analysis for variable management of N fertilizer cannot be understated. Terrain attributes are also statistically correlated canola response to N fertilizer, though the relationship varies between fields. Practitioners of precision agriculture will benefit from analysis of historical yield and terrain attributes, in planning for variable application of N fertilizer.

Additional Knowledge

1. Soil test recommendations and fertility

    a. Analysis of canola yield data for 2014, 2015 and 2016 show few significant differences for fertilizer rates at 50, 100 and 150 % of recommended fertilizer rates, and varied between fields. In general, for fields with significant differences in canola yield, the majority of treatment effects were between the control and rates of fertilizer at 50%, 100% and 150% of soil test fertilizer recommendations. Although the variability of yield response varied considerably between fields, current soil test recommendations for N fertilizer based on spring or fall soil test, may not provide sufficient information for fertilizer recommendations. This may be due to the inability of current soil test methods, based on KCl or NaHCO3 extracts, to measure N from mineralizable forms. I hypothesize that mineralizable N builds up in the soil following rotations with annual applications of N fertilizer, and is available to the crop during the growing season, but is not accounted for in soil test analyses. Phosphorus, potassium and sulphur were judged sufficient for fields in this study. Consequently additional N, available from mineralizable forms during the growing season, decreases yield response due to applied N fertilizer. Detailed analyses and discussion of results will be available in the final report.

2. Project logistics and budgets

    a. Management of precision agriculture trials requires a high level of technical oversight, communication and support for producers and collaborating agencies. Collaborations were most effective where AAFC or MAFRI staff provided immediate on-site support to address technical difficulties. The prescription map for the seeder, should be tested one or two days prior to seeding.

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   b. Several additional fields should be included in precision agriculture studies, to replace those lost due to frost, flooding or hail. Data from reseeded fields are difficult to interpret.

   c. The cost of field scale trials is significantly greater than plot work, a circumstance that producer organizations may not appreciate, if they base their budgets on conventional variety or fertilizer trials. Travel to and within fields takes considerably longer, resulting in higher costs for all field operations including crop and soil sampling.

3. Prescription maps, software, ground based sensors and GPS

   a. Field trials require detailed planning to ensure that there is a sufficient buffer areas surrounding the swathed, or combined area, recorded by the yield monitor within the fertilized strips. This is particularly important when setting the GPS yield monitor baseline (AB line).

   b. Loss of GPS signal may affect application of correct rates, though the loss of treatment related data in 2017 is not attributed to this factor. GPS signal strength was judged adequate for the fields in this study.

   c. RTK level GPS data is critical to field scale trials, particularly for ground based sensors such as the Veris.

   d. Preparation of prescription maps requires significant expertise and experience with the software. Software compatibility for formats is critical and must support the range of seeders on the market such as John Deere and Bourgault, and yield monitors such as John Deere and Loup.

4. Project collaboration

   a. Collaboration with local agronomists and companies who provide precision agriculture services will provide additional synergy and good will. Furthermore this will develop a baseline and support for further research.

   b. Input from Canola Council agronomists was appreciated.

5. Experimental design and UAV data

   a. Control treatments provide important information, and are visual evidence of the importance of fertilizer management. Future studies should include UAV data to document the variability

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of fertilizer response.

6. Field location, growing season and weather related issues

    a. The short growing season in areas of the Parkland, such as Melfort, reduced the time available for post-harvest or pre-seeding soil sampling and analysis. Early snow fall, or extensive fall precipitation precluded soil sampling at Melfort in the fall of 2015.

7. Economic data

    a. Economic data related to agronomic operations such for herbicide control, and operation of equipment, require the assistance and support of a technician to assist the producer and compile the data. In addition the technician should visit the producer as soon as possible after harvest to collect the data.

8. Landform evaluation

    a. Landform evaluation provides additional information for analysis of yield maps. This expertise can be provided by a properly trained agronomist with the appropriate software.

9. Remote sensing data, Landsat and Radarsat

    a. Landsat and Radarsat 2 ultrafine mode are related to some variability in yield, but a detailed analysis of the data is required.

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