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Results of a multi-year field scale study of canola yield, management zones and variable rate N fertilizer response, in Alberta, Saskatchewan and Manitoba

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Brandon Research and Development Centre

Agriculture and Agri-Food Canada

Canada

Questions

- Does precision agriculture work?
- What are options to improve N prescriptions for precision agriculture.
- How does precision agriculture address year to year variability of yield?
- Does precision agriculture provide an economic return to the producer?
- What are the environmental advantages to precision agriculture?

Objectives

- Determine the influence of variable fertilizer management on canola yield based on yield zones.
- Determine which variables are best correlated with canola yield and response.
- Determine the potential of variables of interest such as terrain attributes as a covariate to account for variability in yield response to fertilizer treatments.

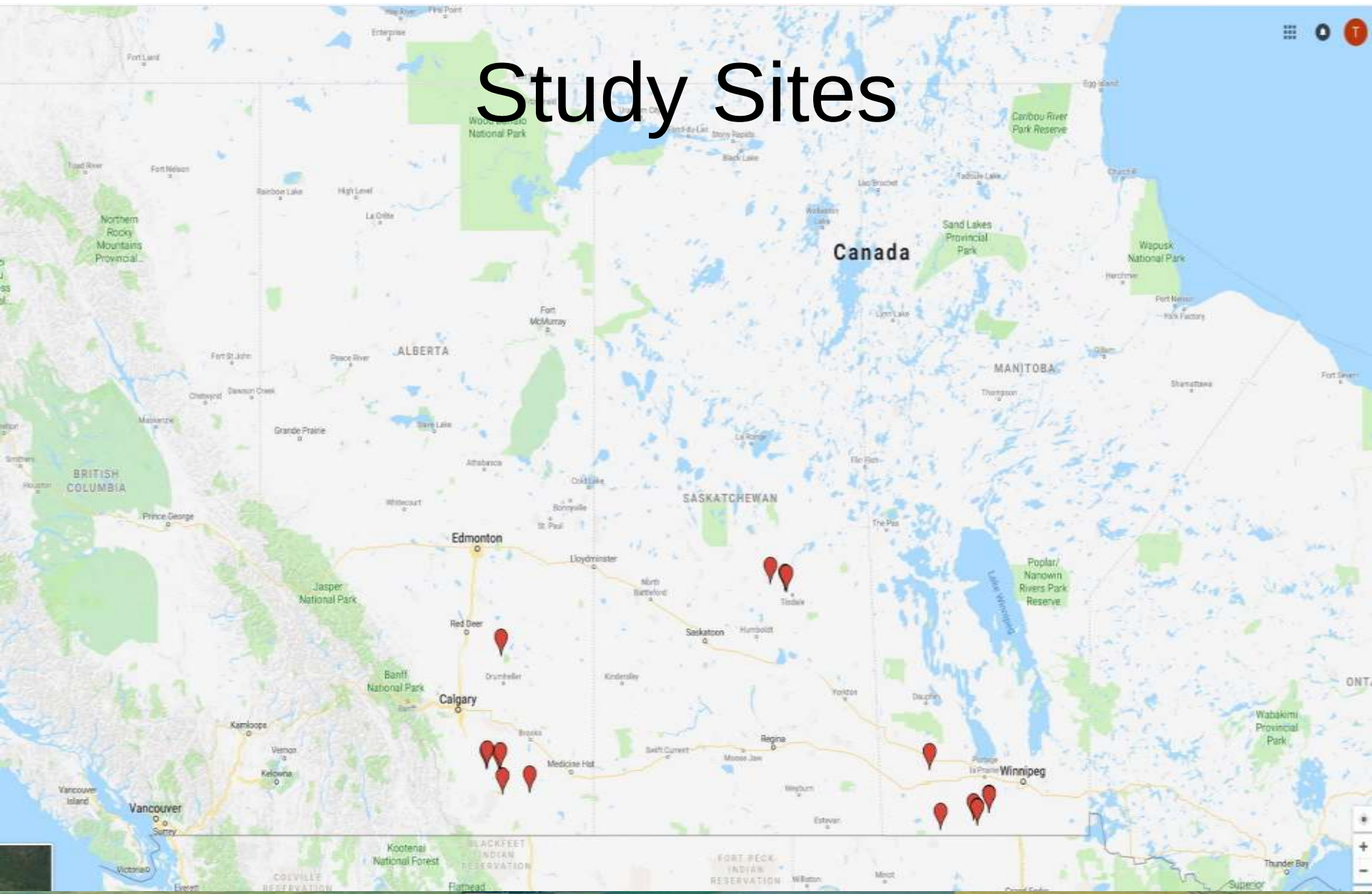
Variables of Interest

- Canola Yield
- Management zone, N fertilizer rates
- Landform and terrain attributes
- Other plant nutrients, P, K and S
- Soil properties, pH, EC,
- Remote sensing data, Radarsat 2 and Landsat
- Growing season temperature and precipitation

Study Design

- Producers (Alberta, Saskatchewan, and Manitoba) with variable rate equipment and yield maps for 3 to 5 years were asked to collaborate.
- Yield maps for 3 to 5 years prior to the study were used to define yield zones.
- Field areas with high, average and low normalized yields were delineated with AgLeader SMS software.

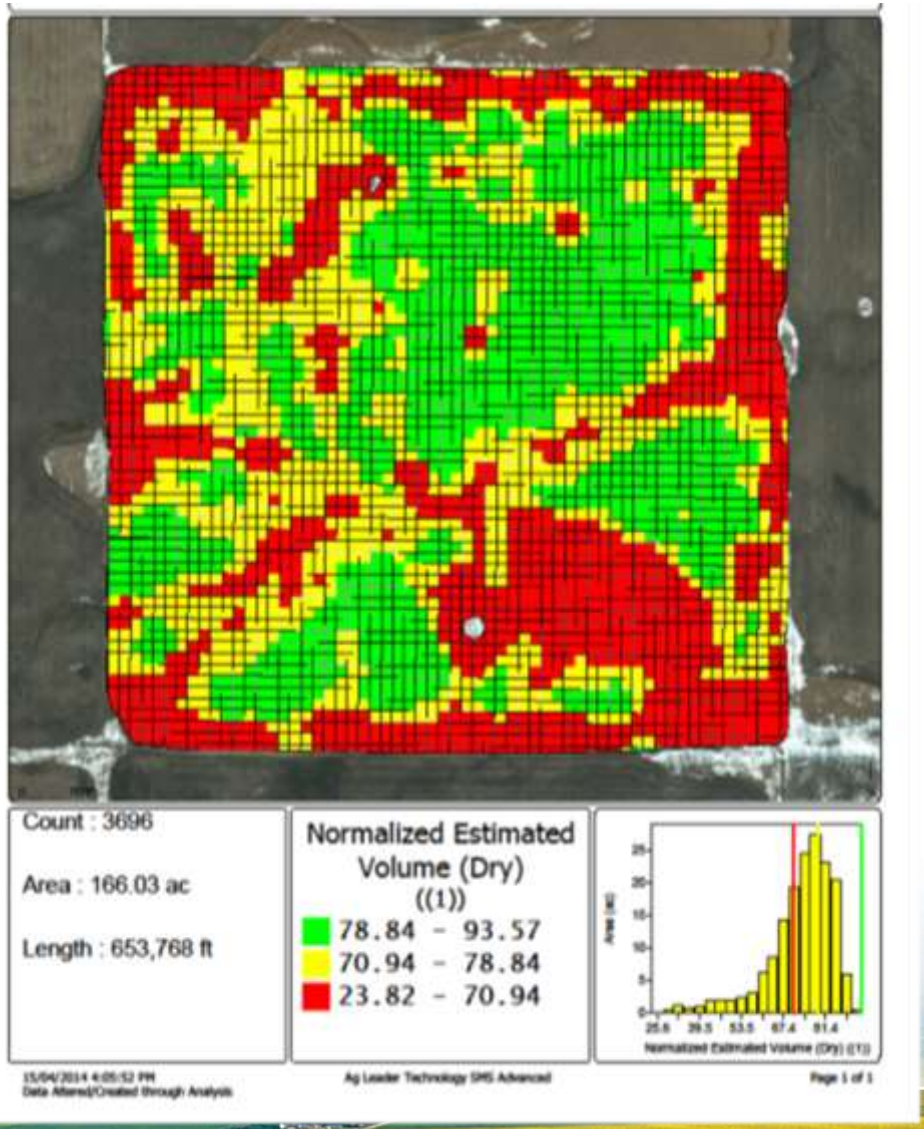
Study Sites


Canada
ALBERTA
SASKATCHEWAN
MANITOBA
BRITISH COLUMBIA
Edmonton
Calgary
Saskatoon
Regina
Winnipeg
Vancouver
Red Deer
Medicine Hat
Lloydminster
Fort McMurray
Grande Prairie
Prince George
Jasper National Park
Banff National Park
Kootenai National Forest
Wapusk National Park
Sand Lakes Provincial Park
Poplar/ Nanown Rivers Park Reserve
Wabakimi Provincial Park
Caribou River Park Reserve
Northern Rocky Mountains Provincial...
Lake Winnipeg

Sources of Variability: Data Collection

- Variability of yield averages in zones
- Yield map and elevation accuracy
- Yield and position outliers
- Alignment of GPS points along harvest paths
- Recalculation of yield position to minimize effects of grain residence time
- Normalize crop for analysis of multiple years
- Multiple combines and calibration

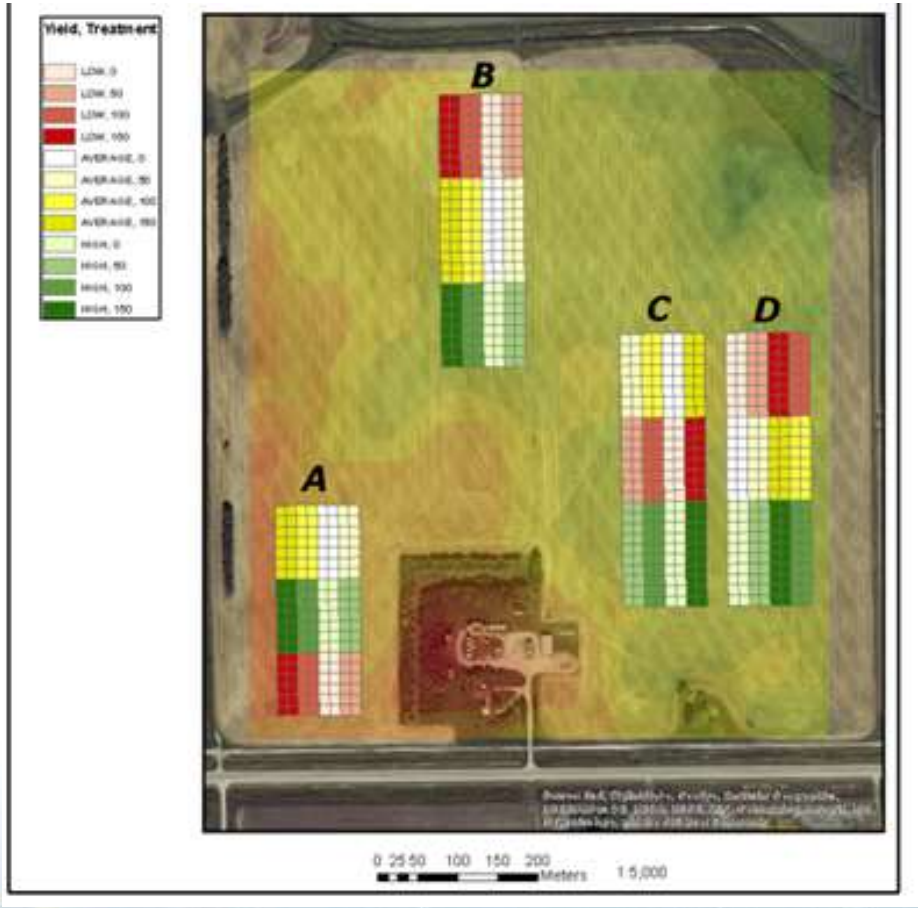
Yield Zones


Count : 3696
Area : 166.03 ac
Length : 653,768 ft
Normalized Estimated Volume (Dry) ((1))
78.84 - 93.57
70.94 - 78.84
23.82 - 70.94
Area (ac)
25.6
39.5
53.5
67.4
81.4
Normalized Estimated Volume (Dry) ((1))
15/04/2014 4:05:52 PM
Data Altered/Created through Analysis
Ag Leader Technology SMS Advanced
Page 1 of 1

Experimental Design

- Treatments included three yield zones and four N fertilizer rates (0, 50%, 100% and 150% N based on soil test).
- Fertilizer treatments were nested within yield zones
- Four replicates located in each field to include low, average and high yield zones.
- Total of 48 plots per field.

Experimental Design



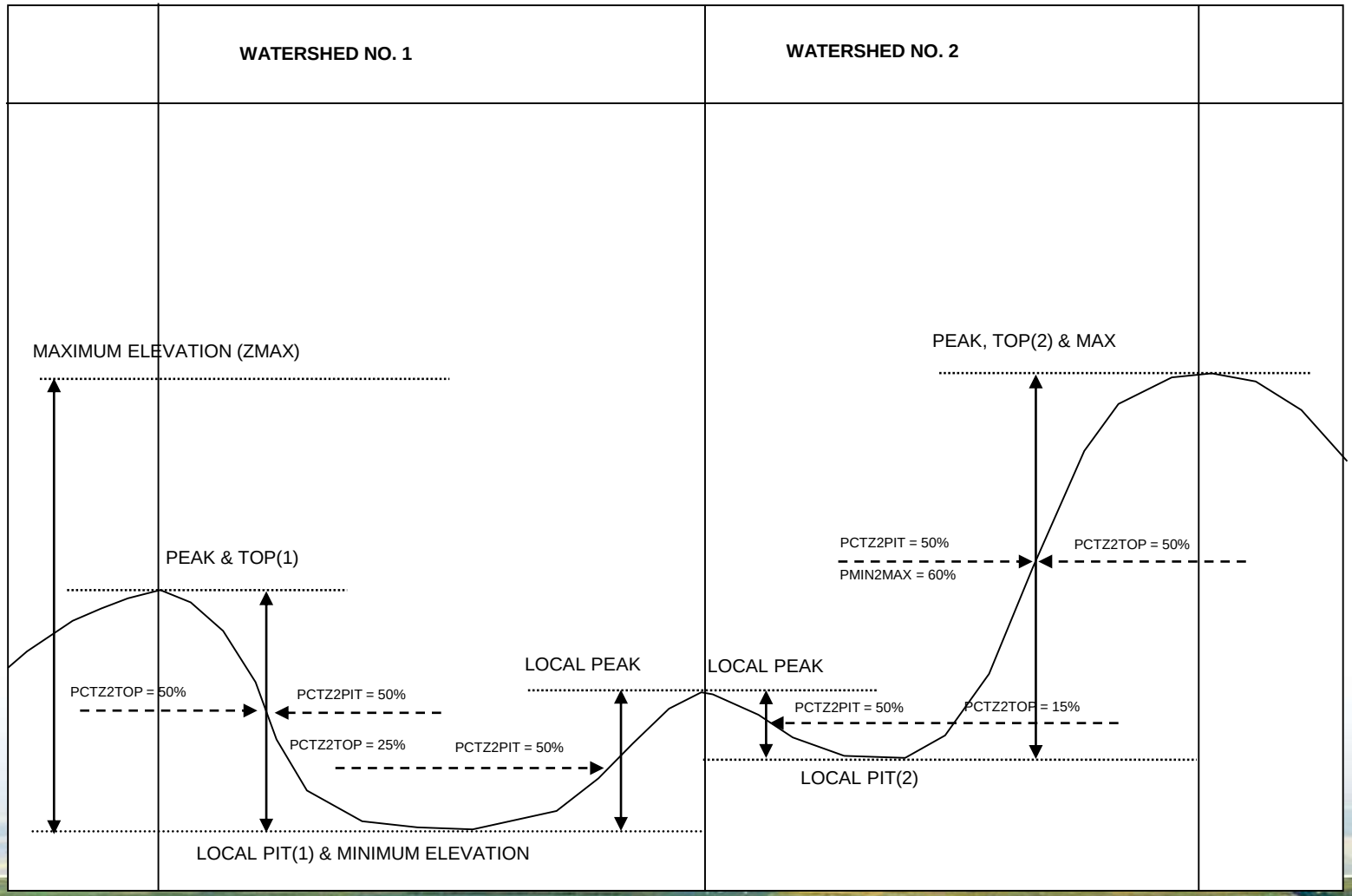
Experimental Design

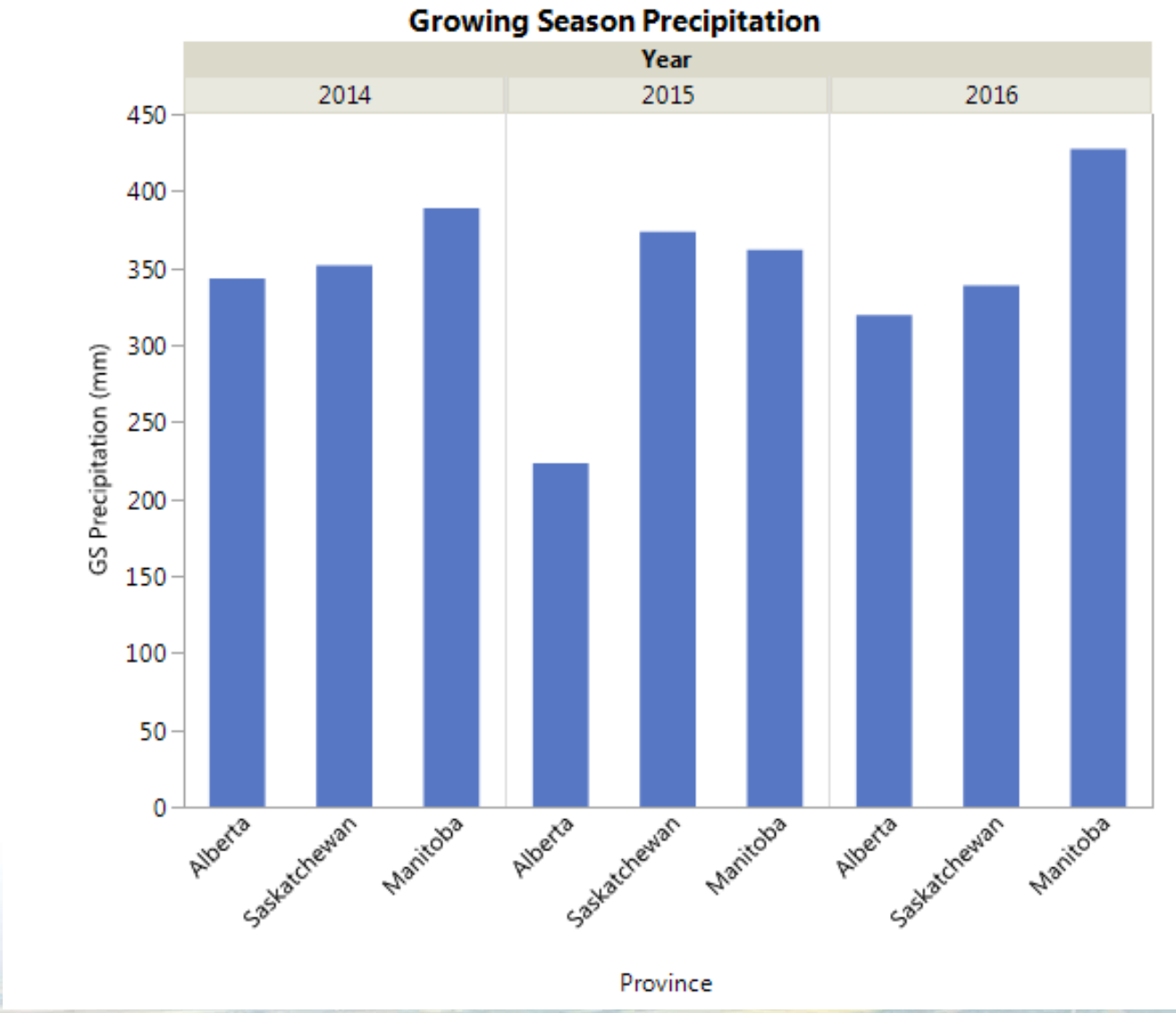
- N fertilizer was applied for each field based on soil test recommendations from Manitoba Agriculture
- Soil samples were collected in each plot during the crop year, in the spring and fall.
- Yield goals were set by the producer for each field and adjusted for each zone based on historical data.
- P, K and S fertilizer rates were based on soil test P, K and S, were uniformly applied in all treatments, and judged sufficient for the study.

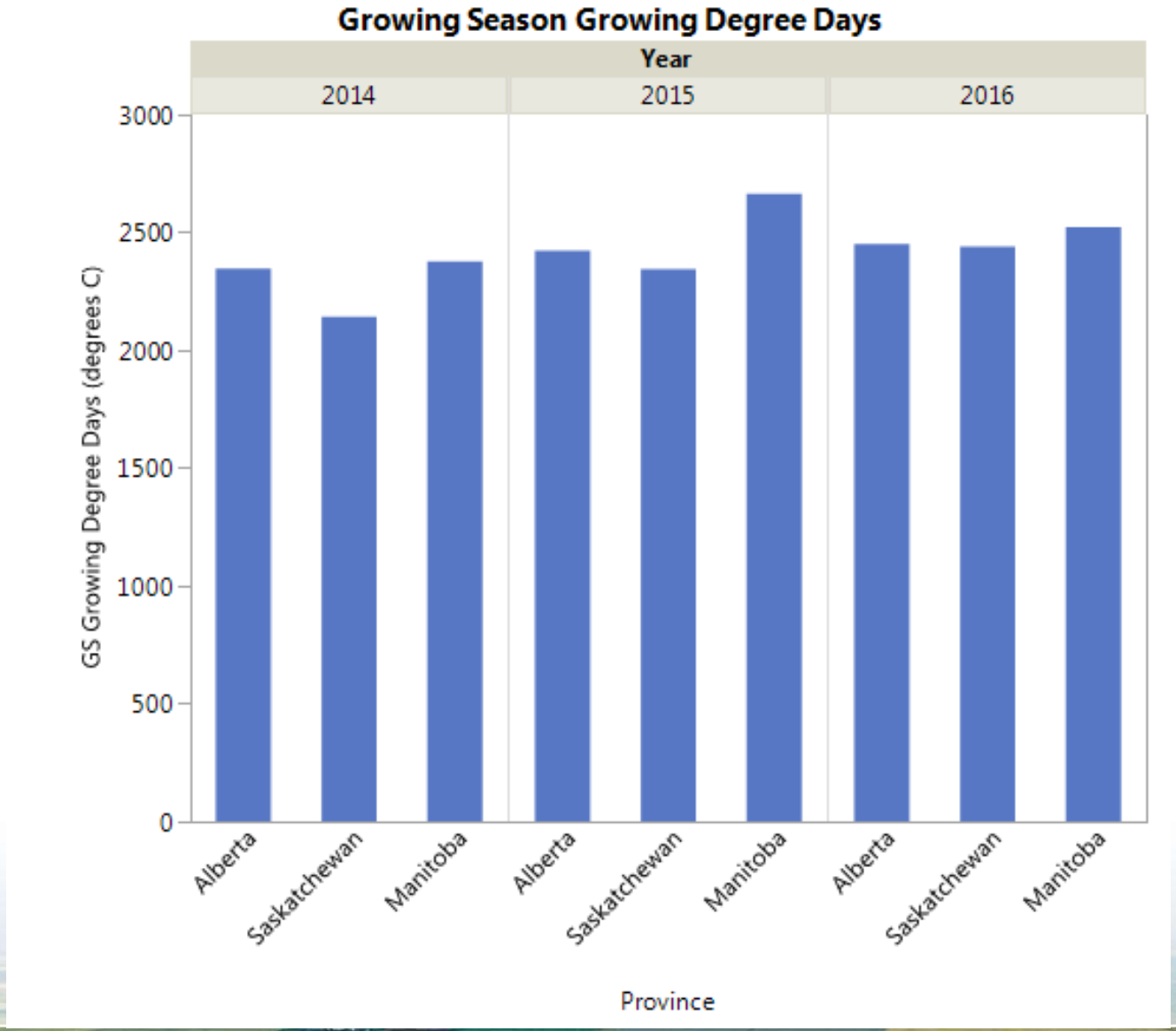
Terrain Attributes

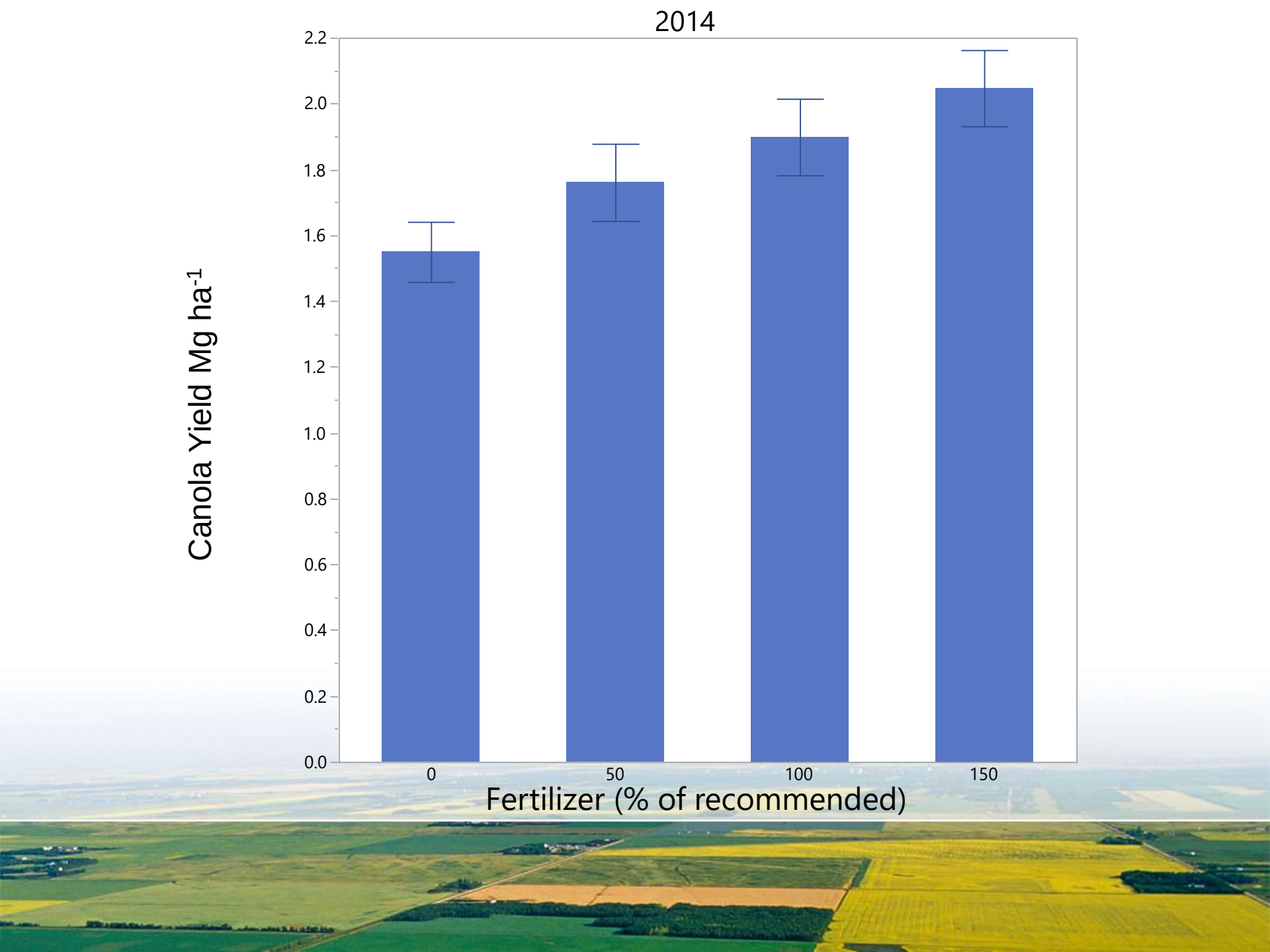
- Terrain attributes were calculated for each field from elevation data collected by the yield monitor GPS
- Attributes were determined with LandMapR and SAGA
- 49 attributes were calculated including elevation, channel network base, slope, distance to pits, wetness indices, and catchment areas.

Terrain Attributes

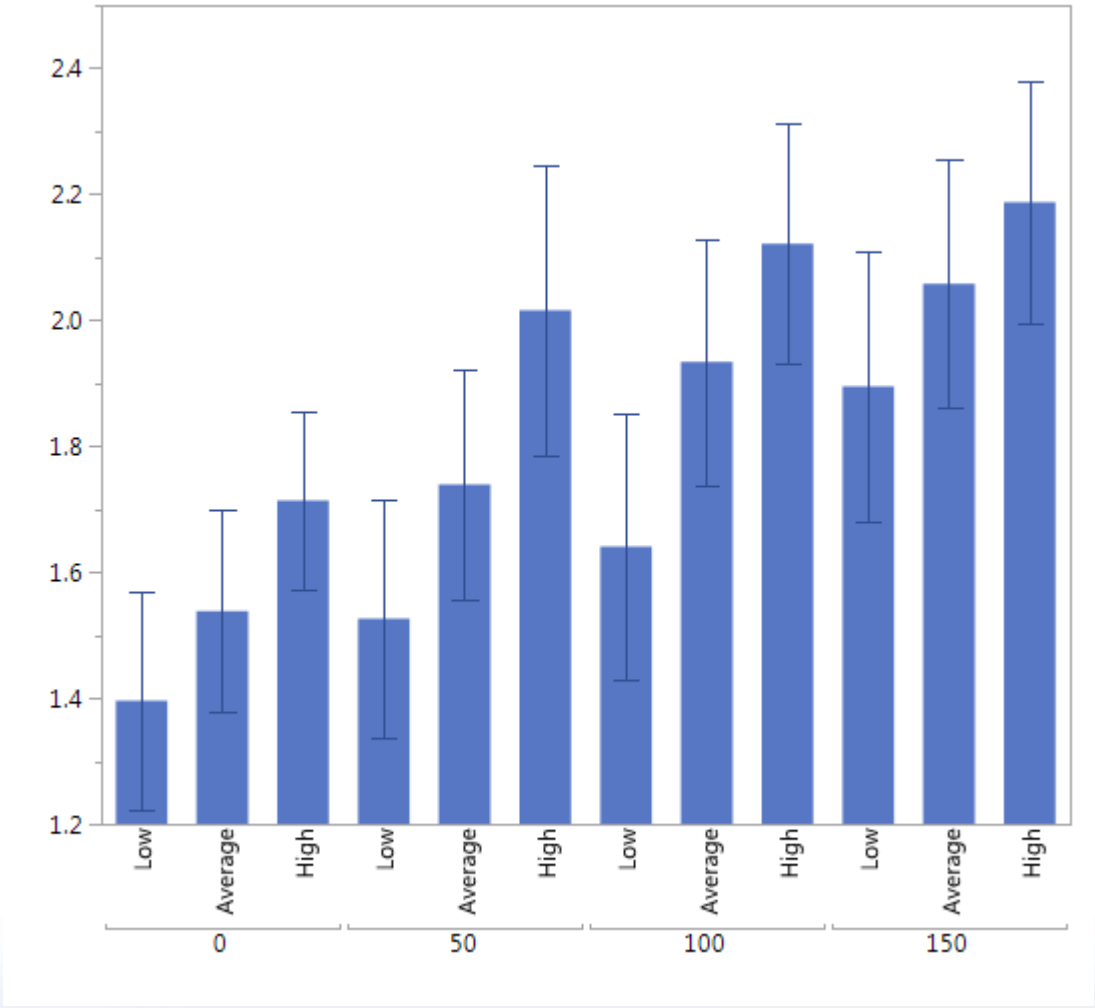



Growing Season Precipitation
Year
2014
2015
2016
GS Precipitation (mm)
450
400
350
300
250
200
150
100
50
0
Alberta
Saskatchewan
Manitoba
Alberta
Saskatchewan
Manitoba
Alberta
Saskatchewan
Manitoba
Province

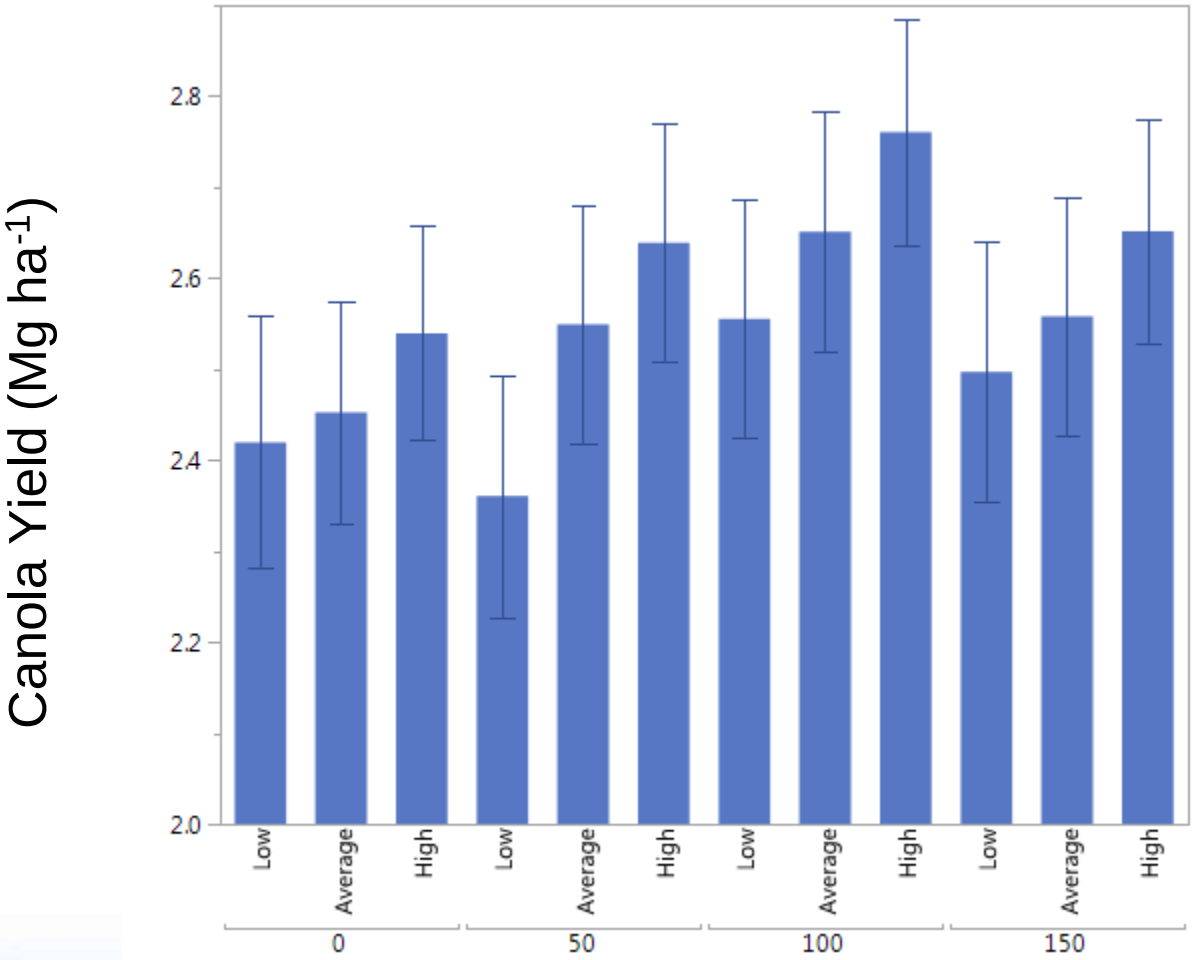

Growing Season Growing Degree Days
Year
2014
2015
2016
GS Growing Degree Days (degrees C)
3000
2500
2000
1500
1000
500
0
Alberta
Saskatchewan
Manitoba
Alberta
Saskatchewan
Manitoba
Alberta
Saskatchewan
Manitoba
Province


2014
Canola Yield Mg ha-1
2.2
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
50
100
150
Fertilizer (% of recommended)

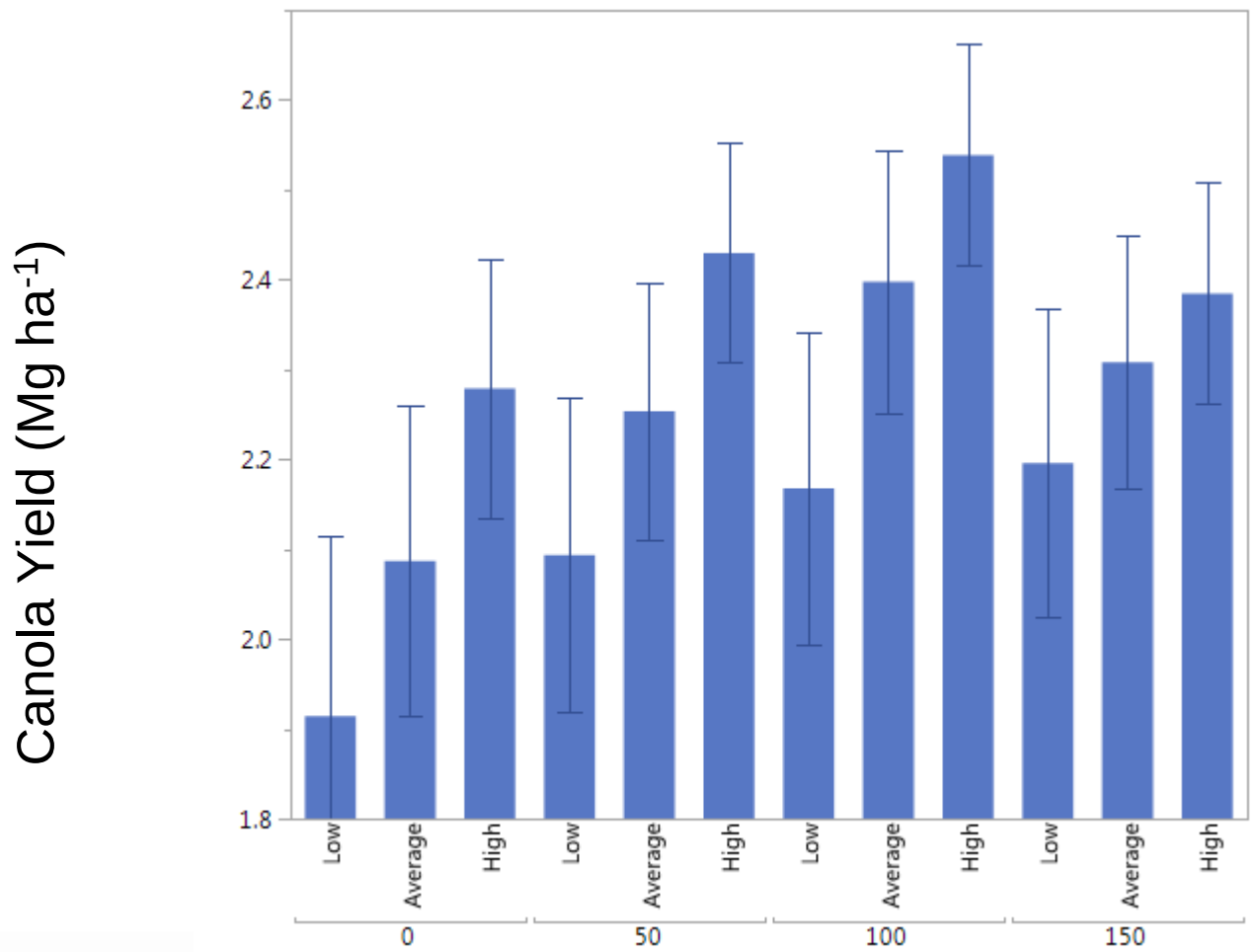
2014


Canola Yield (Mg ha-1)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
Low
Average
High
0
50
100
150
Fertilizer (% of recommended)

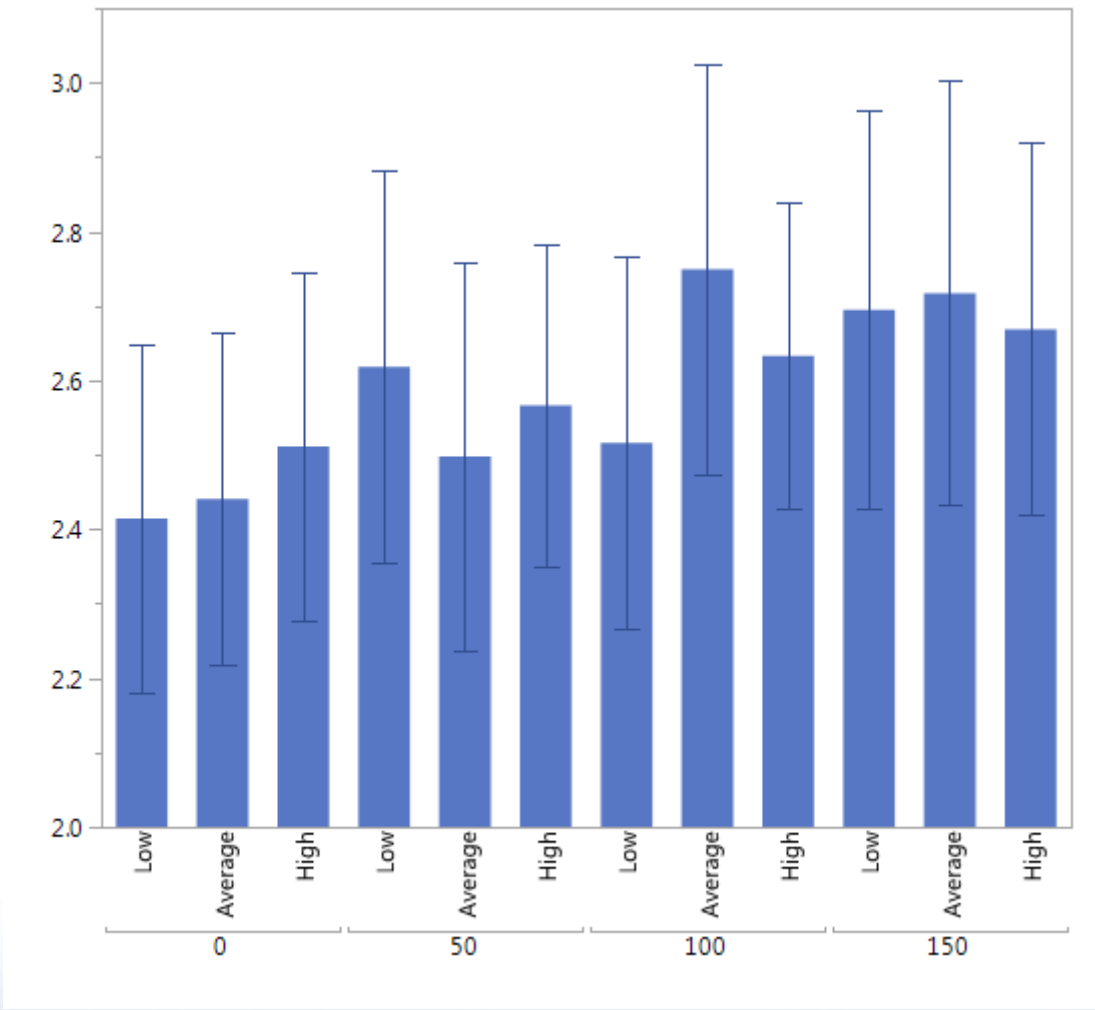
2015

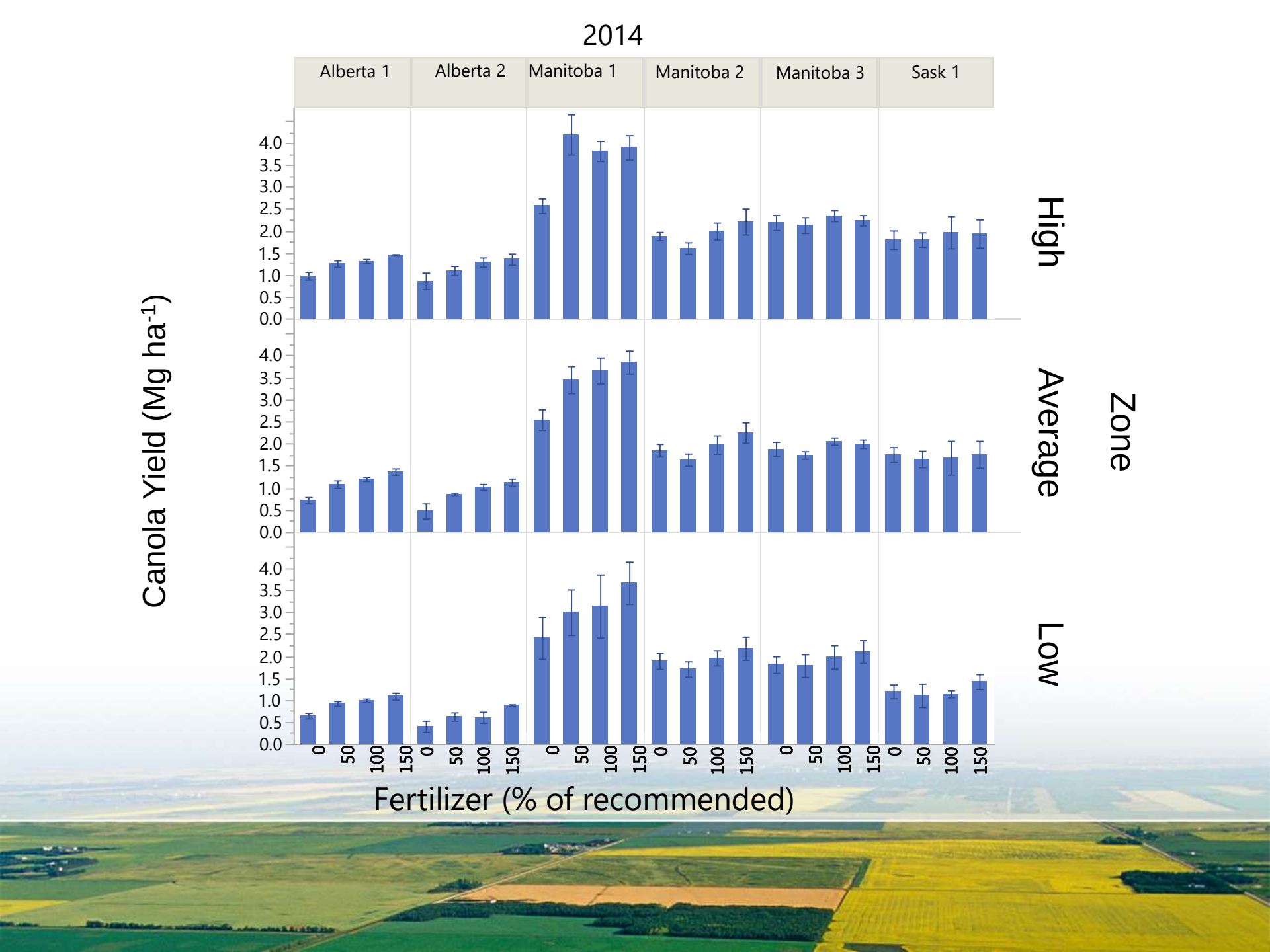

Canola Yield (Mg ha-1)
2.8
2.6
2.4
2.2
2.0
Low
Average
High
0
50
100
150
Fertilizer (% of recommended)

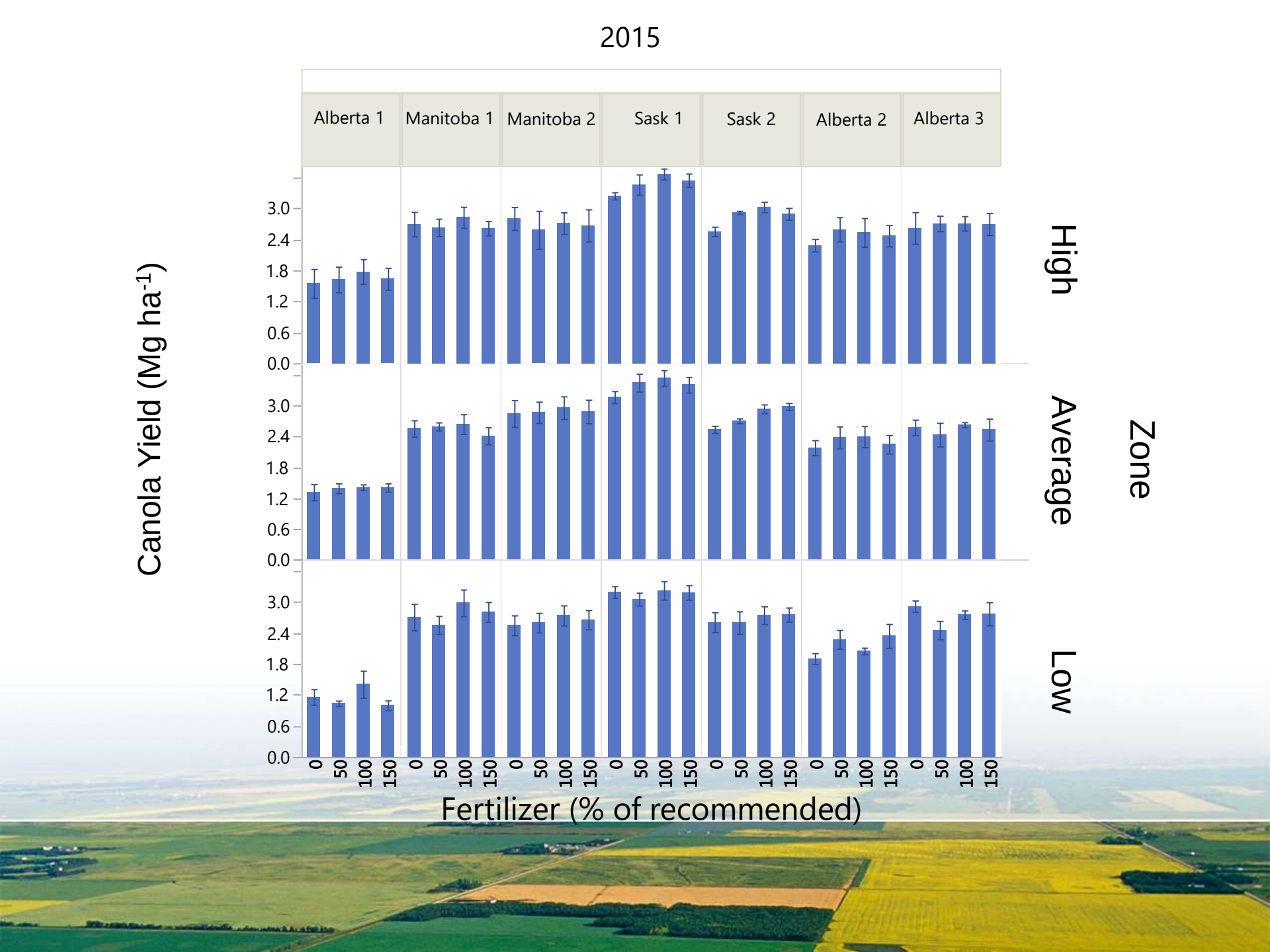
2016

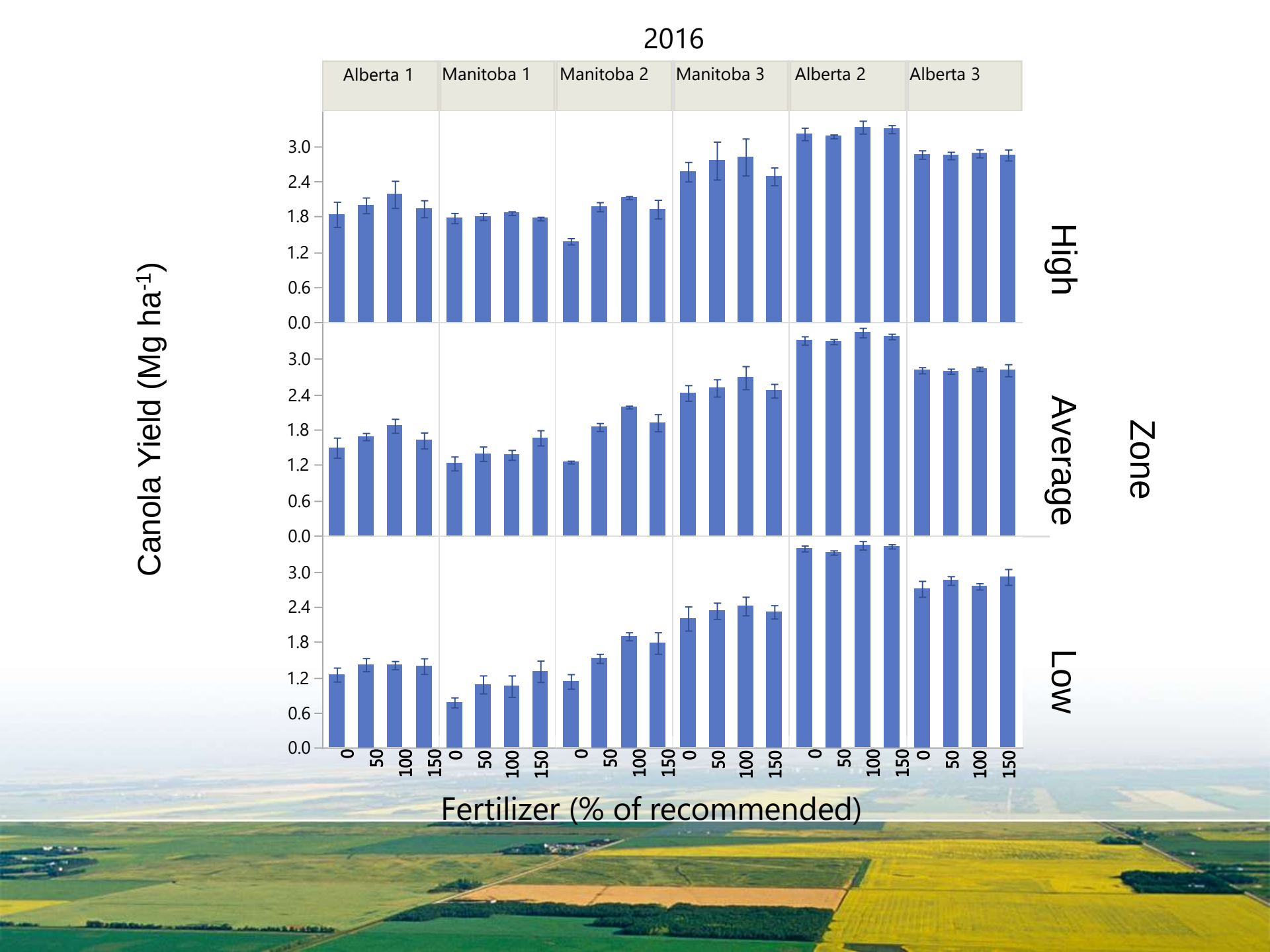

Canola Yield (Mg ha-1)
2.6
2.4
2.2
2.0
1.8
Low
Average
High
0
50
100
150
Fertilizer (% of recommended)

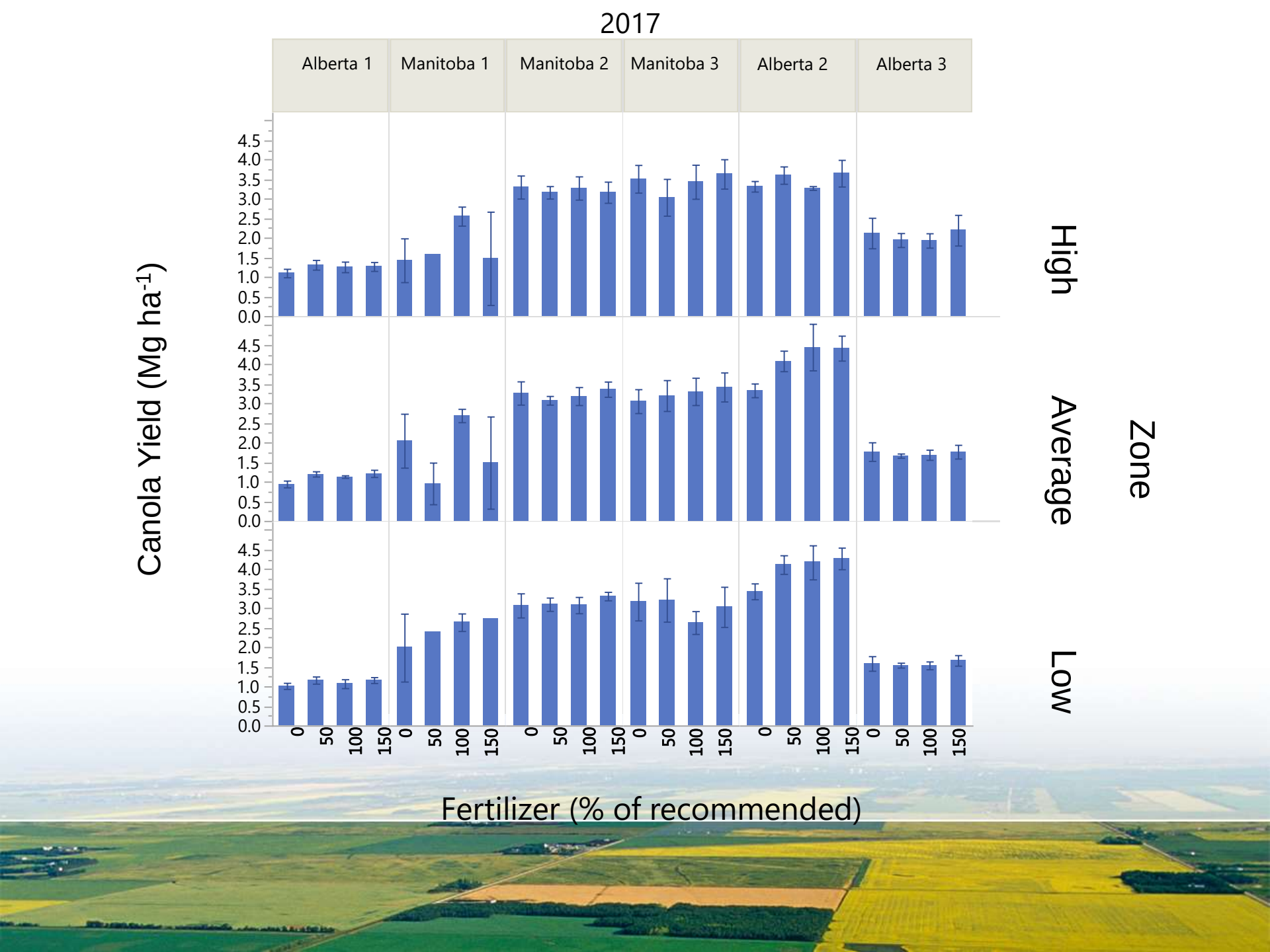
2017


Canola Yield (Mg ha-1)
3.0
2.8
2.6
2.4
2.2
2.0
Low
Average
High
0
50
100
150
Fertilizer (% of recommended)


2014
Alberta 1
Alberta 2
Manitoba 1
Manitoba 2
Manitoba 3
Sask 1
High
Average
Low
Zone
Canola Yield (Mg ha-1)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
0
50
100
150
Fertilizer (% of recommended)


2015
Alberta 1
Manitoba 1
Manitoba 2
Sask 1
Sask 2
Alberta 2
Alberta 3
High
Average
Low
Zone
Canola Yield (Mg ha-1)
0.0
0.6
1.2
1.8
2.4
3.0
0
50
100
150
Fertilizer (% of recommended)


2016
Alberta 1
Manitoba 1
Manitoba 2
Manitoba 3
Alberta 2
Alberta 3
High
Average
Low
Zone
Canola Yield (Mg ha-1)
0.0
0.6
1.2
1.8
2.4
3.0
0
50
100
150
Fertilizer (% of recommended)


2017
Alberta 1
Manitoba 1
Manitoba 2
Manitoba 3
Alberta 2
Alberta 3
Canola Yield (Mg ha-1)
Zone
High
Average
Low
Fertilizer (% of recommended)
0
50
100
150
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5

Crop Yield and Treatments

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

Canola Yield, Treatments and Farm

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

Canola Yield, Treatments, Elevation

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

Canola Yield, Treatments

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

Yield Zone Manitoba 2 2015

Count : 4419

Area : 179.75 ac

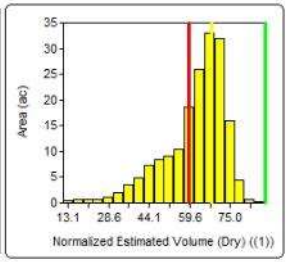
Length : 742,746 ft

Normalized Estimated Volume (Dry) ((1))

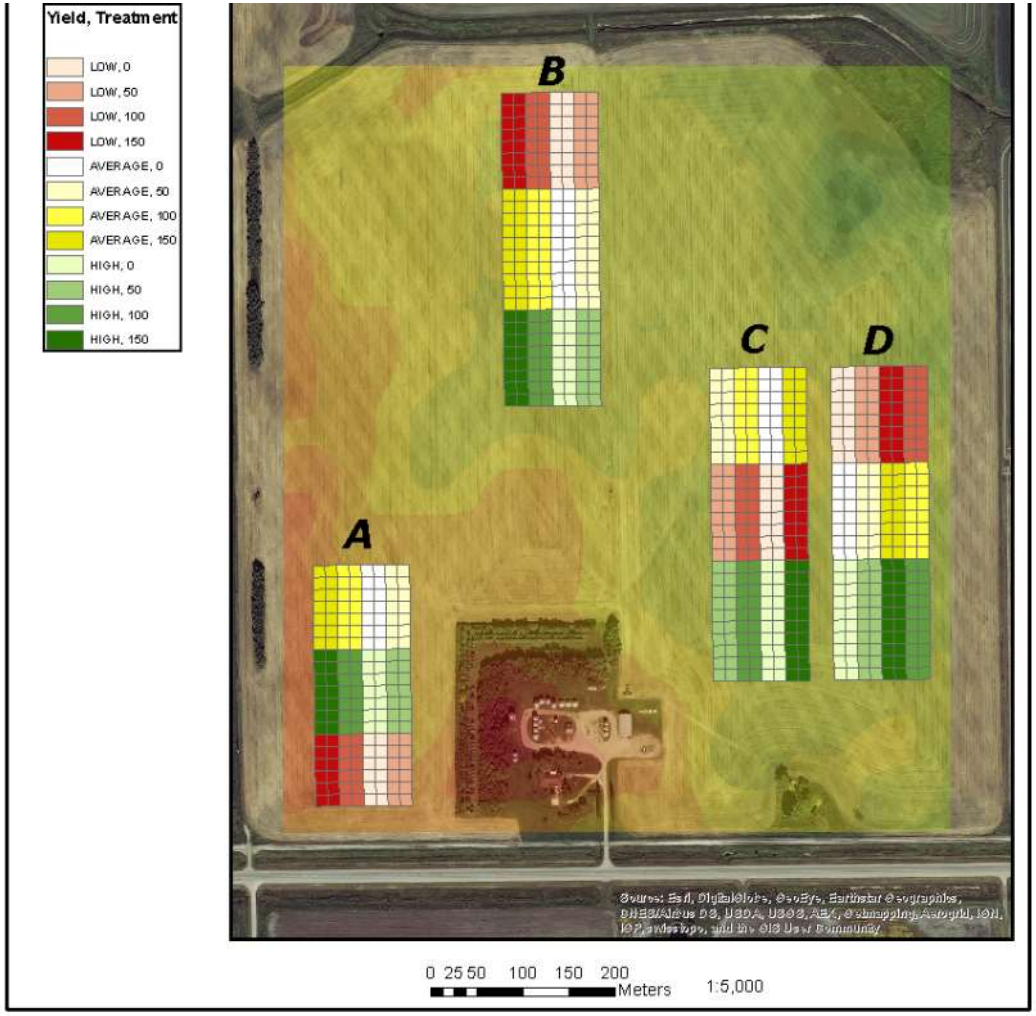
68.41 - 88.58

59.55 - 68.41

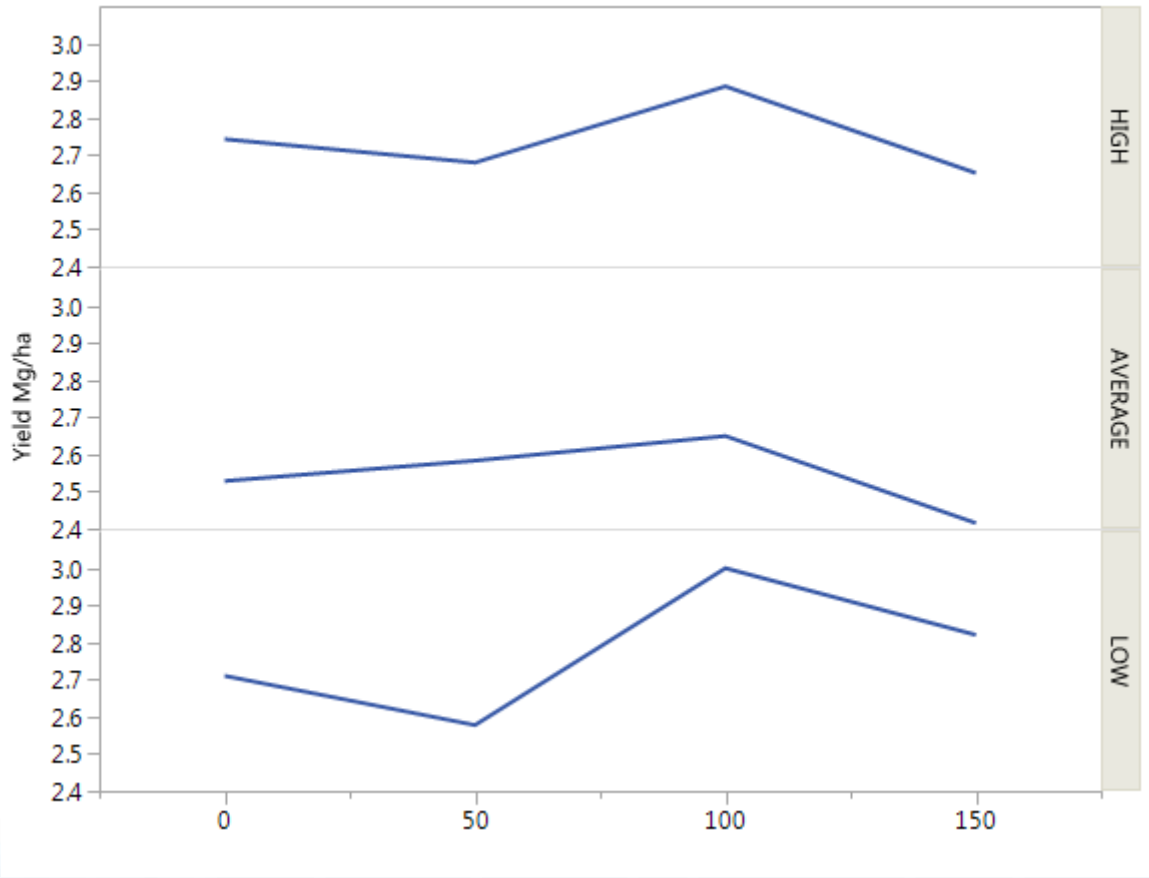
11.21 - 59.55



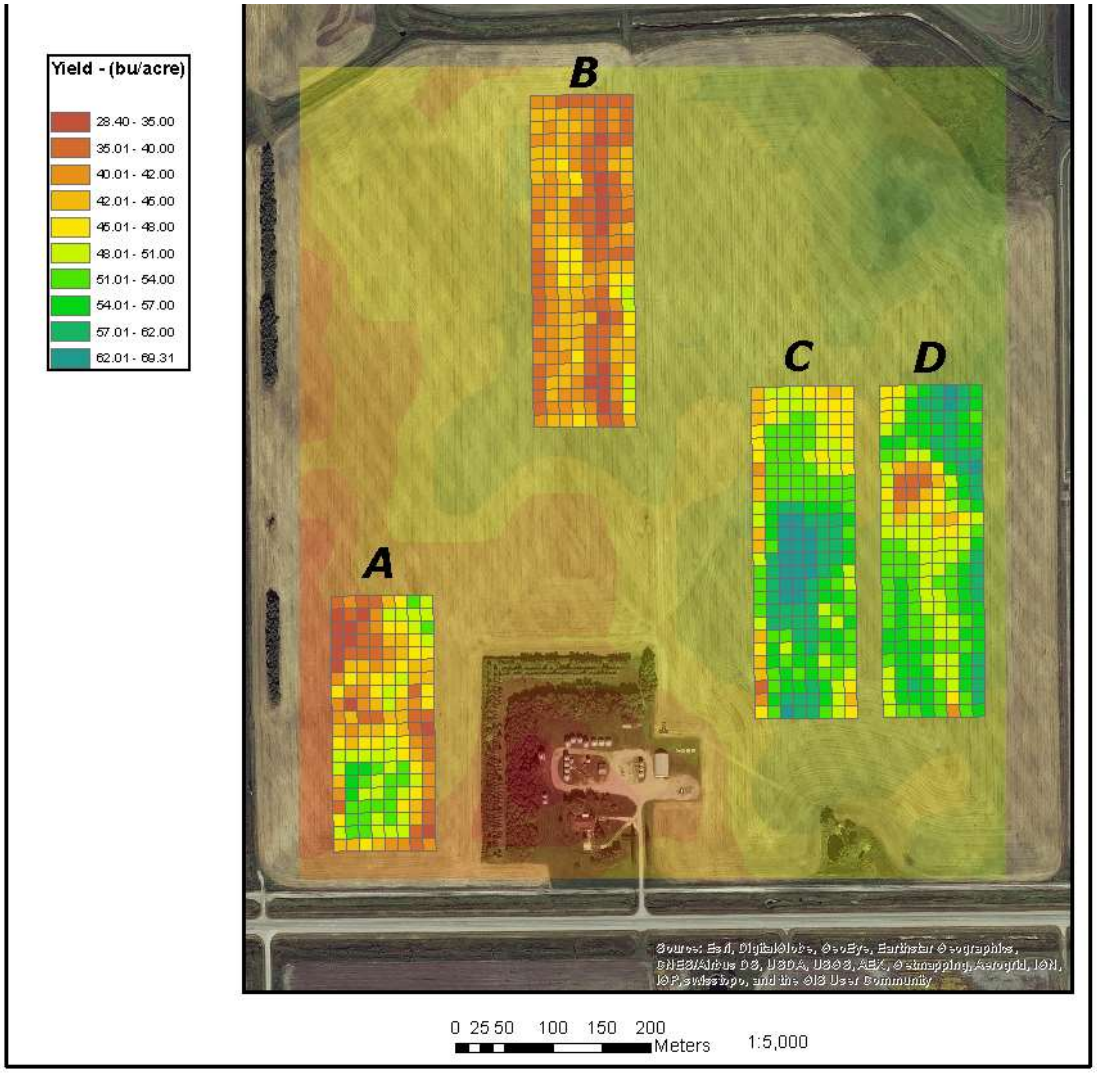
Treatments 2015



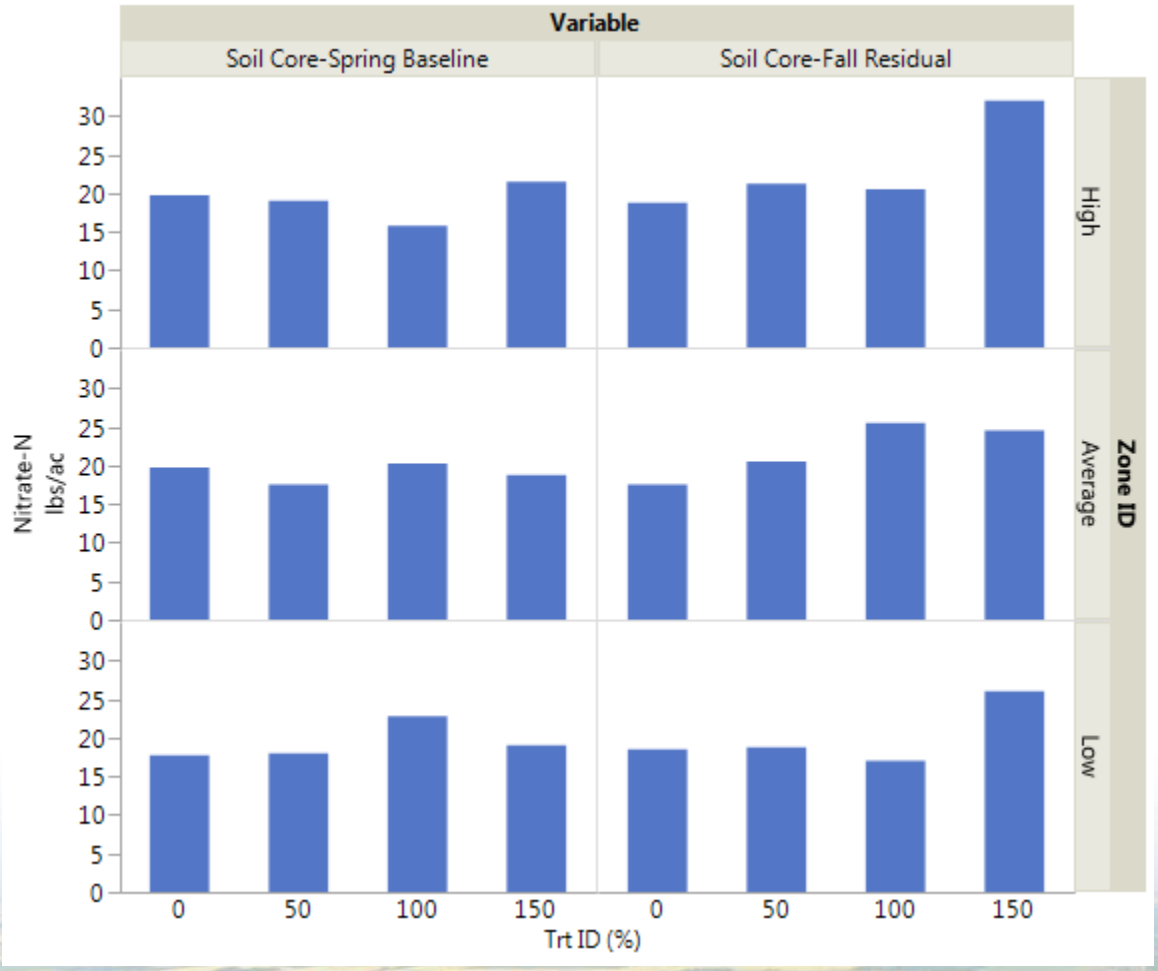
Yield Manitoba 2 2015



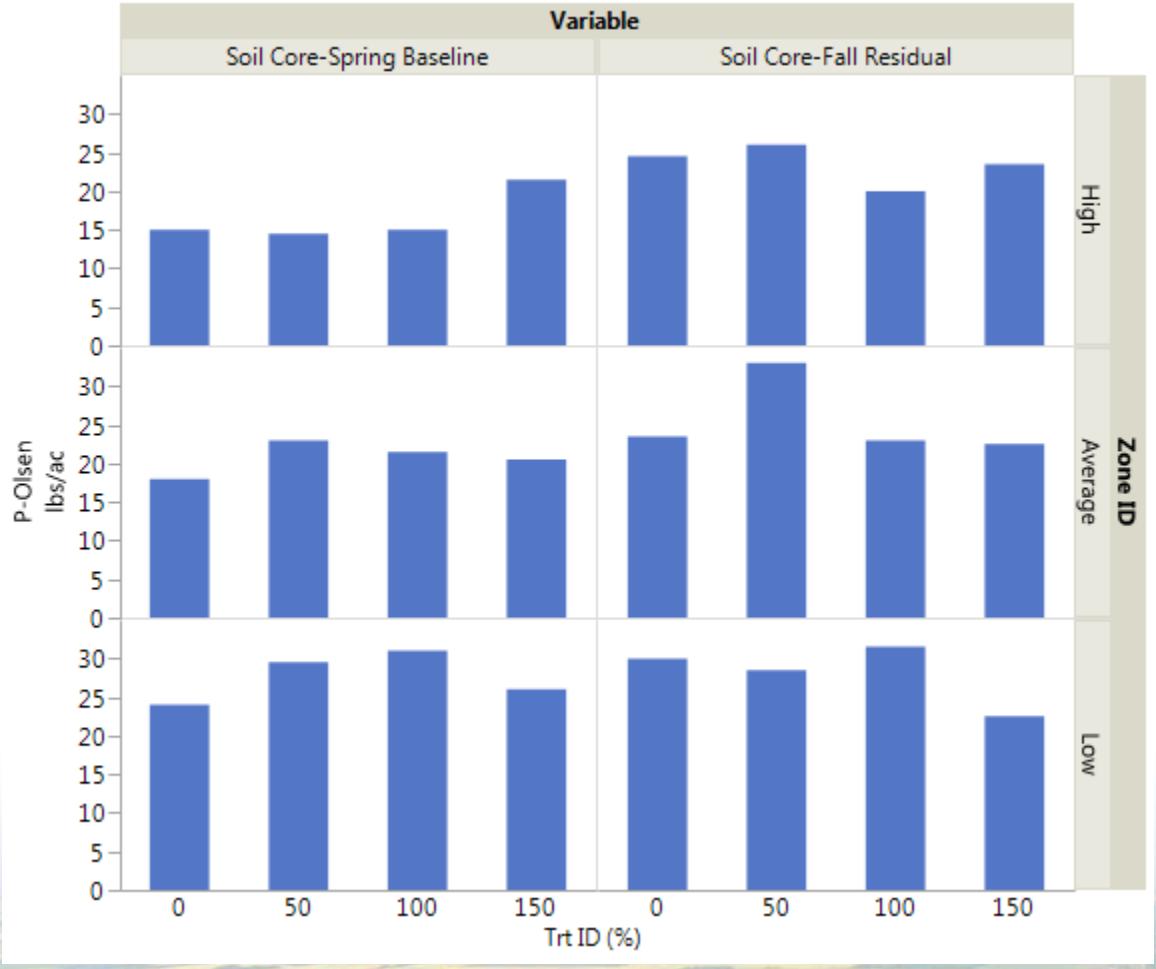
Yield Map 2015



Soil test N 0-15 cm
2015



Soil test P 0-15 cm
2015

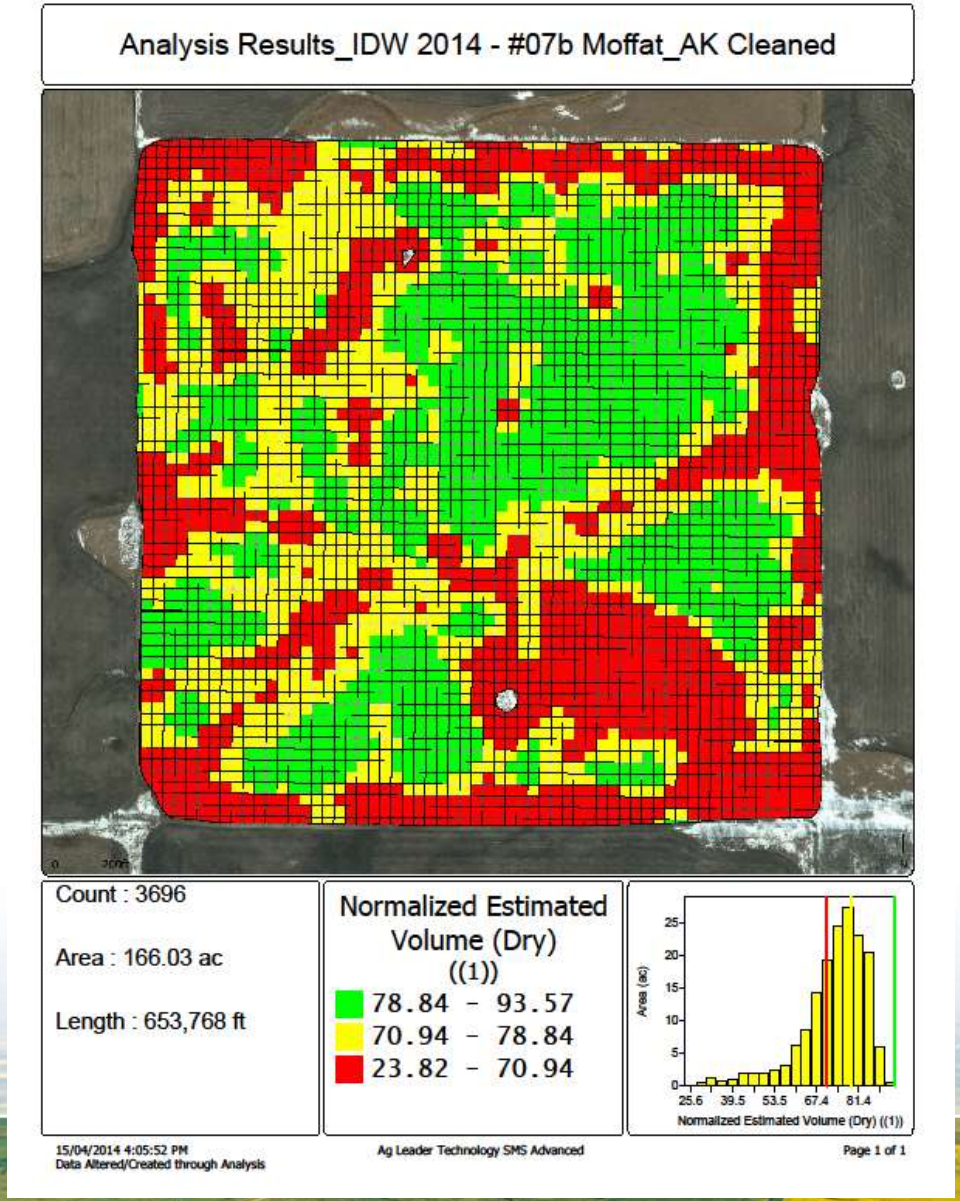


Multi-variate 2015

Variable	Number of Splits	Portion
Channel Network Base LevelMEAN	77	0.1564
Sum(PHCA_WA)	31	0.0899
Sum(Sand_WA)	29	0.0781
Sum(BD_WA)	13	0.0563
Sum(Silt_WA)	16	0.0499
LS FactorMEAN	69	0.0495
ElevationMEAN	67	0.0379
z2pitMEAN	80	0.033
MEAN-NDVI-2015/05/20	85	0.0296
MEAN-NDVI-2015/06/14	118	0.027
MEAN-NDVI-2016/06/23	87	0.0223
MEAN-NDVI-2016/04/29	74	0.021
Sum(Clay_WA)	13	0.0209
Nitrate kg ha-1	88	0.0197
MEAN-NDVI-2016/04/04	80	0.0195
pH 1:2	27	0.019
MEAN-NDVI-2015/04/11	67	0.0164
Modified Catchment AreaMEAN	76	0.0154
Trt	84	0.015

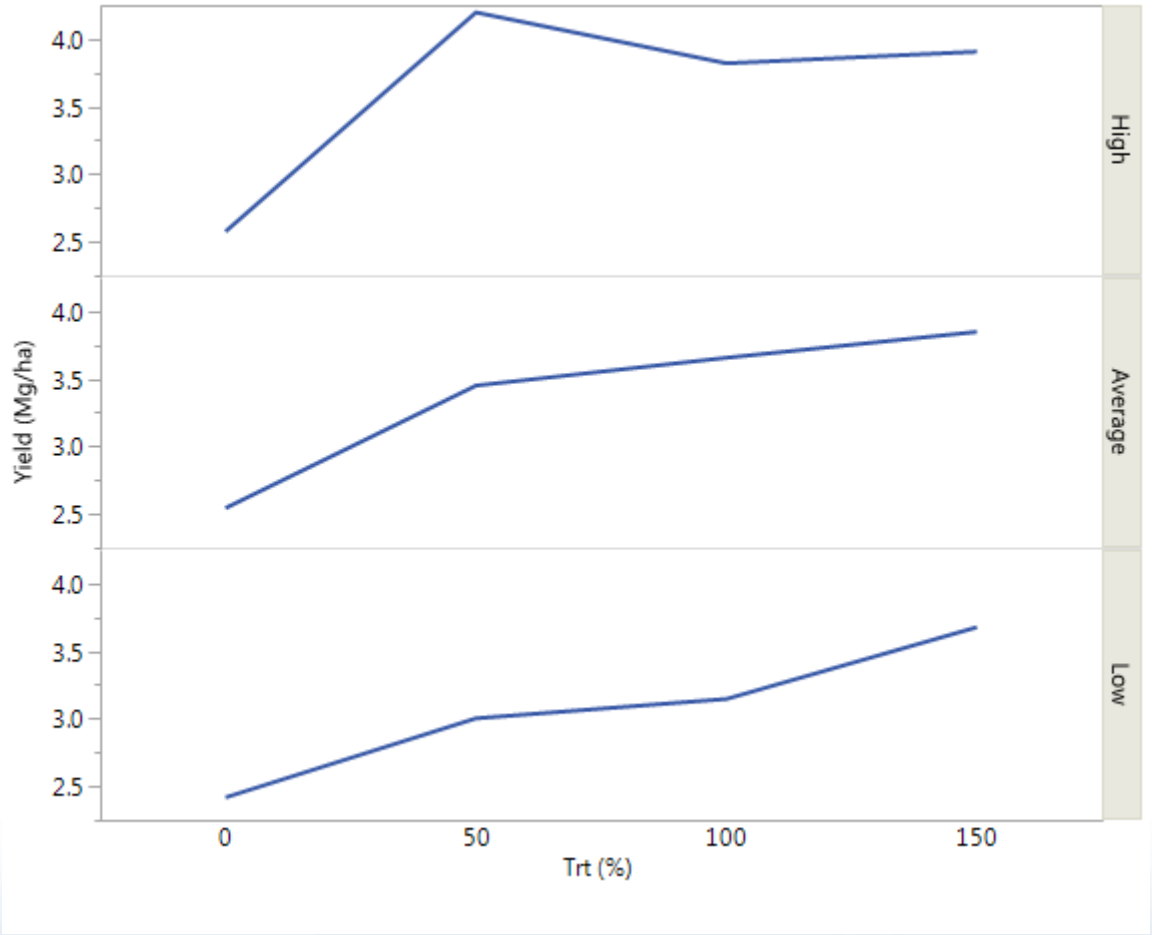
Terrain Attribute 2015

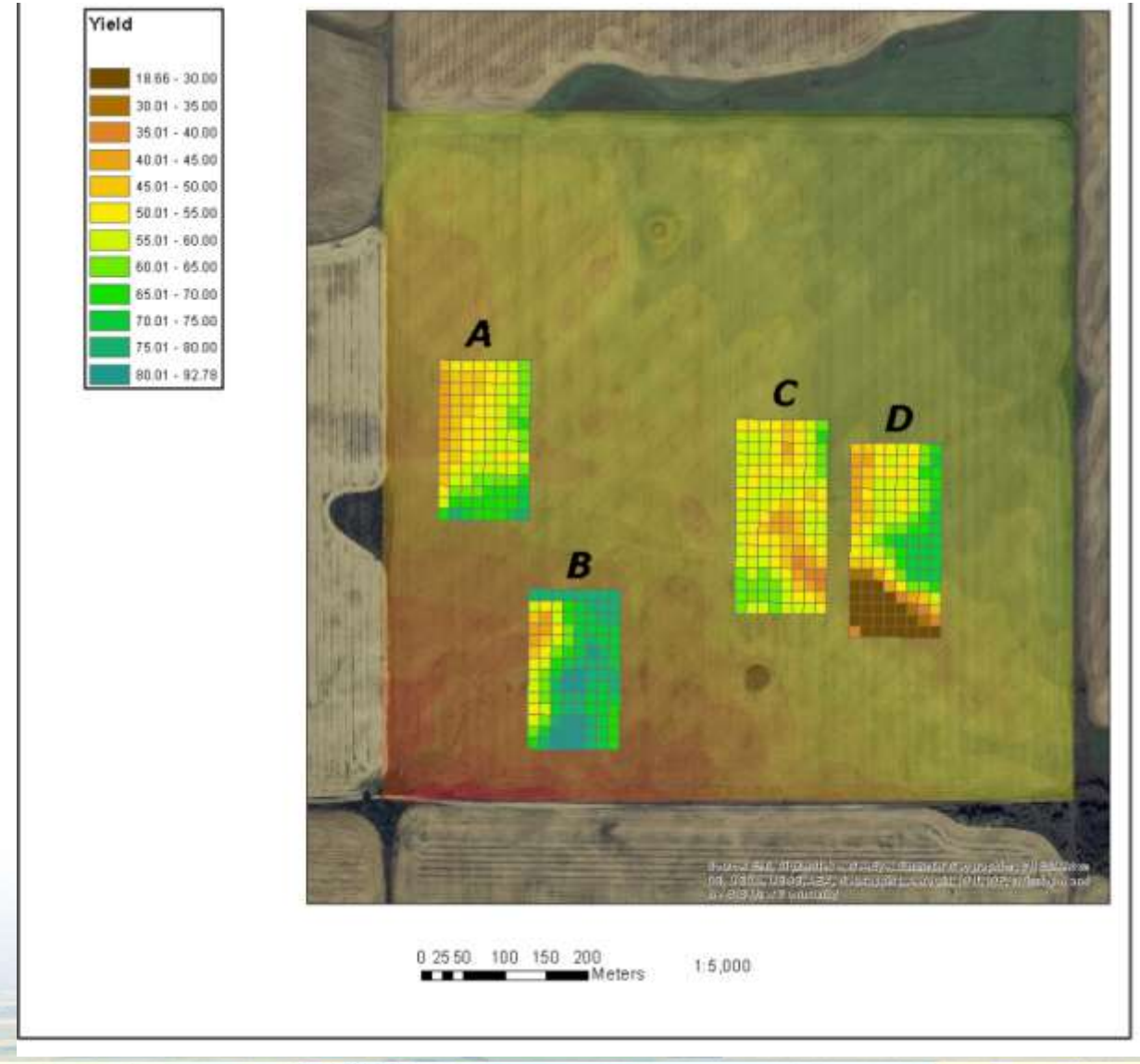
Yield Zone Manitoba 1



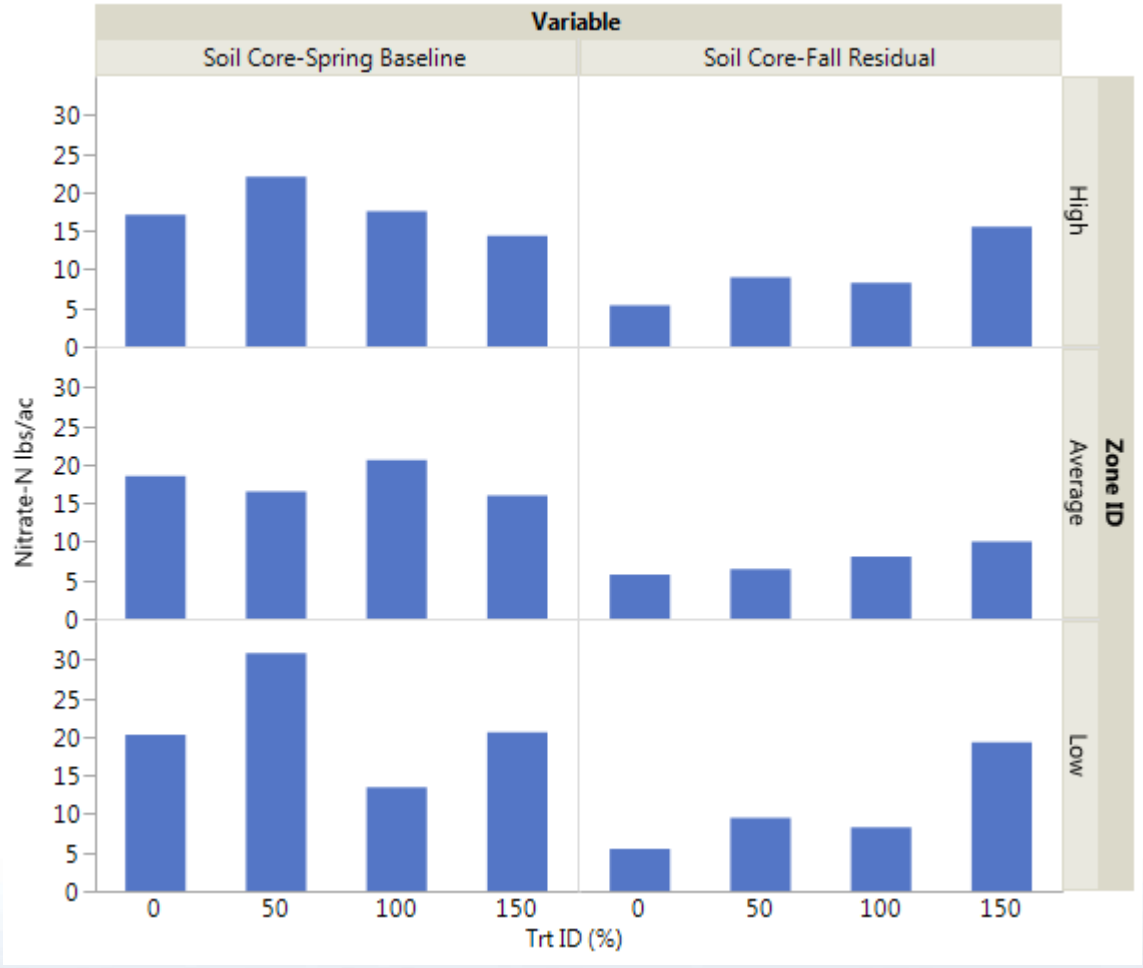

Yield, Trt
LOW, 0
LOW, 50
LOW, 100
LOW, 150
AVERAGE, 0
AVERAGE, 50
AVERAGE, 100
AVERAGE, 150
HIGH, 0
HIGH, 50
HIGH, 100
HIGH, 150
A
B
C
D
0 25 50 100 150 200
Meters
1:5,000

Yield Manitoba 2 2014

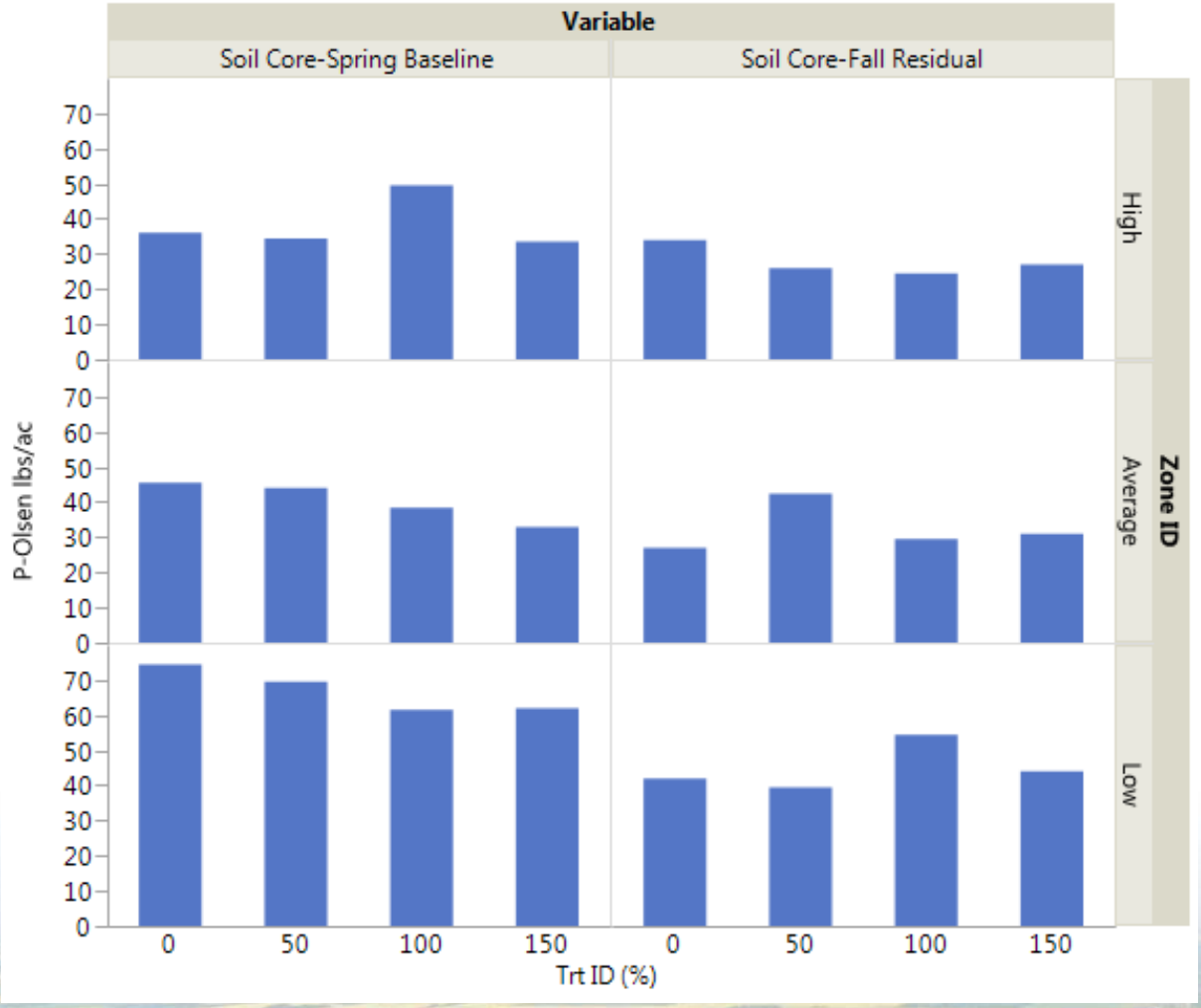



Yield
18.66 - 30.00
30.01 - 35.00
35.01 - 40.00
40.01 - 45.00
45.01 - 50.00
50.01 - 55.00
55.01 - 60.00
60.01 - 65.00
65.01 - 70.00
70.01 - 75.00
75.01 - 80.00
80.01 - 92.78
A
B
C
D
0 25 50 100 150 200
Meters
1:5,000

Soil test N 0-15 cm
Manitoba 2 2014

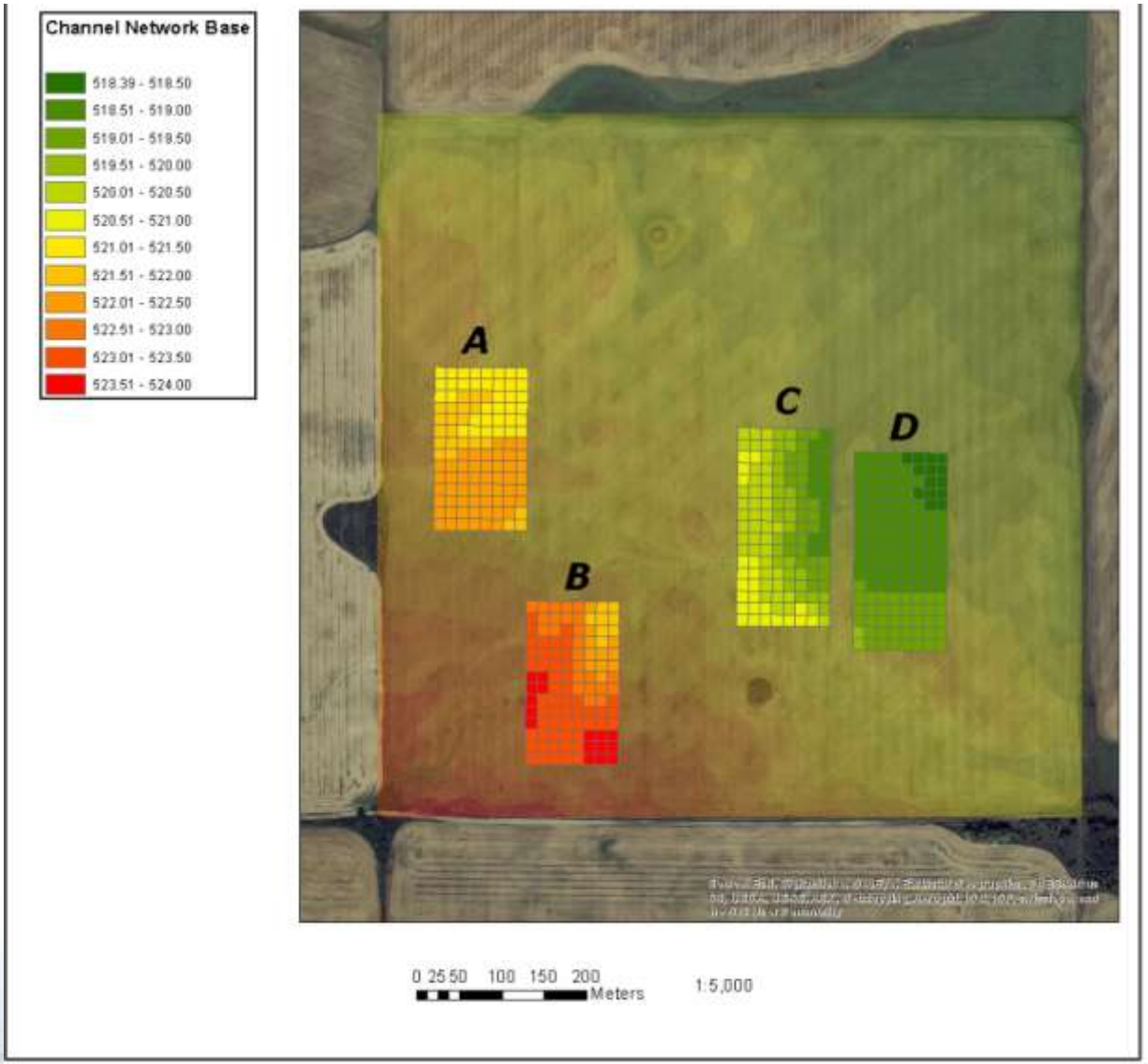


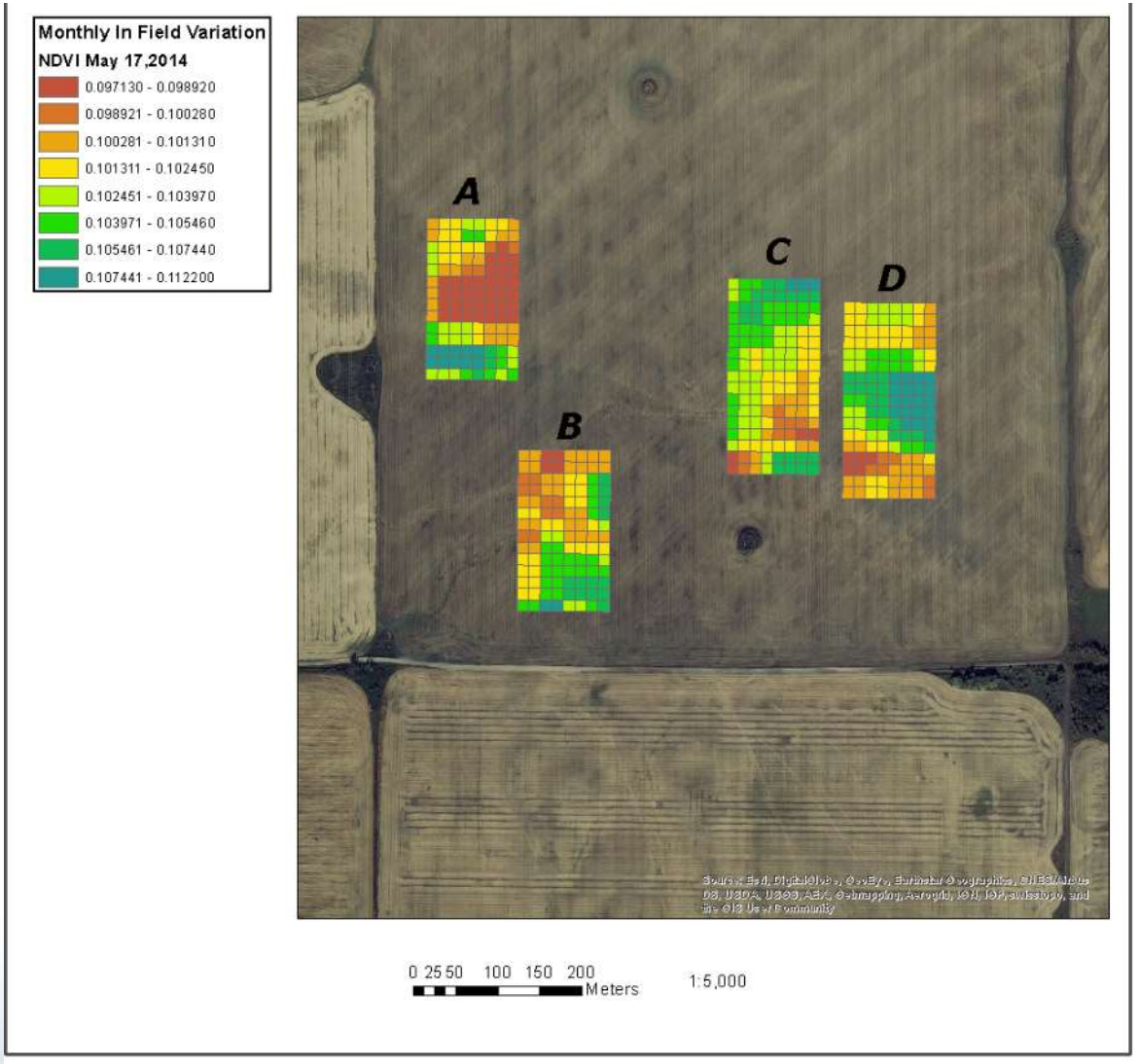
Soil test P 0-15 cm
Manitoba 2 2014



Multi-variate analysis Manitoba 1 2014

Term	Number of Splits	Portion
Trt ID (%	3	0.2107
Channel network base levelmean	1	0.1328
300614-w2-vh	1	0.0992
040714-ndvi	1	0.0964
Slopemean	1	0.091
090614-fq17w-vh	1	0.0903
170415-bsco	1	0.0682
140613-w2-vh	1	0.0498
140513-ndvi	1	0.0355
Elevationmean	1	0.0304
090614-fq17w-hh	1	0.0286
Saga wetness indexmean	1	0.0276
Sand %	1	0.0218
Sum(BD_WA Soil Series 2	1	0.0176


Channel Network Base
518.39 - 518.50
518.51 - 519.00
519.01 - 519.50
519.51 - 520.00
520.01 - 520.50
520.51 - 521.00
521.01 - 521.50
521.51 - 522.00
522.01 - 522.50
522.51 - 523.00
523.01 - 523.50
523.51 - 524.00
A
B
C
D
0 25 50 100 150 200
Meters
1:5,000


Monthly In Field Variation
NDVI May 17,2014
0.097130 - 0.098920
0.098921 - 0.100280
0.100281 - 0.101310
0.101311 - 0.102450
0.102451 - 0.103970
0.103971 - 0.105460
0.105461 - 0.107440
0.107441 - 0.112200
A
B
C
D
0 25 50 100 150 200
Meters
1:5,000

Summary

- It is clear that analysis by field improved interpretation of the effects of management zones and fertilizer treatments particularly for 2015.
- Yield zones and fertilizer management influenced canola yield in analyses which accounted for variability between farms
- Although elevation (channel network base) accounted for a significant proportion of variability of canola yield, the variable did not improve the statistics of fit when added to the analysis as a covariate.
- Remote sensing data will be investigated in subsequent analyses.
- Growing season precipitation and temperature, canola varieties and soil properties will be included in further multivariate analyses to assess variability between farms.
- Soil test recommendations should be reassessed. In my opinion research on soil test recommendations which incorporate mineralizable N, and vertical distribution of N is necessary.

Questions

- Some anecdotal evidence indicates management by yield zones does not work.
- Why practice precision agriculture? Producers already know where the high and low producing areas are located.
- Do we need prescription maps? Current soil survey maps have ample information for varying N fertilizer management.
- We already know that elevation is related to yield.
- There are simple methods for measuring mineralizable N, why invent a new one?
- Can crops access Nitrate N which accumulates below the normal rooting zone? This would affect N use in dry years, and prescription maps.

Collaborators

- Farming Smarter (Lethbridge, Alberta), the Northeast Agricultural Research Foundation (Melfort, Saskatchewan), and Deerwood Soil and Water Management (Miami, Manitoba) will collaborate in field scale research with producers in 2014-2016.

Acknowledgements

- Canola Council staff, Curtis Rempel, Lisa Campbell, Taryn Dickson, Shawn Senko, Kristen Phillips
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- Funding from AAFC and Canola Council 2014-2015, ASI and MAFRD 2008-2012
- John Lee, Agvise Labs

Acknowledgements

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- Andrew Kopeechuk and technical staff from the Brandon Research Centre, AAFC
- Nicole Rabe of the Assiniboine Community College collaborated on the MZTRA project and yield zone analysis.
- Lindsay Coulthard, board of the MZTRA, staff members (MAFRD)

Questions?

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Thank you!

For more information, please contact:

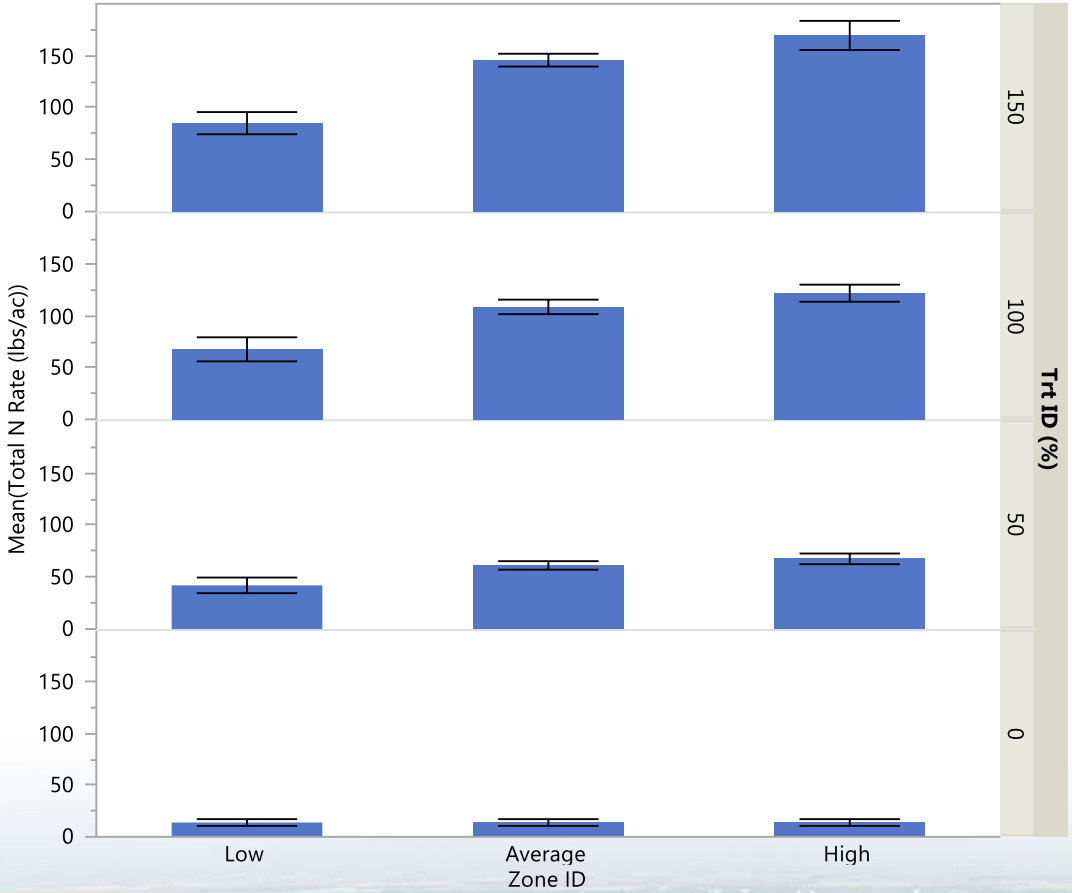
alan.moulin@agr.gc.ca

Canada

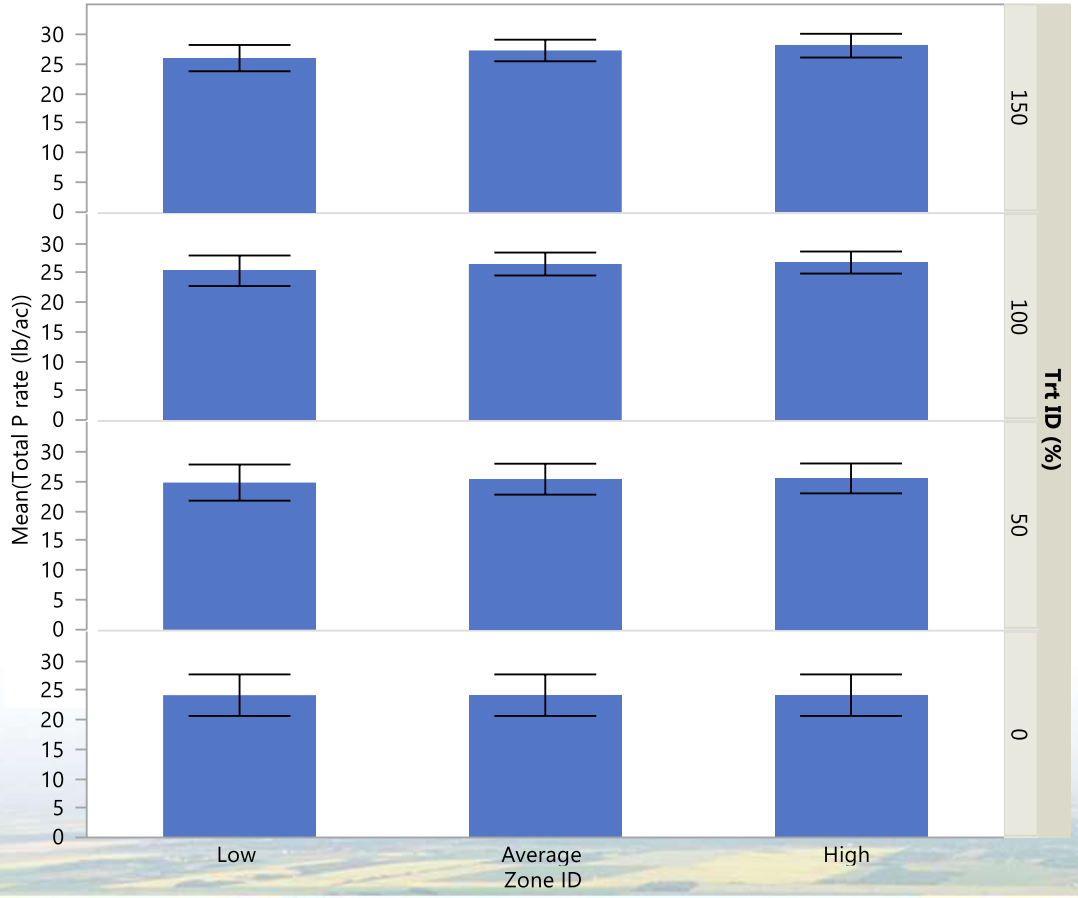
General guidelines

- 2.8 tonnes ha^{-1}, 50 bushel $acre^{-1}$ target yield
- 173 kg ha^{-1}, 50 lb $acre^{-1}$ available N required, 1.4 kg, 3 lb N per bushel
- 70 kg ha^{-1}, 62.5 lb $acre^{-1}$ P2O5 required, 0.56 kg 1.25 lb per bushel
- 45 kg ha^{-1}, 40 lb $acre^{-1}$ available Sulphur required, 0.4 kg, 0.8 lb per bushel
- 140 kg ha^{-1} ,125 lb $acre^{-1}$ K2O required, 1.1 kg, 2.5 lb per bushel
  - Canola Council of Canada

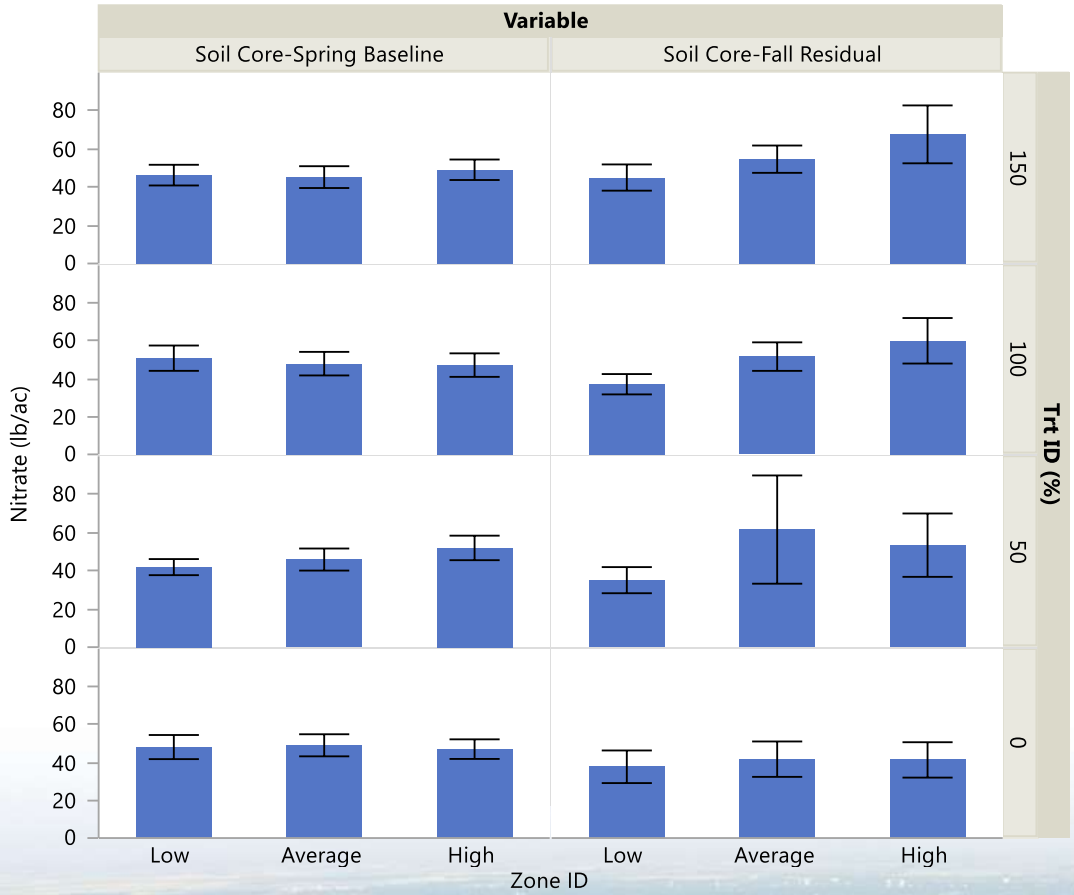
N Rate (lbs/ac) 2015



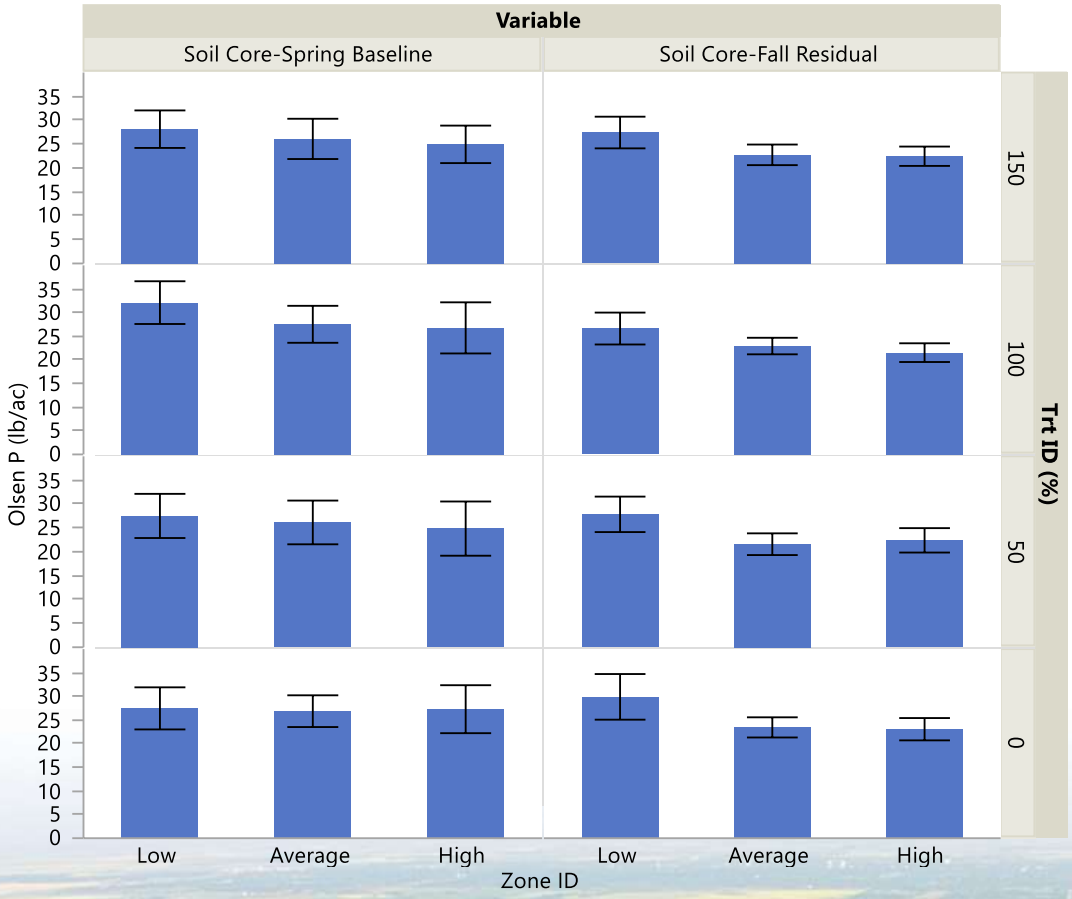
P rate (lb/ac) 2015



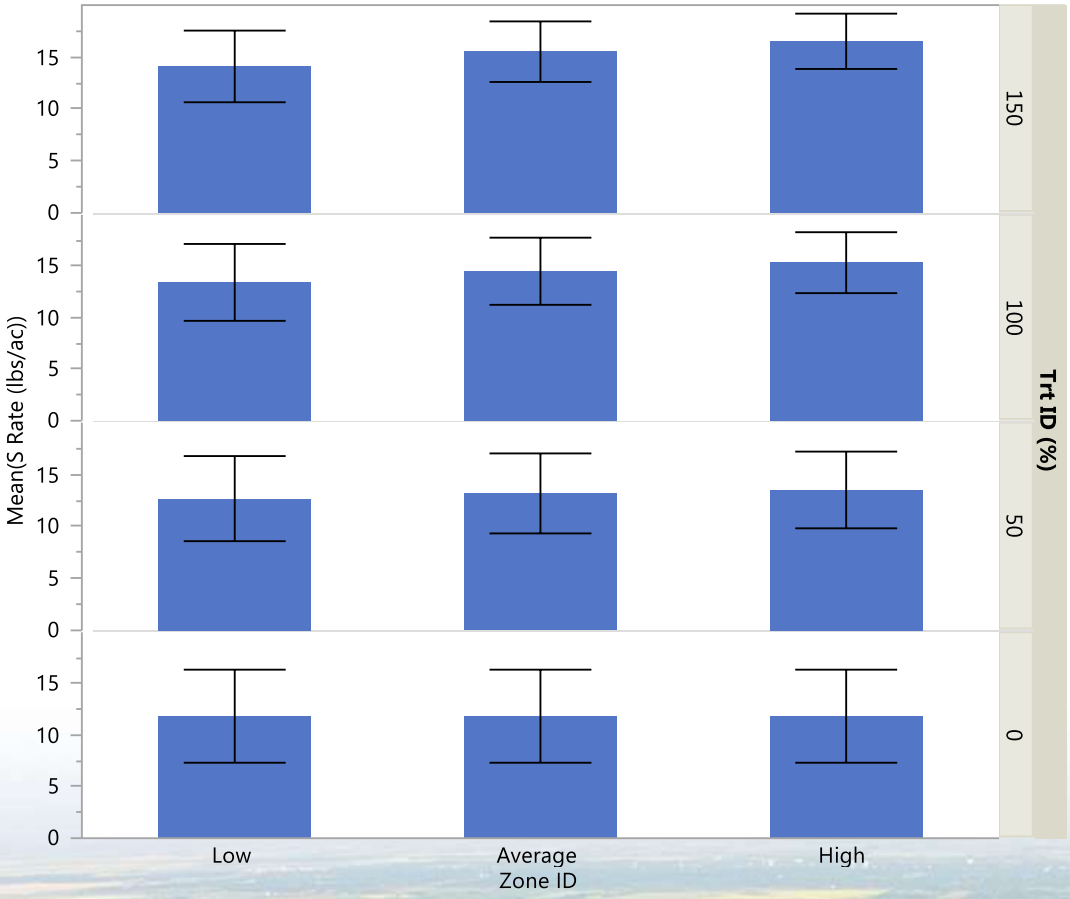
Nitrate-N (lb/ac) 2015



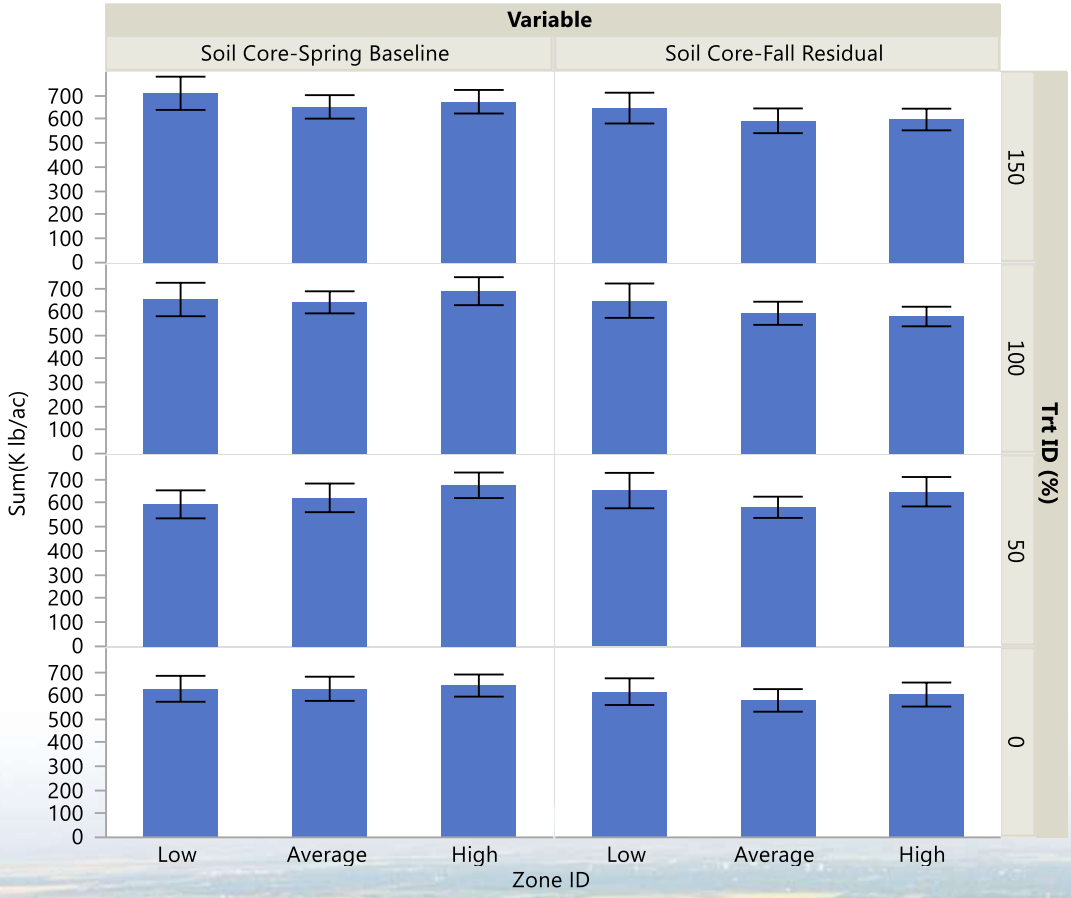
P (lb/ac)
2015


Variable
Soil Core-Spring Baseline
Soil Core-Fall Residual
Olsen P (lb/ac)
0
5
10
15
20
25
30
35
150
100
50
0
Trt ID (%)
Low
Average
High
Zone ID

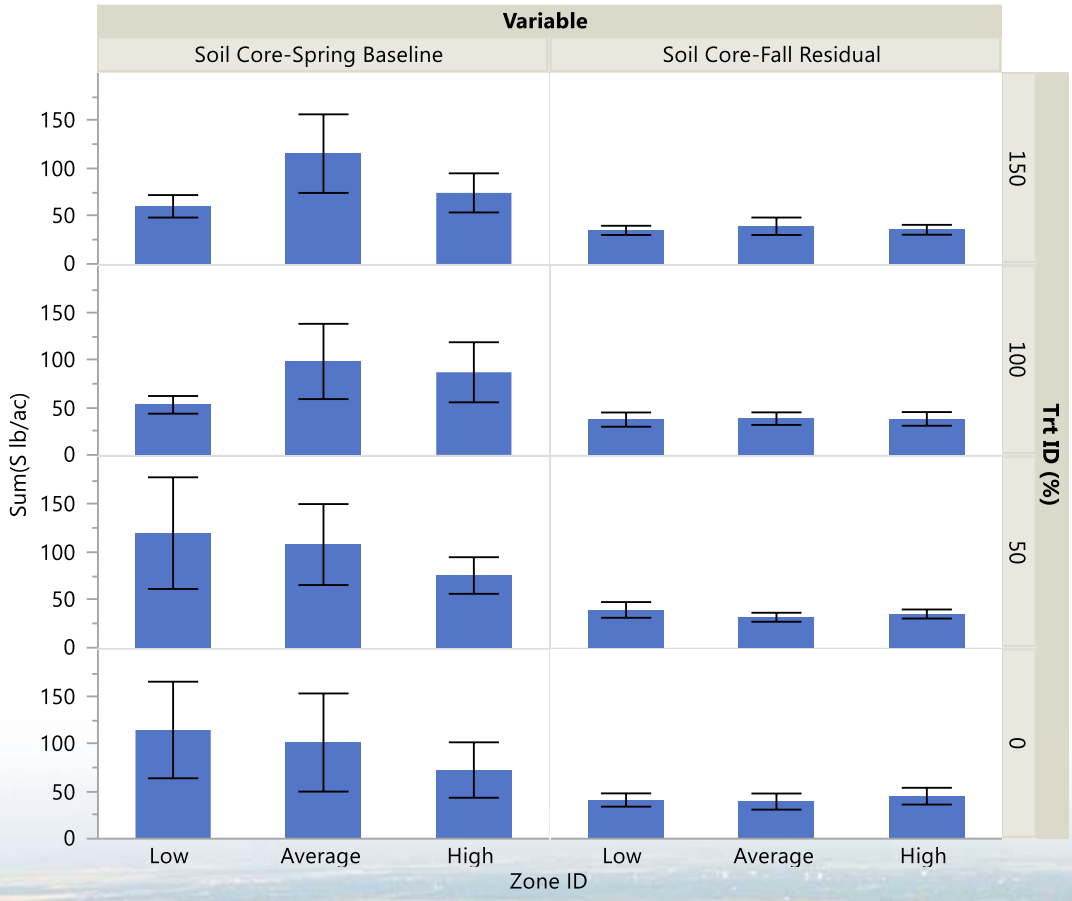
S Rate (lb/ac)
2014



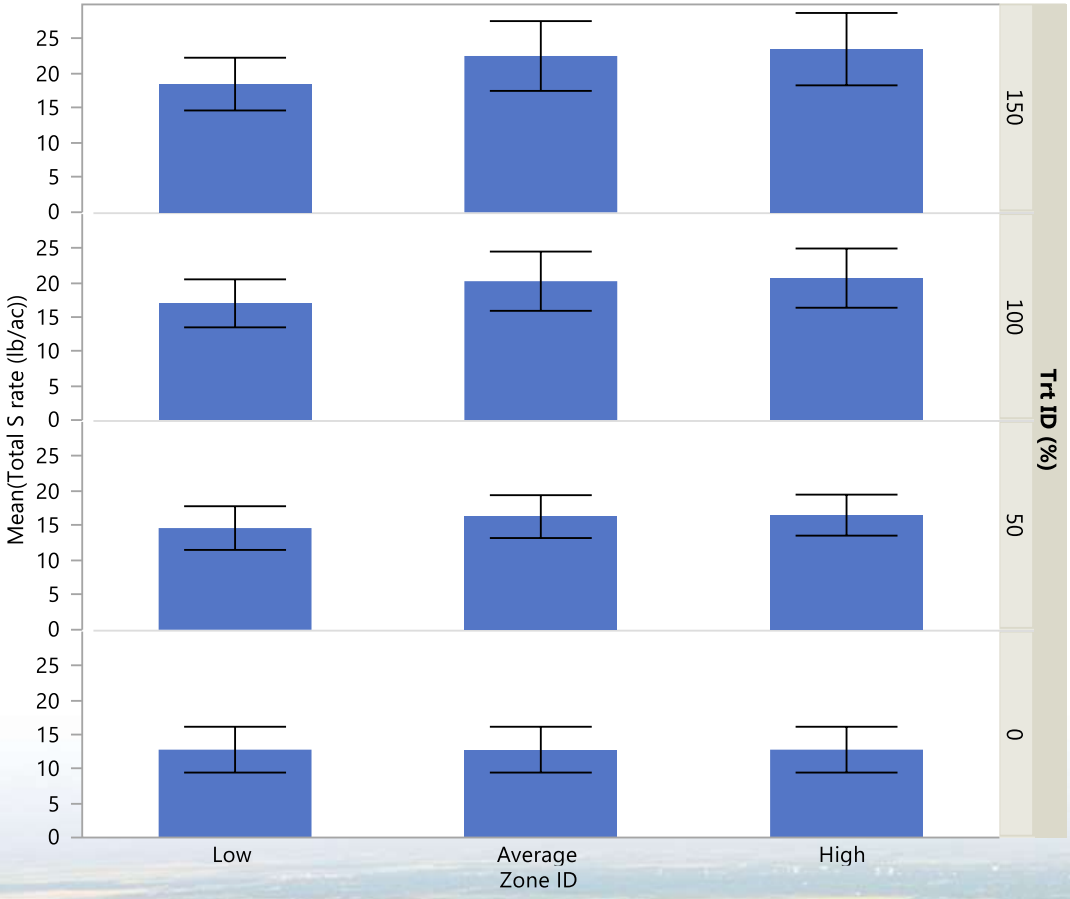
K (lb/ac)
2014


Variable
Soil Core-Spring Baseline
Soil Core-Fall Residual
Sum(K lb/ac)
0
100
200
300
400
500
600
700
Trt ID (%)
150
100
50
0
Low
Average
High
Zone ID

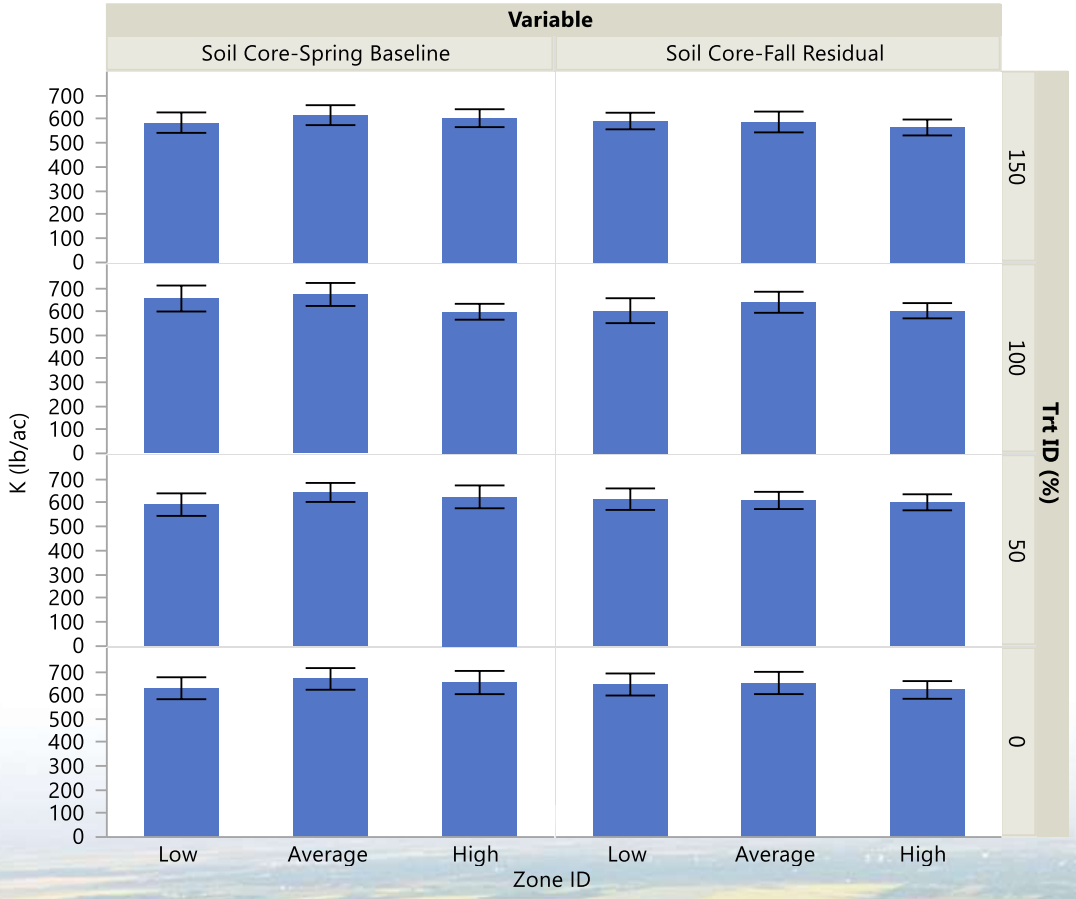
S (lb/ac)
2014


Variable
Soil Core-Spring Baseline
Soil Core-Fall Residual
Sum(S lb/ac)
Trt ID (%)
150
100
50
0
Low
Average
High
Zone ID

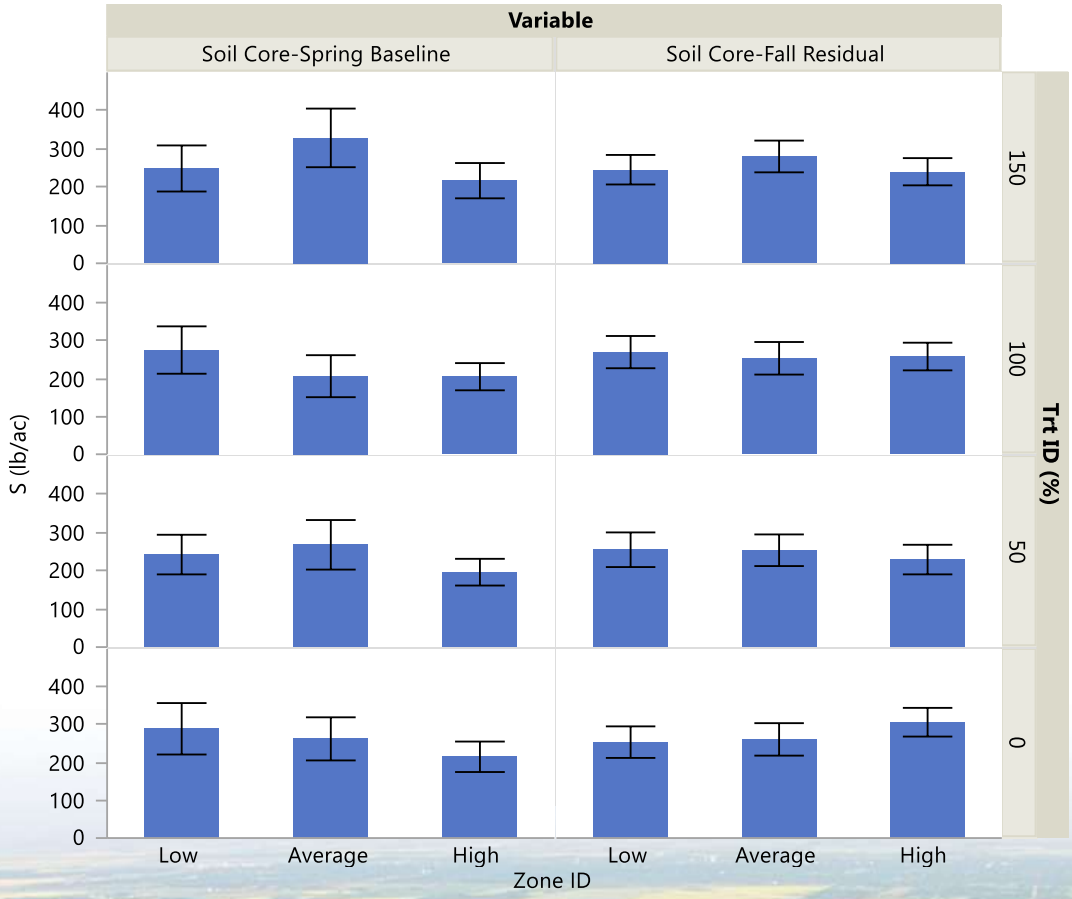
S rate (lb/ac)
2015



K (lb/ac)
2015


Variable
Soil Core-Spring Baseline
Soil Core-Fall Residual
K (lb/ac)
0
100
200
300
400
500
600
700
Trt ID (%)
150
100
50
0
Low
Average
High
Zone ID

S (lb/ac)
2015


Variable
Soil Core-Spring Baseline
Soil Core-Fall Residual
S (lb/ac)
400
300
200
100
0
Trt ID (%)
150
100
50
0
Low
Average
High
Zone ID