Topographical and Hydrological Determinants of Crop Yield in Farm Fields across Alberta, Canada

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Nov 8th, 2016

Outline

• Introduction
  — agronomic versus non-agronomic factors that affect yield
• Farm-scale experimental data
  • Study area
  • Data sources [Yield monitor, Yield, urea-ammonium nitrate (UAN) application]
  • Preliminary results: a profile of ten farms and case studies
• Conclusions

Agronomic vs non-agronomic factors that limit yield

Limiting factors for the crop yield

• Agronomic factors
  • Fertilizers (N, P, K)
  • Moisture
  • Vegetation growth condition
  • Soil pH, organic matter, micronutrients (Fe, Na, Mg), EC, etc.
  • Improved varieties
• Non-agronomic factors
  • Topographical
  • Hydrological
  • …

Topographical factors

• Aspect
• Slope
• Curvature

Hydrological factors

• Flow direction
• Flow length
• Flow basin
• Flow accumulation
Yield monitor data provides a new opportunity to study in-field topographical and hydrological variation.

Yield responses to agronomic (UAN) and non-agronomic factors in the presence of spatial pattern.

Addressing the Spatial autocorrelation
- Ordinary least squares
- Correlogram, variogram
- Spatial autoregressive regression (SAR)
- Random forest
  - Remove the SP effect
  - Keep the SP effect
- Collinearity
- Bootstrap regression
  - Estimate the coefficients by partitioning out the SP effect
  - Empirical distribution of coefficients of regression
- Multi-collinearity

Random forest analyses—importance values of agronomic and non-agronomic predictors on yield

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Yield map
Application map (UAN)
Topographical and hydrological map

Barley, 2011 (3.98 t/ha)
Barley, 2012 (3.14 t/ha)
Barley, 2013 (2.78 t/ha)
Barley, 2014 (2.67 t/ha)
Wheat, 2012 (3.04 t/ha)
Wheat, 2013 (3.63 t/ha)
Wheat, 2014 (2.52 t/ha)
Canola, 2012 (2.35 t/ha)
Canola, 2013 (3.14 t/ha)
Canola, 2014 (3.12 t/ha)

Random forest model (1 step): Yield ~ UAN + TOPO + HY + e

Random forest model (2 steps): Yield ~ SP + Residual
Residual ~ UAN + TOPO + HY + e

NOSP_NOLL
NOSP_LL
SP_NOLL
SP_LL
Conclusions

- New tools to study field farming based on agronomic and non-agronomic factors
- Agronomic (e.g., UAN) factors are not always the key determinant of yield
- Non-agronomic factors (2-12%), e.g., elevation, curvature, overall terrain (longitude/latitude), flow-length, may be more important than UAN effect (0.1%-10%) in some farm fields
- Spatial effect varies among farms
- Recommendation based only on agronomic performance should be treated with caution
- Potential influences of site-specific topographical/hydrological factors should be integrated into future agronomic research

Acknowledgement

- Data suppliers: Beyond Agronomy, ARECA, FarmersEdge
- Data analysis: Dr. Zhiqiu HU
- Financial support:
  - In-Kind Support
    - Trublood Farms Ltd., University of Alberta
    - Westlock Seed Cleaning Co-op Ltd