Slide 1

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An Uncertainty-Based Comprehensive Decision Support System for Site-Specific Crop Management

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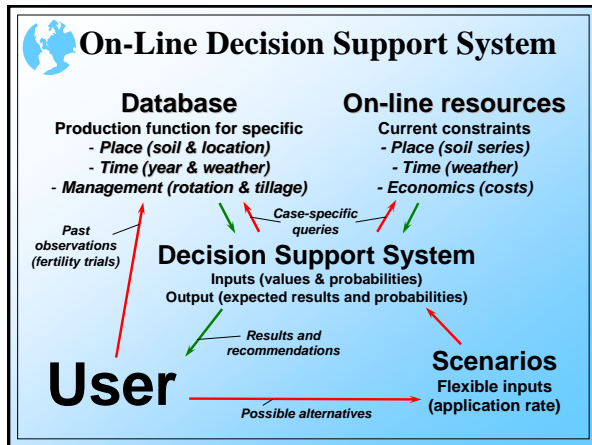Agriculture et Agroalimentaire Canada   Agriculture and Agri-Food Canada
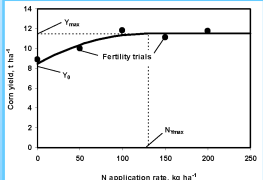
Slide 2

SCAN Platform

- DSS for optimal N rate calculation
- Model based on meta-analyses
- Tested and validated on farms
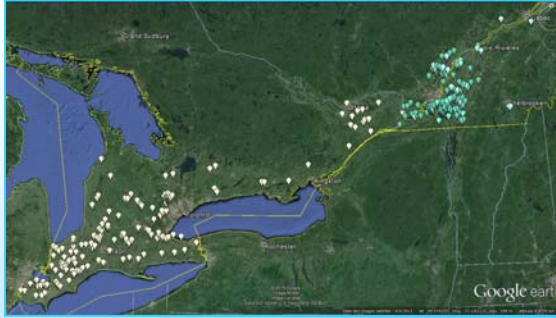- Commercialized in Quebec since 2017
- However, no simulation capacity

Slide 3

On-Line Decision Support System

Database
Production function for specific
- *Place (soil & location)*
- *Time (year & weather)*
- *Management (rotation & tillage)*

On-line resources
Current constraints
- *Place (soil series)*
- *Time (weather)*
- *Economics (costs)*

Case-specific queries

Past observations (fertility trials)

Decision Support System
Inputs (values & probabilities)
Output (expected results and probabilities)

Results and recommendations

User

Possible alternatives

Scenarios
Flexible inputs (application rate)

Slide 4

Database

- **Production function**
  - **Maximum yield**
  - **Minimum fertilizer rate to achieve maximum yield**
  - **Minimum yield or maximum yield increase due to the use of fertilizer**
- **Metadata**
  - **Geographic location**
  - **Key soil attributes**
  - **Landscape parameters**
  - **Weather summary**
  - **Cultivar and rotation**
  - **Other descriptors**

Slide 5

Trial Database

Slide 6

On-line Resources

- **Regional geo-database**
  - **Soil series**
  - **Soil organic matter**
- **Climate assessment**
  - **Summary of present conditions**
  - **Weather forecast**
- **Economics**
  - **Price of yield**
  - **Cost of fertilizer**

with uncertainties

Numeric Simulation

- **Inputs**
  - **Given place and management resulting in an estimated production function with uncertainties**
  - **Given time resulting in adjusting production function and derivation of the profit function, with uncertainties, for current conditions**
- **Outputs**
  - **Probability of a positive net return over cost of fertilization for each possible rate**
  - **Rate of fertilization with the greatest expected net return over cost of fertilization (e.g., profit)**

Objective function:

\$/ha ➡ MAX

Methodology: Estimate

Yield response:

$$Y = \begin{cases} a_0 + a_1 N + a_2 N^2 & for \quad N < N_{Y\,max} \\ a_0 + a_1 N_{Y\,max} + a_2 N_{Y\,max}^2 & for \quad N \geq N_{Y\,max} \end{cases}$$

Net Return over Cost of Fertilization:

$$NRCF = Y \cdot c_Y - N \cdot c_N$$

NRCF for a specific case (scenario):

$$NRCF_i = Y\left(Y_{0i}, Y_{max\,i}, N_{Y\,max\,i}, N\right) \cdot c_{Yi} - N \cdot c_{N_i}$$
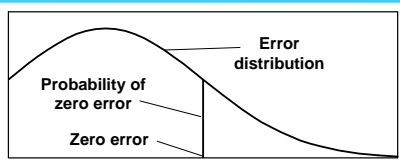

Methodology: Probability

Expected NRCF:

$$NRCF_{est} = \sum_{i=1}^{N} \left(NRCF_i \cdot p\left(NRCF_i\right)\right)$$

Probability of a given NRCF scenario:

$$p\left(NRCF_i\right) = p\left(Y_{0i}\right) \cdot p\left(Y_{max\,i}\right) \cdot p\left(N_{Y\,max\,i}\right) \cdot p\left(c_{Yi}\right) \cdot p\left(c_{Ni}\right)$$

$$\sum_{i=1}^{N} p(NRCF_i) = 1$$

Error distribution

Probability of zero error

Zero error

Methodology: Query

- **Weight of probability**
- **Attribute proximity**
- **Parameter imputation**

- **Pilot application**
  - **1,500 database records**
  - **Over 60K production function scenarios**
  - **15 categorized economic scenarios**
- **Under 5 min computation time**

NumericAg

NumericAg is a decision support system designed to help farmers and their consultants identify the least risky site-specific rate of key agricultural inputs, such as nitrogen fertilizer. This numeric simulation process integrates previous fertility trial records, information about local conditions and economic considerations to estimate probable net return over cost of fertilization. Please enter your data below and submit the form. Certain inputs mean maximum profit.

http://www.numericag.com

Input Form

Report (E-mail)

Viacheslav:
Based on the information provided, please find our best estimate of the probable effect of **Nitrogen** fertilization on the expected Net Return over Cost of Fertilization (NRCF) for the conditions specified. Maximum expected NRCF is achieved with **170 kg/ha** rate of fertilization. However, please apply your risk preference when selecting the right application rate and accept our best wishes for your farming operation.

Input parameters:

Current crop	Climate (AWDR)	Previous crop	Season	Soil type	Tillage
Corn	50-75	Corn	2017	Clay	Conventional

Tabulated results:

N rate kg/ha	NRCF > 1000 $/ha	NRCF > 1500 $/ha	NRCNF > 2000	NRCF > 2500 $/ha	Expected NRCF $/ha	EFB $/ha
0	19 %	1 %	0 %	0 %	640	0
10	33 %	6 %	1 %	0 %	870	230
:	:	:	:	:	:	:
200	81 %	43 %	22 %	11 %	1586	946

Report 1

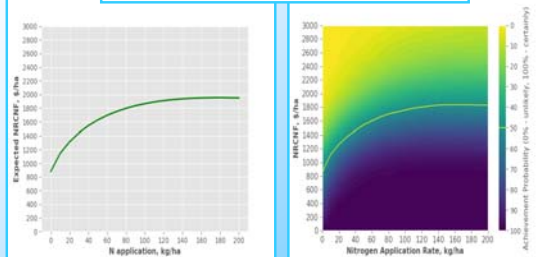| Current crop	Climate (AWDR)	Previous crop	Season	Soil type	Price Mean/SD	Cost Mean/SD
Corn	50-75	Corn	2017	Loam	180/55	0.62/0.15

Maximum expected NRCF is achieved with **180 kg/ha**
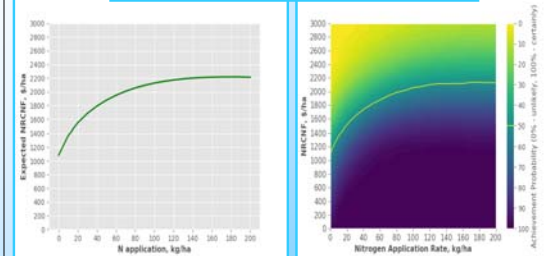
Report 2

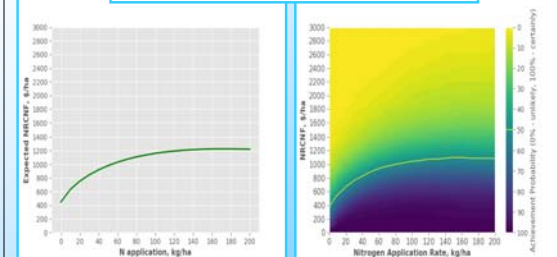| Current crop	Climate (AWDR)	Previous crop	Season	Soil type	Price Mean/SD	Cost Mean/SD
Corn	25-50	Corn	2017	Loam	180/55	0.62/0.15

Maximum expected NRCF is achieved with **170 kg/ha**

Report 3

Current crop	Climate (AWDR)	Previous crop	Season	Soil type	Price Mean/SD	Cost Mean/SD
Corn	50-75	Corn	2017	Sand	180/55	0.62/0.15

Maximum expected NRCF is achieved with **180 kg/ha**

Summary

- **The proposed decision support system enables**
  - **the determination of the optimum average application rate that maximizes expected profits (net return over cost of fertilization)**
  - **to define the range of such rates for a case of variable rate application**
- **Uncertainty-based treatment of each model input and dynamic data exchange with the underlying production function database**
- **Balance between expected profit losses from potential under-application and over-application errors**

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