USING ON-FARM DATA AND OBSERVATIONAL METHODS FOR AGRONOMIC RESEARCH

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IHARF Soil & Crop Management Seminar

February 2, 2022

“Classic” Agronomic Research

- Fisher’s Principles: Theory of experimental design and statistical methodology developed while studying effects of fertilizers on crops at Rothamsted Research Station in 1920-30s

- Replicated block designs: effective at isolating effects of treatment variables

Block 1

Trt 1	Trt 2
Trt 4	Trt 3

Block 2

Trt 2	Trt 4
Trt 3	Trt 1

Block 3

Trt 4	Trt 3
Trt 1	Trt 2

- Potential for “uncontrolled” variables increases when scaling up from greenhouse to small-plot to field scale – limits application to whole system

“Variable” = measurable or definable attribute than can take on different values
E.g. Variety, seeding rate, plant height, yield

“Systems” approach to agronomic research

- No experimental manipulation
  - Observational or survey data
  - Exploratory vs Confirmatory – adequate replication is important
- Unbalanced (orthogonality)
- Large number of inter-correlated variables
- “Noisy” data

“Replicate” in observational study = single observation or data point, for which the value of all variables is measured

Replicate	Variable A	Variable B	Variable C
1	1	15	125
2	1	20	110
3	2	5	325

On-Farm Data

- Representative of management practices and variability of conditions in commercial crop production

- Data sources:
  - Manual - direct in-field measurements
  - Digital – Yield maps, in-field weather stations
  - Remote – satellite, regional weather data

Management by Environment Interactions

- G x E interaction: varieties (genotypes) respond differentially to growing conditions
  - E.g. Drought tolerant varieties
- G x M interaction: varieties respond differentially to management
  - E.g. Varieties have different nitrogen response curves
- G x E x M interaction:
  - E.g. Varieties' N response curves will be different under dry and wet conditions

Management X Environment interaction is similar to G x E x M, but variety included as a management variable; Comparable to site-year interactions in classic studies

Projects

On-farm approach to evaluate the interaction of management and environment on

1) canola stand establishment

2) Fusarium Head Blight development in wheat

SaskCanola
Saskatchewan Canola Development Commission

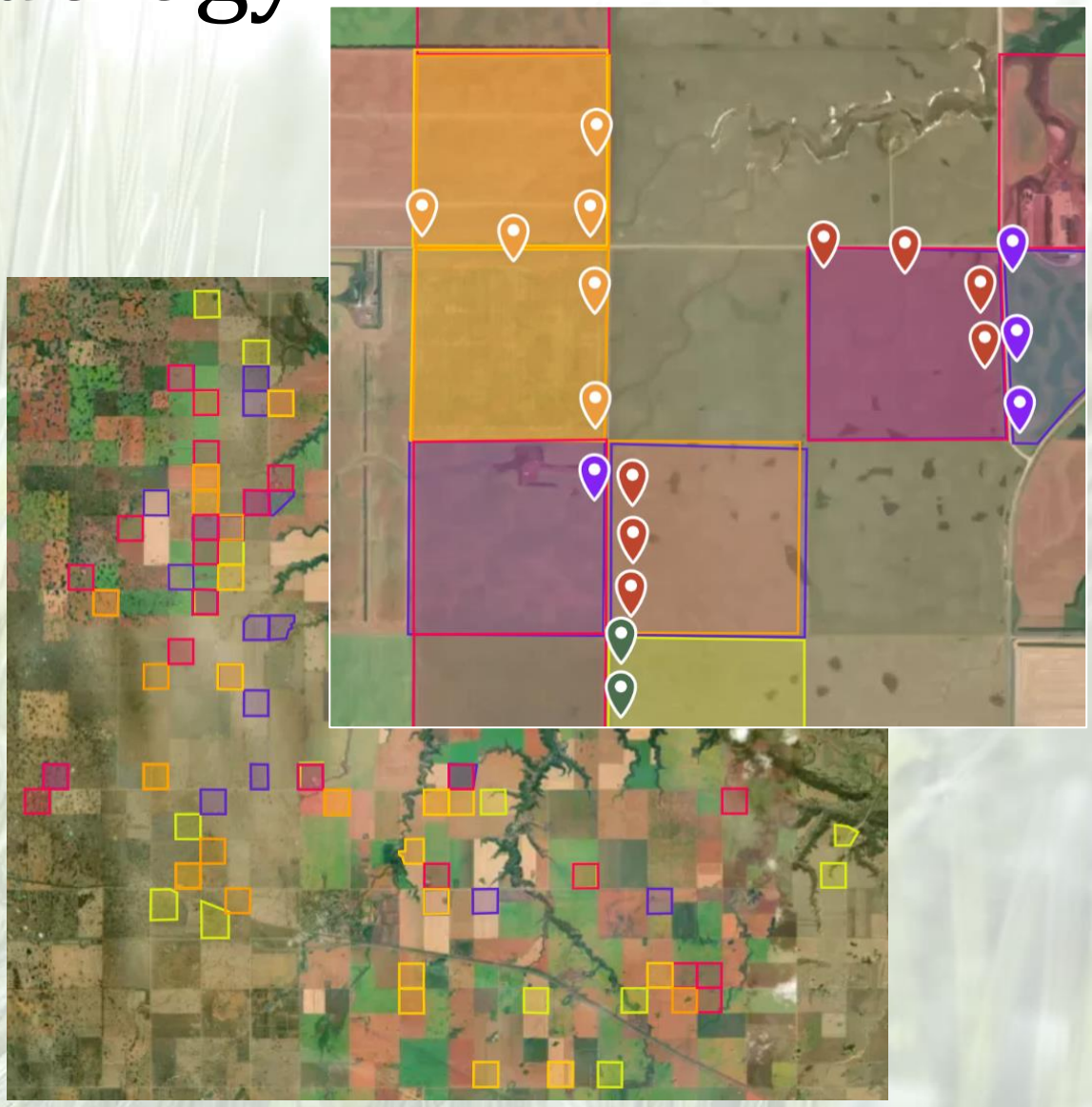
Sask Wheat
DEVELOPMENT COMMISSION

Study Design & Methodology

- Data collected from commercial crop fields in collaboration with producers
  - No experimental manipulation

- Canola emergence:
  - Indian Head 2018-2020
  - 57 fields from 6 operations

- Fusarium Head Blight in wheat:
  - Indian Head, Scott, Melfort 2018-2020
  - 91 fields from 12 operations



Study 1: Interaction of management and environment on canola establishment

Management Variables

- Surface residue (% cover)
- Seeding depth (directly measured one year only)
- Seeding date
- Seeding density
- Cultivar
- Seed size (TSW)
- Seed treatment
- Applied N, P, K, S rate
- Seeding speed
- Crop rotation (previous crop, previous crop type, number of canola, cereal, and pulse crops in 4 years)

Environmental variables

- Residual nutrients (N, P, K, S)
- SOM, pH, CEC
- Soil moisture
- Soil temperature
- Rain gauge precipitation
- Air temperature (GDD calculated)
- Regional precipitation

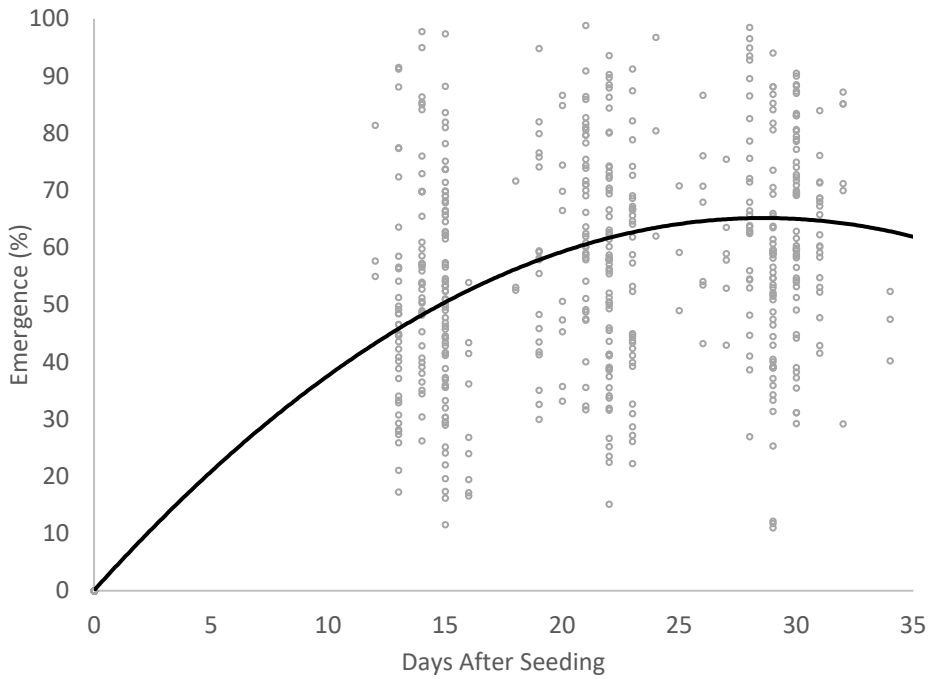
Measured weekly and intrapolated to obtain daily values

Environment Canada weather

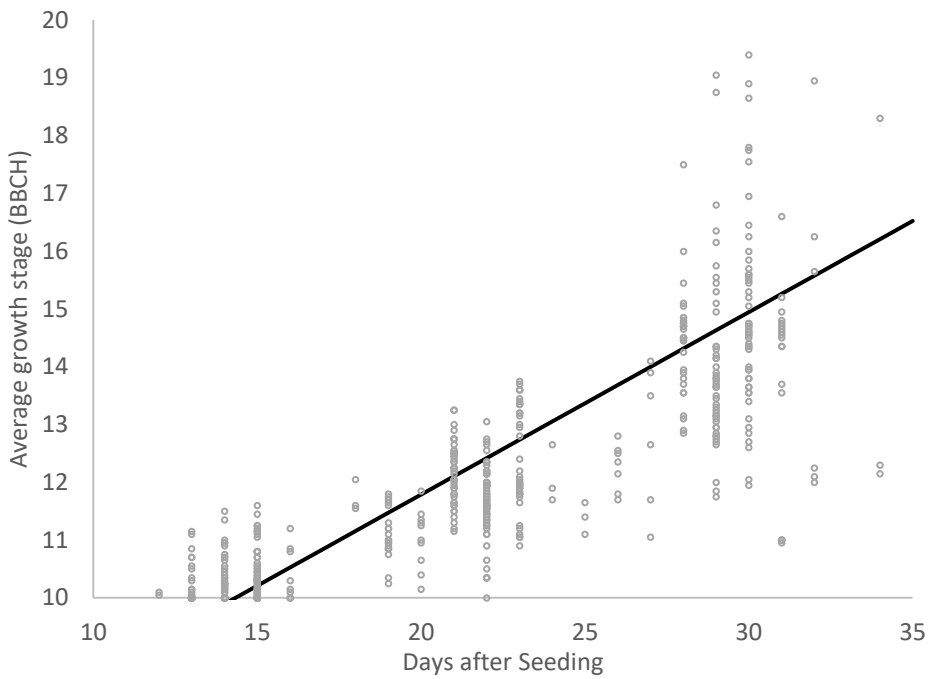
Environmental variables averaged or totaled for pre-seeding date period and over post-seeding date intervals of 7, 14, and 21 days

Study 1: Interaction of management and environment on canola establishment

- Response variables: Percent Emergence & Average Growth Stage



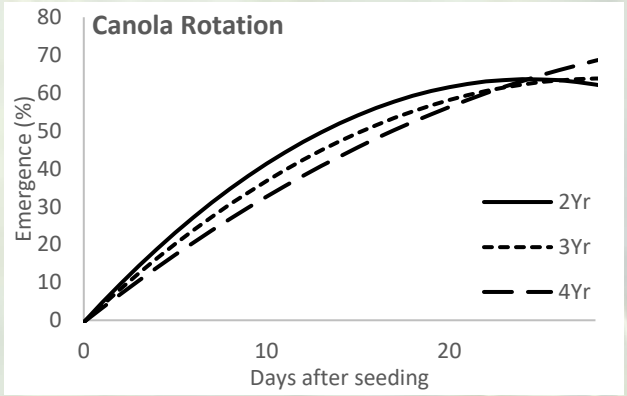
Emergence Rate = percent emergence with days after seeding

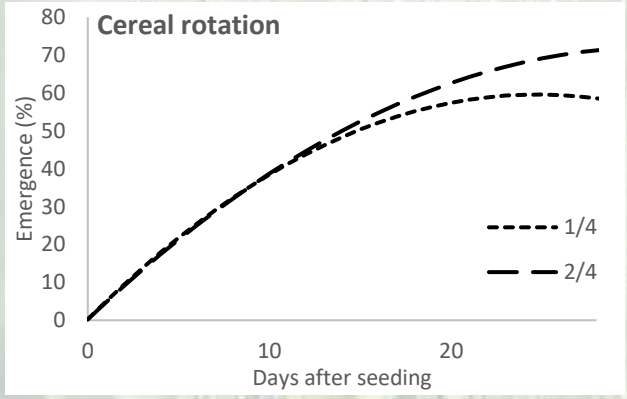


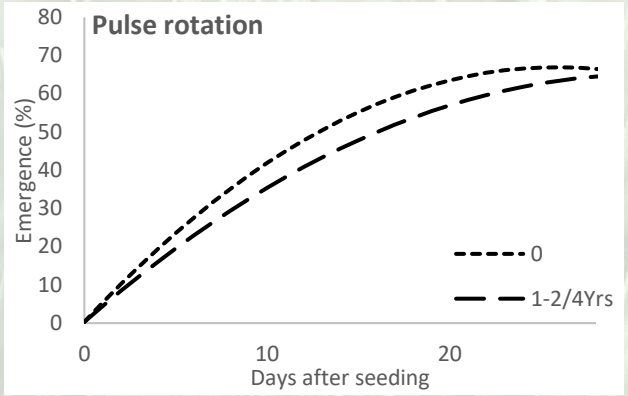
Early Growth Rate = Avg growth stage with days after seeding

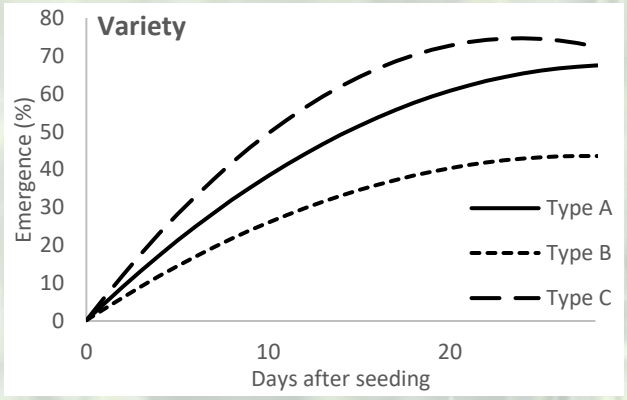
Study 1: Interaction of management and environment on canola establishment

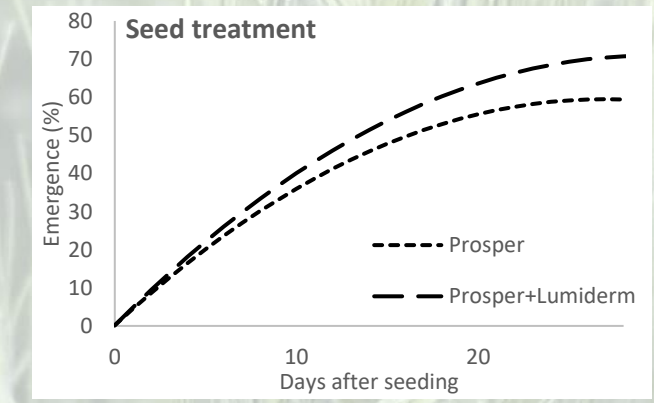
- Results of forward-selection multiple regression for emergence rate

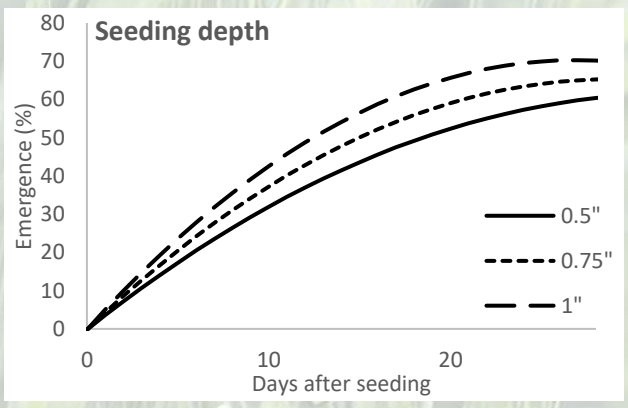












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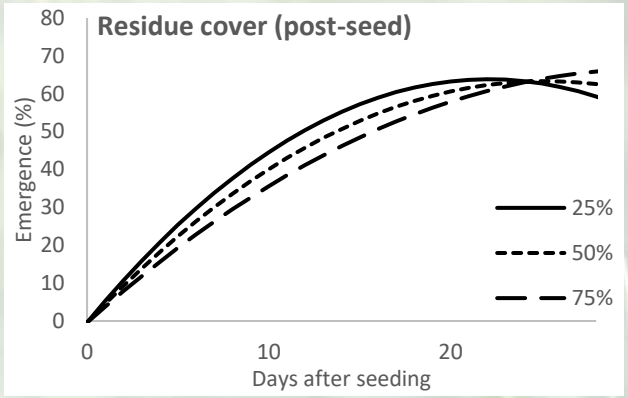
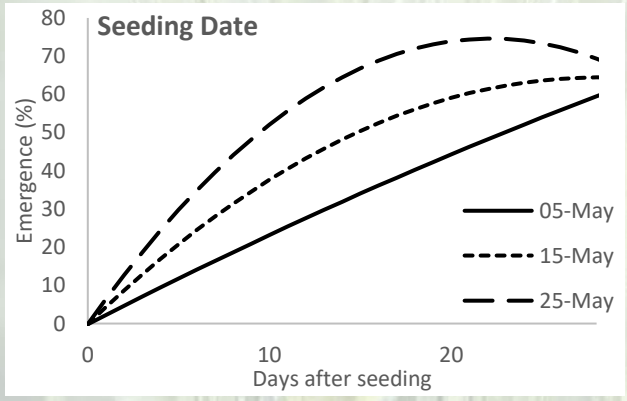
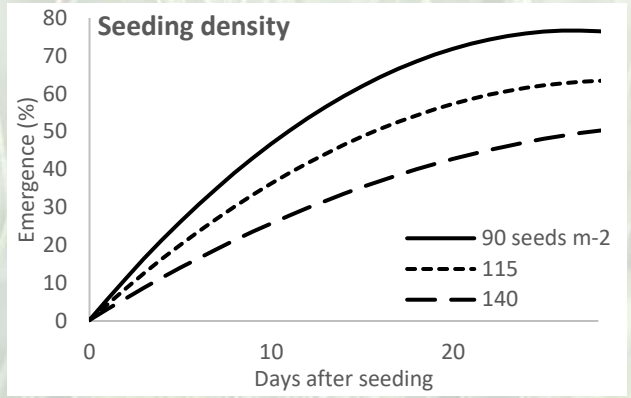
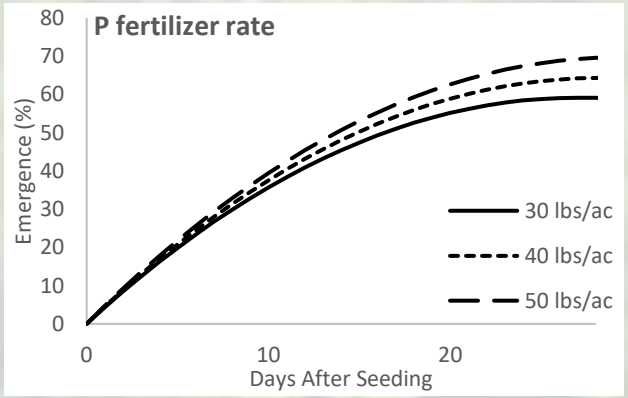
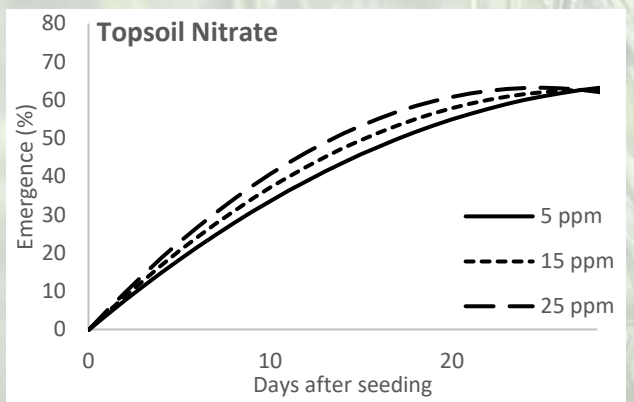
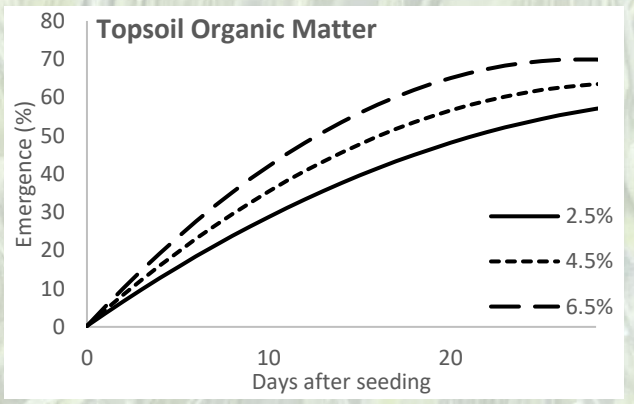


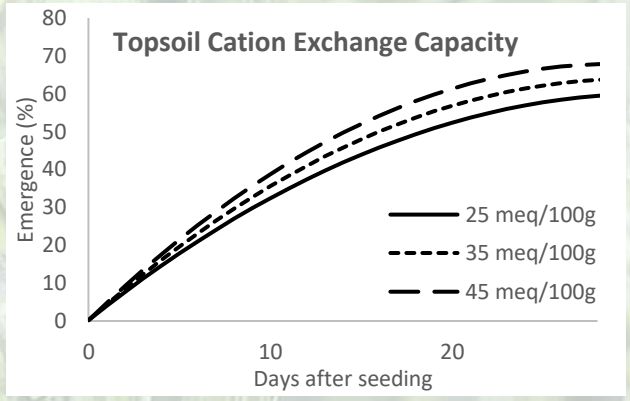






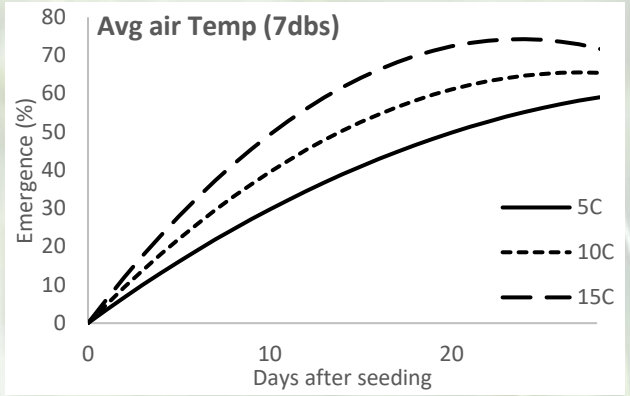


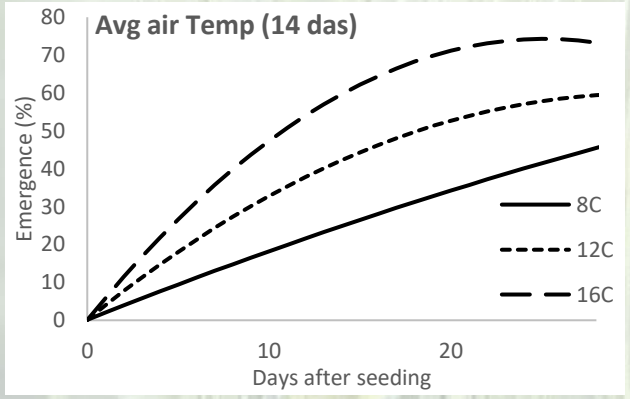


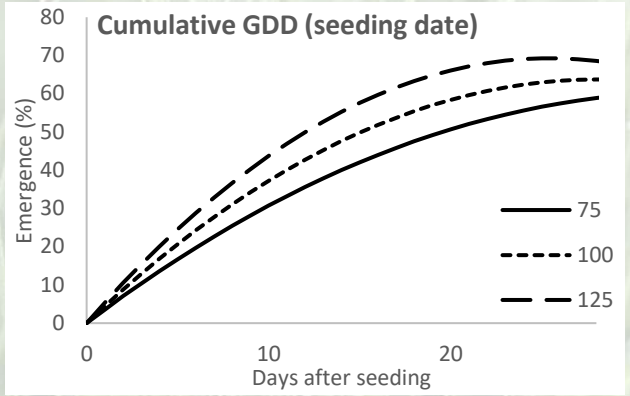


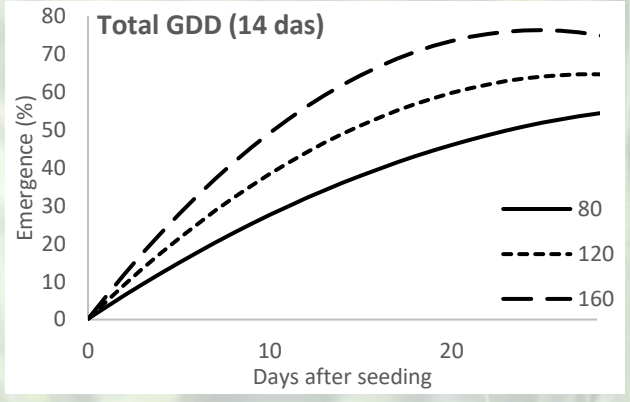
Study 1: Interaction of management and environment on canola establishment

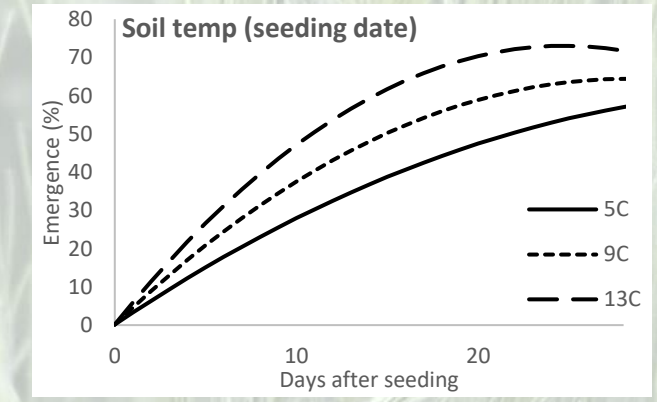
- Results of forward-selection multiple regression for emergence rate

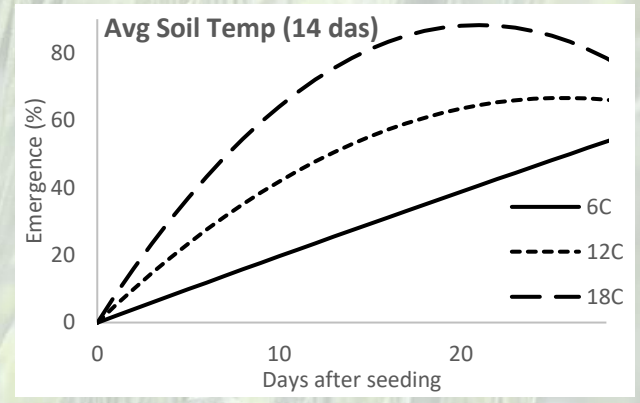












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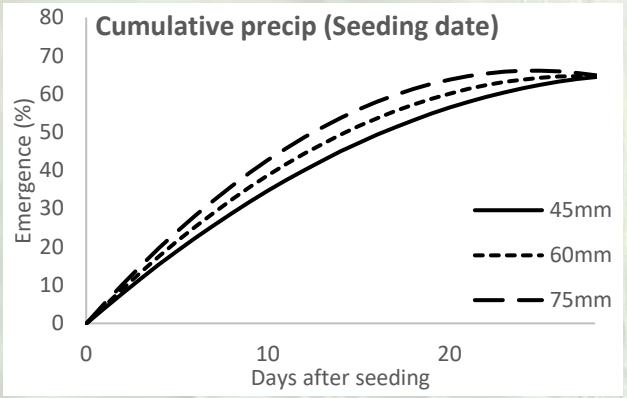
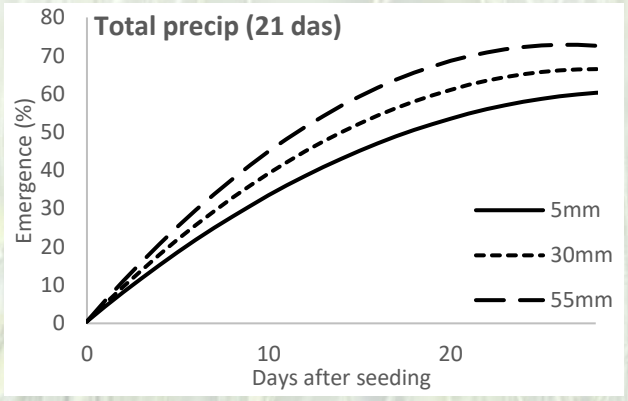
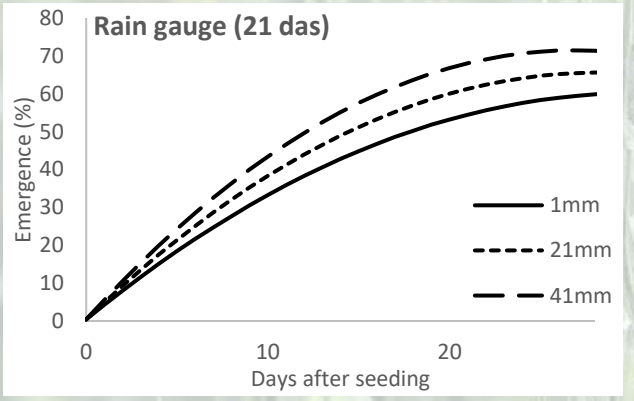
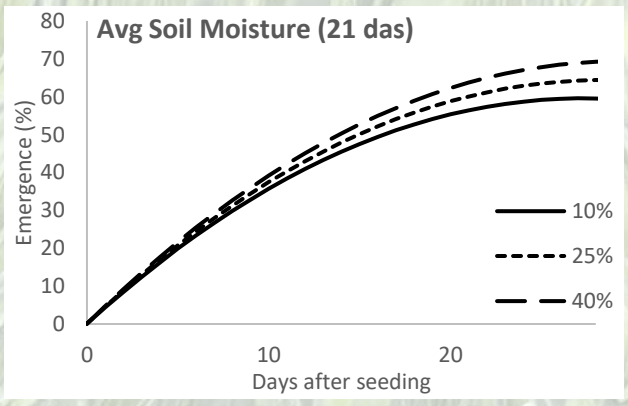








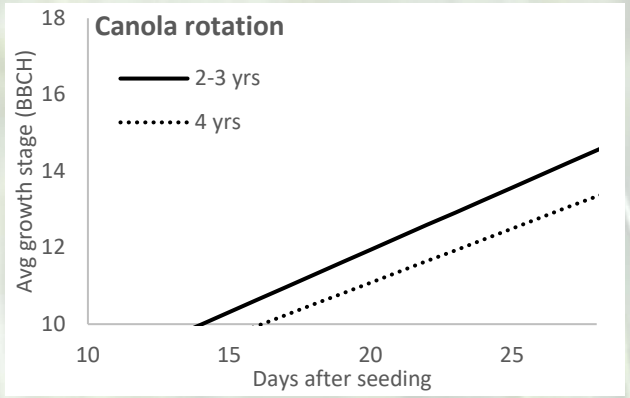
Study 1: Interaction of management and environment on canola establishment

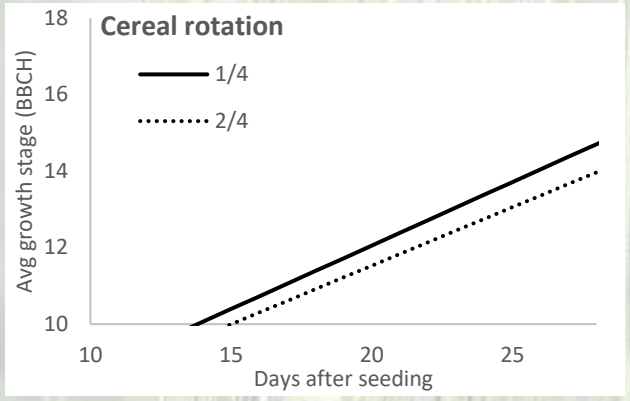
- Results of competing models for emergence rate

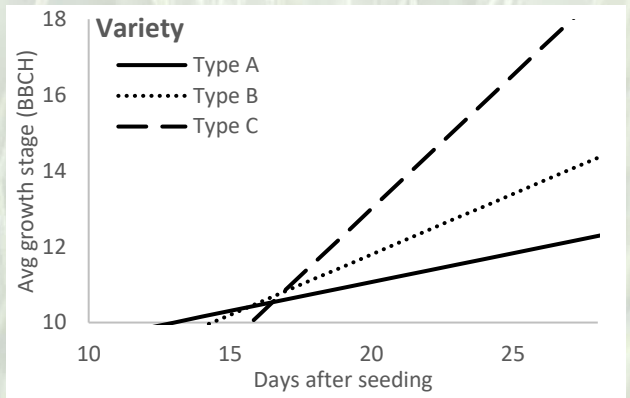
Model rank	Management variable	Environmental variable	Interaction significant?	Model weight
1	Variety	Avg soil temp (14 das)	Yes	0.795
2	Variety	Total GDD (14 das)		0.167
3	Variety	Avg air temp (14 das)		0.036
4	Variety	Avg air temp (7 dbs)		0.002
5	Seed treatment	Avg air temp (14 das)	Yes	<0.001
6	Canola rotation	Avg air temp (14 das)		<0.001
7	-	Avg air temp (14 das)		<0.001
8	Seed treatment	Total GDD (14 das)		<0.001
9	Seed treatment	Avg soil temp (14 das)		<0.001
10	Residue cover	Avg air temp (14 das)		<0.001

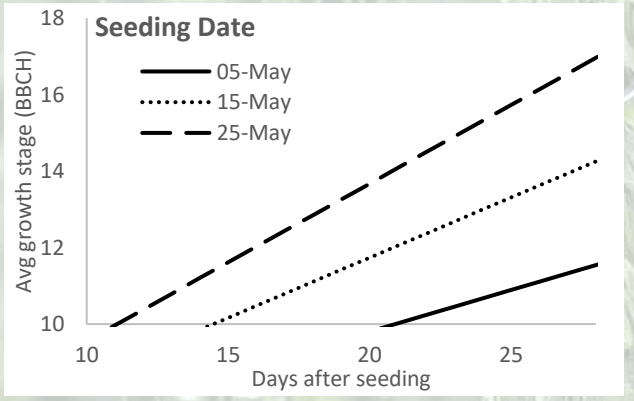
Study 1: Interaction of management and environment on canola establishment

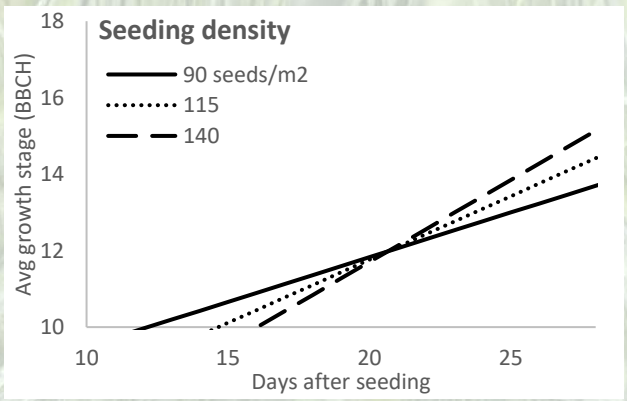
- Results of forward-selection multiple regression for growth rate





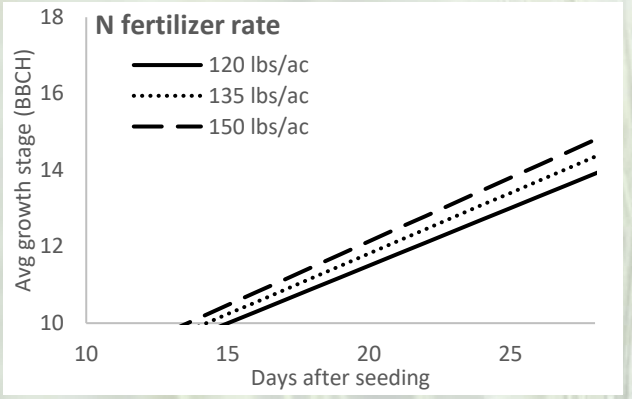


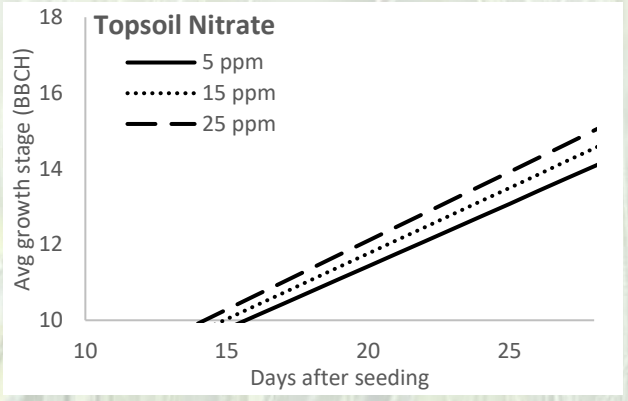


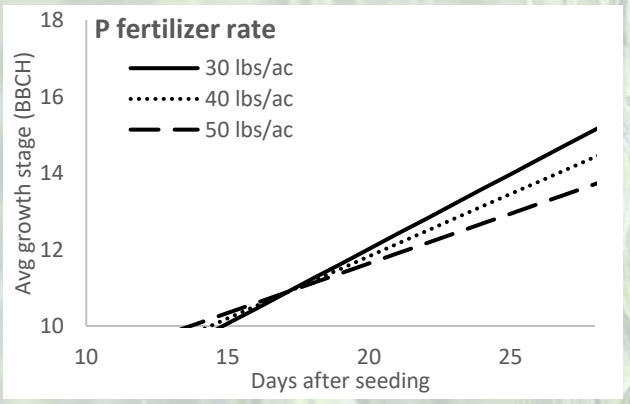


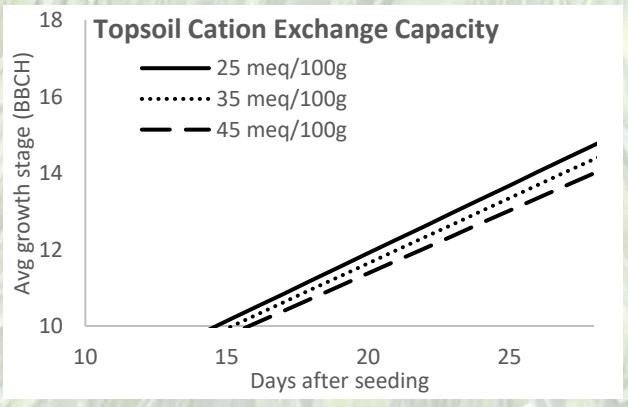
Study 1: Interaction of management and environment on canola establishment

- Results of forward-selection multiple regression for growth rate









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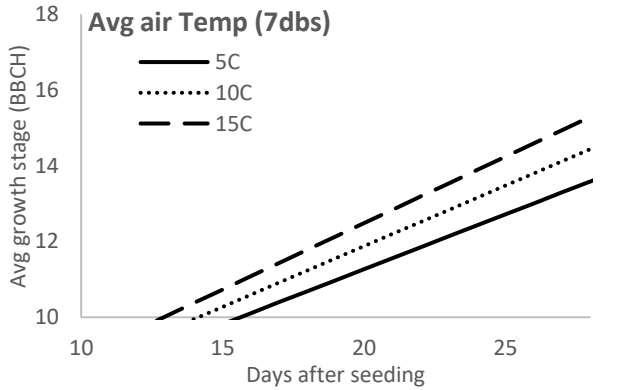
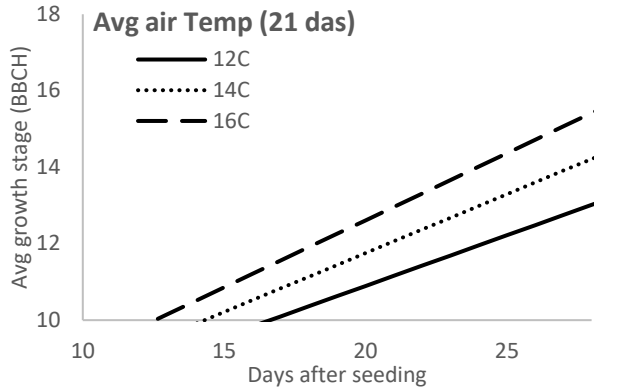
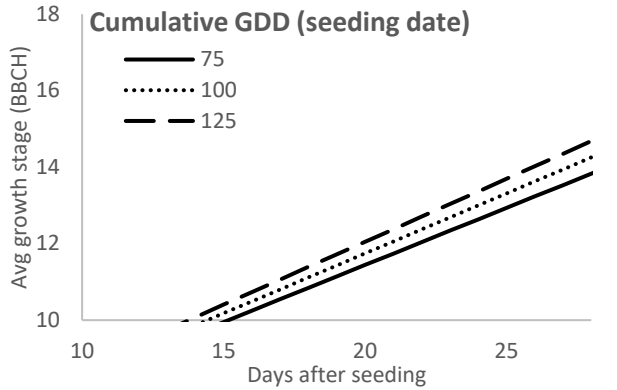
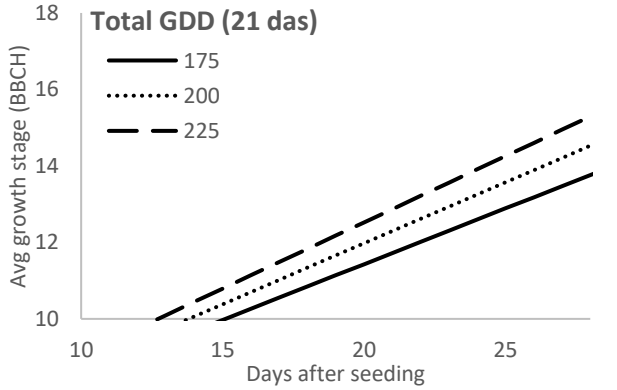
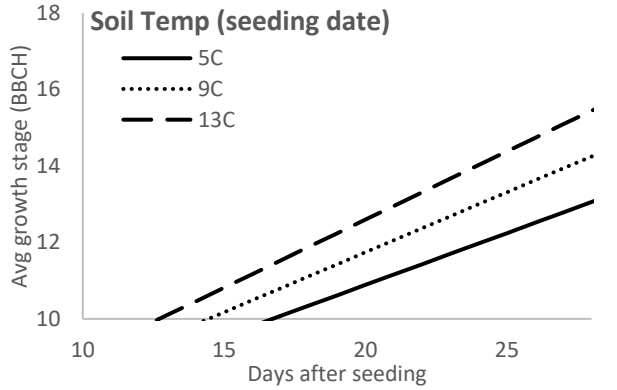
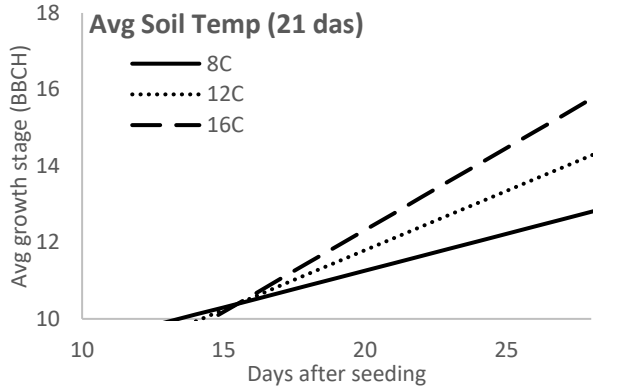






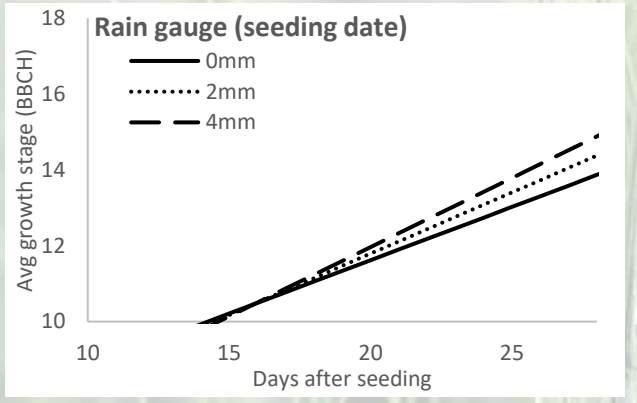


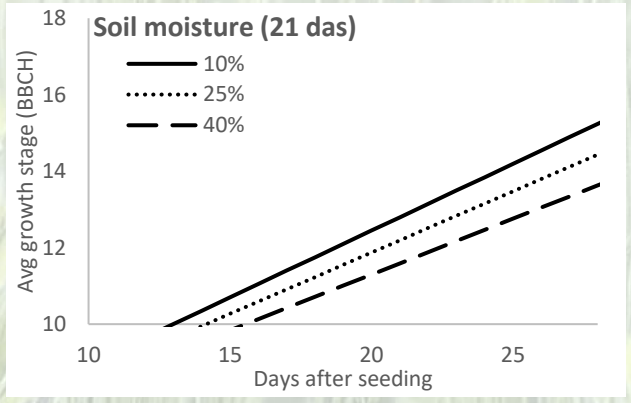




Study 1: Interaction of management and environment on canola establishment

- Results of forward-selection multiple regression for growth rate





Study 1: Interaction of management and environment on canola establishment

- Results of competing models for growth rate

Model rank	Management variable	Environmental variable	Interaction significant?	Model weight
1	Variety	Avg soil temp (21 das)	Yes	0.999
2	Variety	Soil temp (seed date)	Yes	0.001
3	Variety	Rain gauge (seed date)		<0.001
4	Variety	Avg air temp (21 das)		<0.001
5	Seeding date	Soil moisture (21 das)		<0.001
6	Seeding date	-		<0.001
7	-	Avg soil temp (21 das)		<0.001
8	Variety	-		<0.001
9	Canola rotation	Avg soil temp (21 das)		<0.001
10	Variety	Total GDD (21 das)		<0.001

Study 1: Interaction of management and environment on canola establishment

- Conclusions & Recommendations
  - Variety was the most influential management variable on both the emergence rate and early growth rate, and also influenced spatial uniformity (not shown)
  - Effect of seeding date mainly a function of environmental variables
  - Most environmental variables influenced emergence and had additive and sometimes interactive effects with management
  - Temperature and heat units were more influential than precipitation and moisture – could be a function of dry conditions

Study 2: Interaction of management and environment on *Fusarium* in wheat

Management / Agronomic variables

- Surface residue (% cover)
- Crop rotation (frequency of wheat, frequency of cereals, number of years since last wheat and last cereal crop)
- Variety & FHB resistance rating
- Seed quality (% Fus gram., TKW, % germ), seed source, seed treatment
- Seeding date, anthesis date
- Staginess of crop at anthesis
- Fungicide application date, product, water volume, speed
- Fungicide rotation (frequency of same active ingredient or mode of action on previous wheat or cereal crops)
- Plant density, tiller density
- Seeding rate, seeding depth
- Applied N, P, K, S rate

Environmental variables

- Residual nutrients and salts (spring soil sample)
- Various measures of soil texture and soil quality (soil maps)
- Soil moisture
- Soil temperature
- Rain gauge precipitation

Measured weekly and intrapolated to obtain daily values

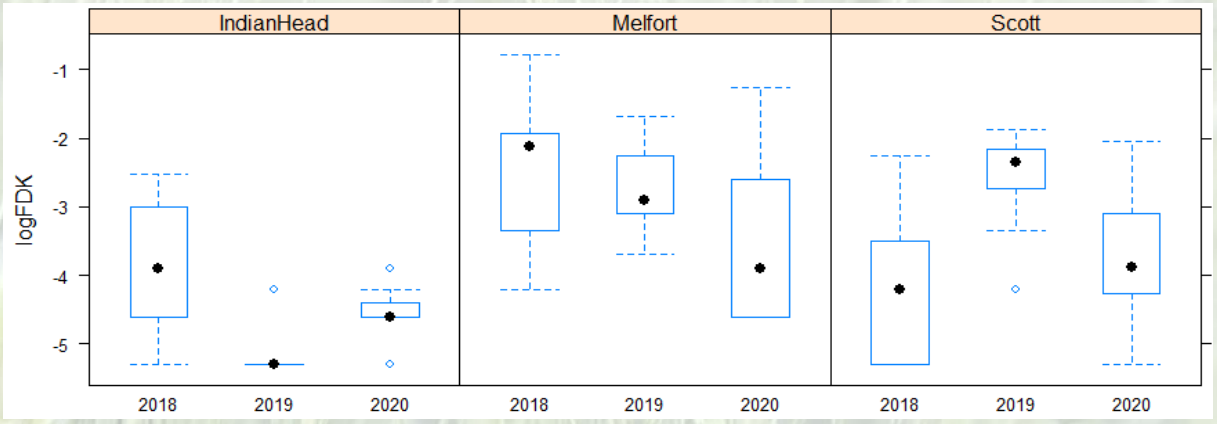
- Air temperature (GDD calculated)
- Regional precipitation
- Relative humidity
- Wind speed

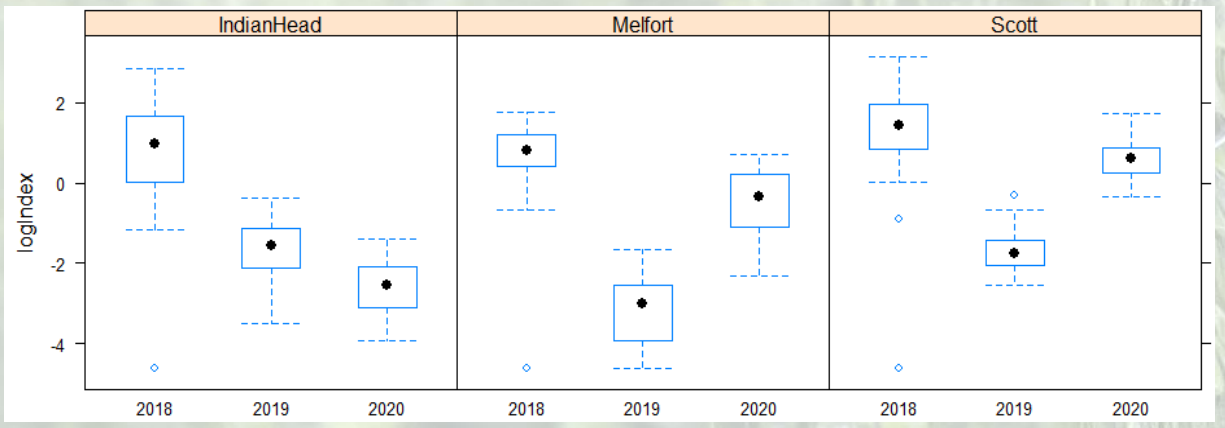
Environment Canada weather

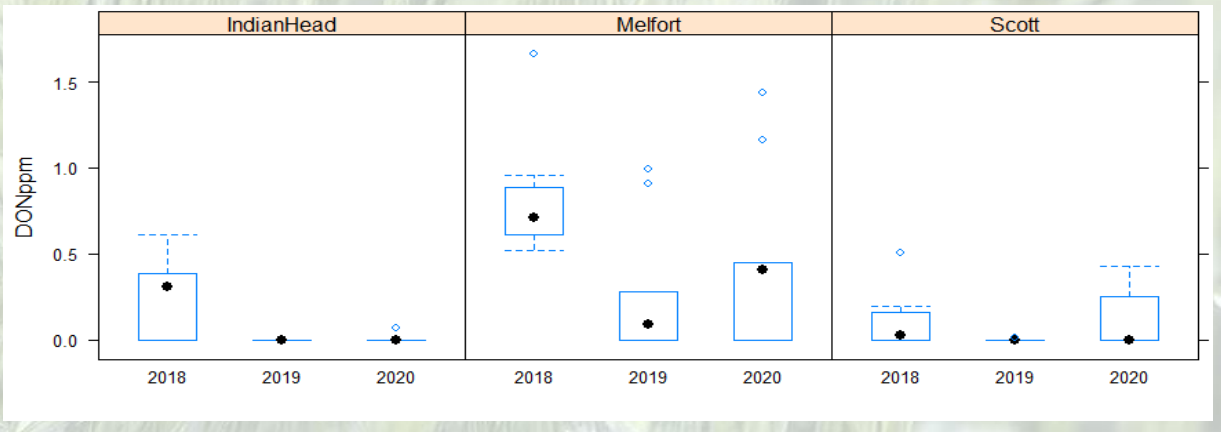
Environmental variables averaged or totaled for pre- and post-anthesis intervals of 3, 7, 14, and 30 days

Study 2: Interaction of management and environment on *Fusarium* in wheat

- Response variables: FHB Index, Fusarium Damaged Kernels (FDK), and % Deoxynivalenol (DON)







Study 2: Interaction of management and environment on *Fusarium* in wheat

- Results of forward-selection multiple regression for FDK
  - Differed significantly between varieties, fungicide product, active ingredient and mode of action, soil types, soil textures

Positive association

- # cereal crops in 4-year rotation
- Seed contamination with Fus. Gram.
- Seeding density
- Soil texture (increasing coarseness)
- Residual Mg
- Pre-anthesis:
  - Rain gauge precipitation
  - Regional precipitation
  - Relative humidity
- Post-anthesis:
  - Soil moisture
  - Rain gauge precipitation
  - Relative humidity

Negative association

- Seed size
- Seeding date
- Fungicide timing
- Repeated use of same fungicide group on previous wheat crops
- Anthesis date
- Subsoil pH
- Residual Sulfur
- Pre- and post-anthesis:
  - Soil temperature
  - Air temperature
  - GDD

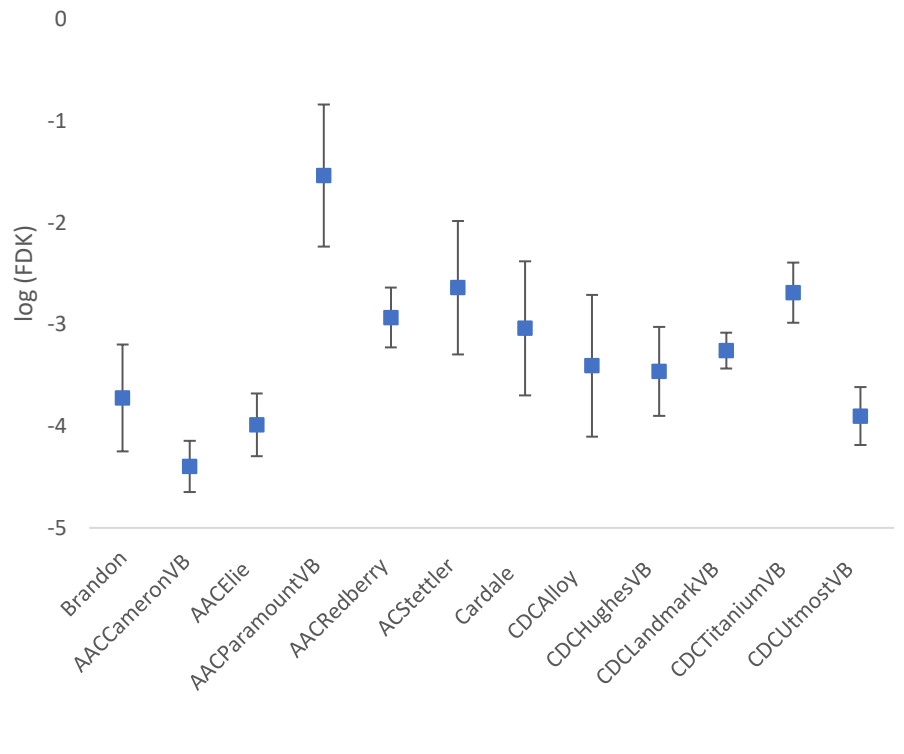
Study 2: Interaction of management and environment on *Fusarium* in wheat

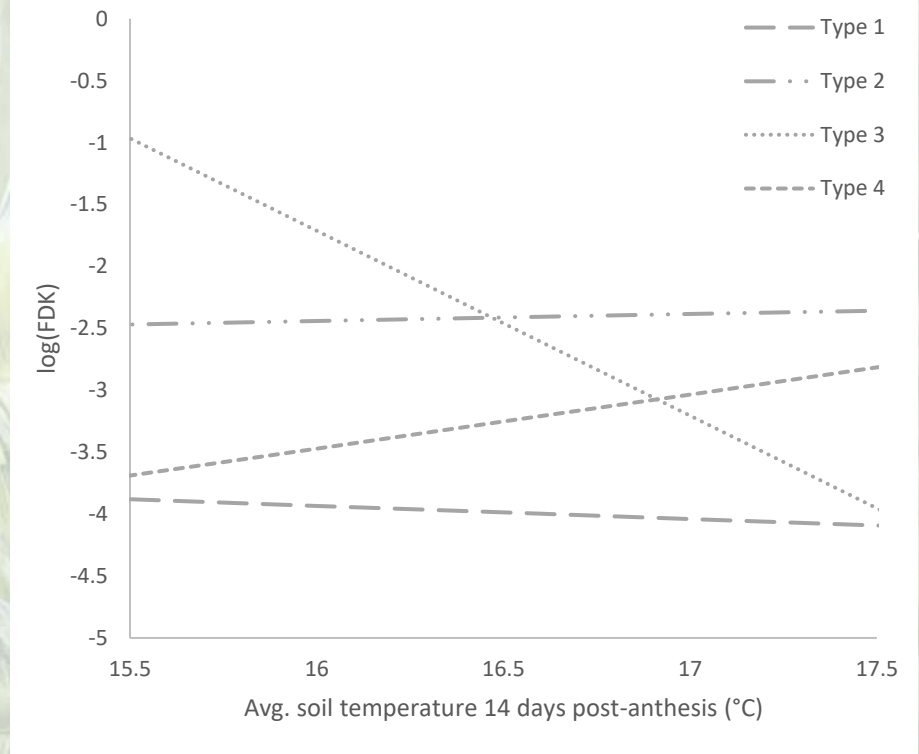
- Results of competing models for FDK

Model rank	Variable 1	Variable 2	w_i	P(>F) Variable 1	P(>F) Variable 2	P(>F) Interaction
1	Variety	avgSoilTemp14daysPost	0.999	<0.001	0.471	<0.001
2	Variety	avgSoilMois3daysPre	0.001	<0.001	0.603	<0.001
3	Variety	avgSoilTemp30daysPost	<0.001	<0.001	0.738	<0.001
4	Variety	avgSoilTemp3daysPost	<0.001	<0.001	0.556	<0.001
5	Variety	avgSoilTemp3daysPre	<0.001	<0.001	0.426	<0.001
6	Variety	avgSoilTemp7daysPre	<0.001	<0.001	0.611	<0.001
7	Variety	avgSoilTemp14daysPre	<0.001	<0.001	0.359	<0.001
8	Variety	avgSoilTemp30daysPre	<0.001	<0.001	0.406	0.001
9	fungProduct	avgRH14daysPost	<0.001	<0.001	0.351	<0.001
10	FHBresistance	seedDate	<0.001	<0.001	0.155	<0.001
11	fungGroup	avgRH14daysPost	<0.001	0.010	0.118	0.011
12	fungGroup	avgMeanT30daysPre	<0.001	0.036	0.007	0.035
13	fungActive	avgRH14daysPost	<0.001	0.010	0.336	0.010
14	soilTexture	anthesisDate	<0.001	0.006	0.711	0.006
15	FHBResistance	avgMeanT14daysPre	<0.001	<0.001	<0.001	<0.001
16	FHBResistance	avgSoilMois3daysPre	<0.001	<0.001	0.001	<0.001
17	soilTexture	avgSoilTemp3daysPre	<0.001	0.086	0.663	0.085
18	fungProduct	avgMeanT14daysPre	<0.001	0.011	0.402	0.009
19	FHBResistance	avgSoilMois3daysPost	<0.001	<0.001	<0.001	<0.001
20	fungGroup	avgRH7daysPost	<0.001	0.012	0.020	0.014

Study 2: Interaction of management and environment on *Fusarium* in wheat

- Results of competing models for FDK





Study 2: Interaction of management and environment on *Fusarium* in wheat

- Results of competing models for FDK

Model rank	Variable 1	Variable 2	w_i
9	fungProduct	avgRH14daysPost	0.524
10	FHBresistance	seedDate	0.193
11	fungGroup	avgRH14daysPost	0.084
12	fungGroup	avgMeanT30daysPre	0.066
13	fungActive	avgRH14daysPost	0.056
14	soilTexture	anthesisDate	0.014
15	FHBresistance	avgMeanT14daysPre	0.013
16	FHBresistance	avgSoilMois3daysPre	0.007
17	soilTexture	avgSoilTemp3daysPre	0.006
18	fungProduct	avgMeanT14daysPre	0.006

Model weights without variety

Study 2: Interaction of management and environment on *Fusarium* in wheat

- Conclusions and Recommendations
  - Most recommended management practices – variety and fungicide – were highly influential
    - Fungicide application timing not highly weighted
  - Crop rotation variables not highly ranked, though often recommended as key integrated management strategy
  - Environmental variables not additive, largely interactive with management
    - Predictive models should take into account interactive effects of management – especially, variety and fungicide strategy

There's more than one way to do on-farm research….

- Be open-minded to research opportunities that fall out of the scope of "classic" agronomy research
- Observational studies can be conducted at field scale but don't require maintaining field trials or plots
- Classic designs have high interpretability, and most are familiar with the concept
- How can we modify typical study design to increase adoption?

Acknowledgements

- Funding organizations, Saskatchewan Canola Development Commission (SaskCanola) and Saskatchewan Wheat Development Commission (SaskWheat)
- Collaborators Jessica Enns and Kayla Slind at the Western Applied Research Corporation (WARC), Brianne McInnes and Jessica Slowski at the Northeast Agriculture Research Foundation (NARF)
- IHARF staff, in particular, seasonal technicians Michelle Ross, Logan Fahlman, and Marissa Glofcheskie.
- Above all, the cooperative involvement of local producers was invaluable in the completion of these projects.

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