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Ultra-early seeding improves yield and stability of wheat

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Canada

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Alberta Grains

Alberta Pulse Growers

WGRF

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University of Saskatchewan

POGA Prairie Oat Growers Association

Saskatchewan Pulse Growers

Western Ag Innovations

Integrated Crop Agronomy Cluster

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Alberta Innovates Bio Solutions

Saskatchewan

SaskCanola

Manitoba Crop Alliance

Farming Smarter Growing new ideas

Crop Production Services CPS

B.C. Grain Producers Association

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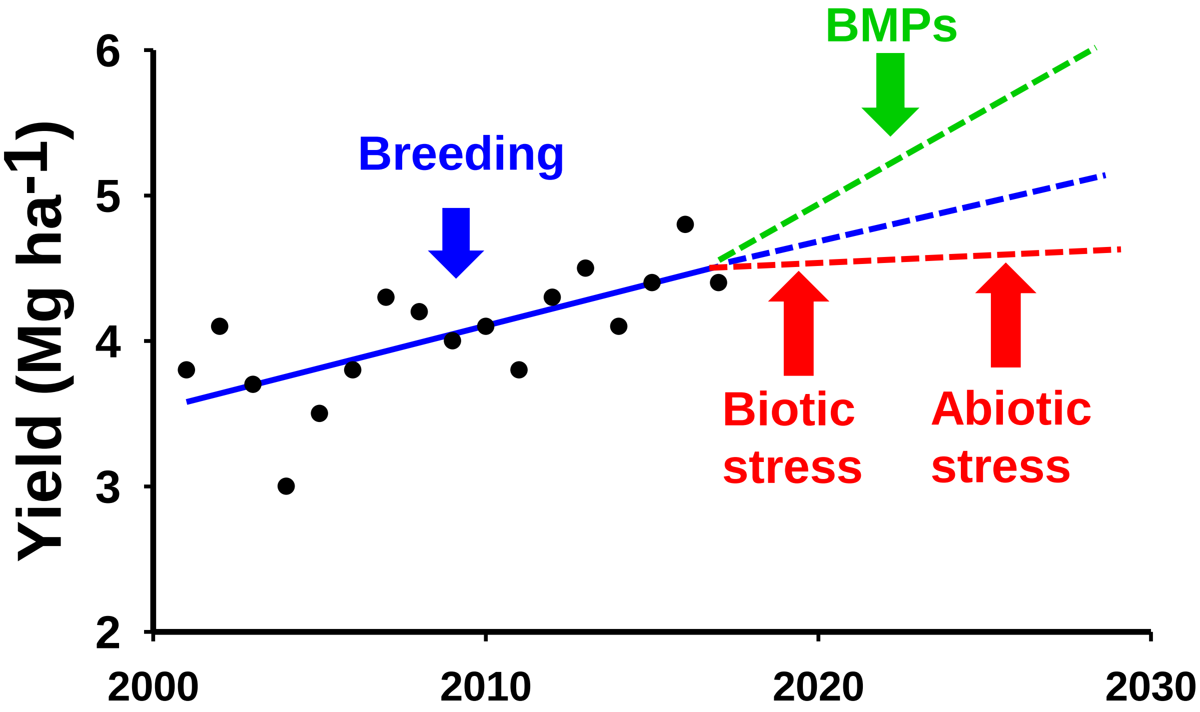
Trend of crop yield



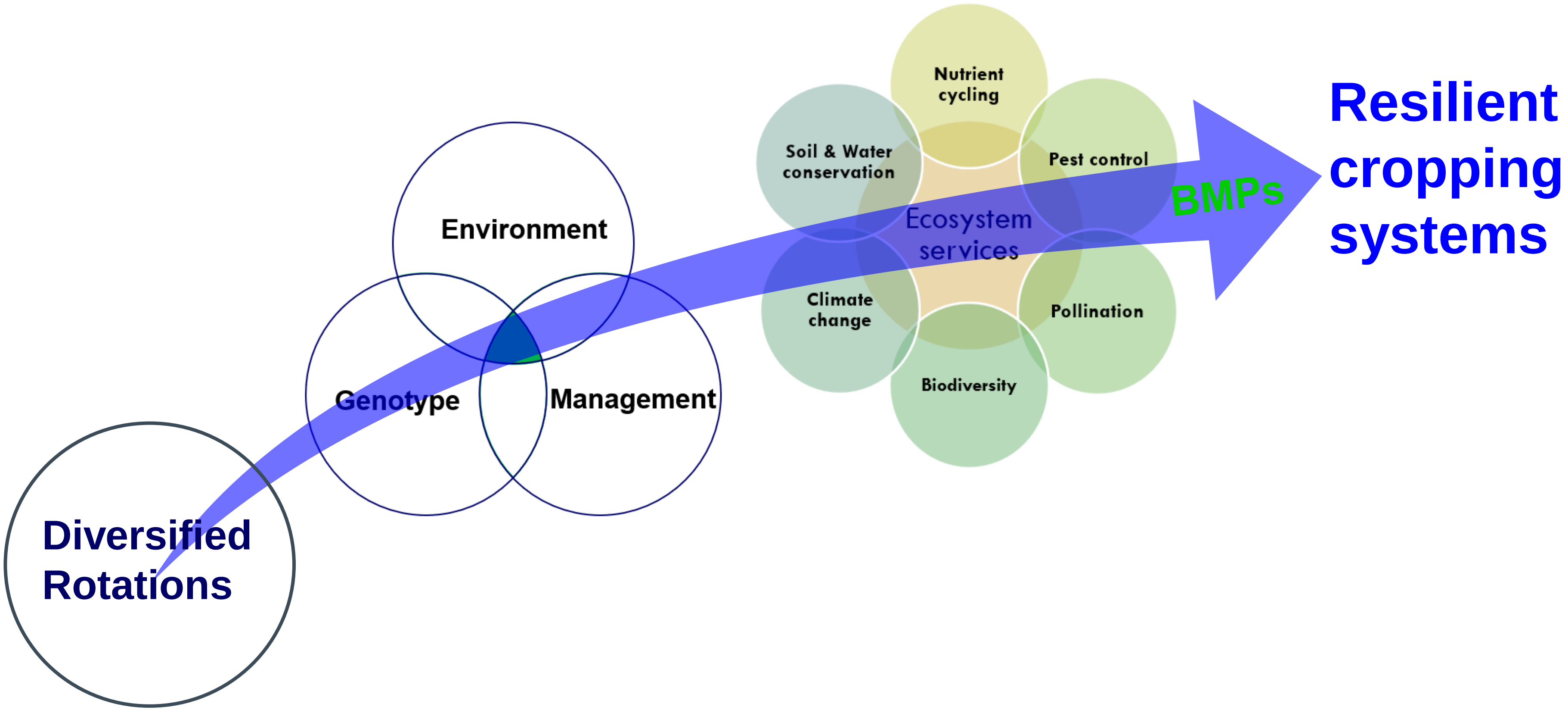
- Adopt BMPs to enhance resilience to biotic and abiotic stresses; however, producers struggle with developing BMPs

Climate change trends on the prairies

Growing degree days	Canada (1948–2016)	Increase (15 degree-days)	Vincent et al. (2018)
	Alberta agricultural region (1901–2002)	Increase (77.5 degree-days)	Shen et al. (2005)
Effective growing degree days	Canada (1895–2007)	Increase (172 degree-days)*	Qian et al. (2010)
Frost-free period	Canada (1895–2007)	Increase (22.0 days)*	Qian et al. (2010)
	Canada (1948–2016)	Increase (20.1 days)	Vincent et al. (2018)
	Southern Canada (1900–2016)	Increase (25 days)	Vincent et al. (2018)
	Alberta agricultural region (1901–2002)	Increase (13.3 days)	Shen et al. (2005)
Killing-frost-free period	Canada (1895–2007)	Increase (21.6 days)*	Qian et al. (2010)
Number of frost days	Canada (1948–2016)	Decrease (15 days)	Vincent et al. (2018)
	Southern Canada (1900–2016)	Decrease (22.9 days)	Vincent et al. (2018)
Growing season length	Canada (1948–2016)	Increase (15 days)	Vincent et al. (2018)
	Southern Canada (1900–2016)	Increase (15 days)	Vincent et al. (2018)
	Canada (1950–2010)	Increase (10.2 days)	Natural Resources Canada (2020)
	Prairies (1920–2020)	Increase (3–12 days)	Major et al. (2021)
	Alberta agricultural region (1901–2002)	No change (0 days)	Shen et al. (2005)
Average annual precipitation	Canada (1948–2012)	Increase (19%)	Vincent et al. (2015)
	Southern Canada (1900–1998)	Increase (12%)	Zhang et al. (2000)
	Southern Canada (1900–2012)	Increase (18%)	Vincent et al. (2015)
	Western Canada (1950–2010)	Increase (9.6 cm) and decrease (6 cm)	O'Neil et al. (2017)
Number of days with rainfall	Canada (1948–2016)	Increase (7.4 days)	Vincent et al. (2018)
	Southern Canada (1900–2016)	Increase (8 days)	Vincent et al. (2018)
Number of rainfall events	Agricultural Prairies region (1951–2004)	Increase (16–21 events)*	Cutforth and Judiesch (2007)
Intensity of rainfall events	Agricultural Prairies region (1951–2004)	Decrease (23.3%)*	Cutforth and Judiesch (2007)
Average annual rainfall	Prairies (1956–1995)	Increase (51.2 mm)	Akinremi et al. (2001)
Growing season precipitation	Prairies (1956–1995)	Increase (39.2 mm)	Akinremi et al. (2001)
	Alberta agricultural region (1901–2002)	Increase (18 mm)	Shen et al. (2005)
	Alberta (1901–2002)	Increase (32 mm)	Shen et al. (2005)
Off season precipitation	Western Canada (1950–2010)	Decrease (0–3 cm)	O'Neil et al. (2017)
	Alberta (1950–2017)	Decrease (3.5 cm)	Newton et al. (2021)
Snow cover duration	Canada (1948–2012)	Decrease (18 days)	Vincent et al. (2015)

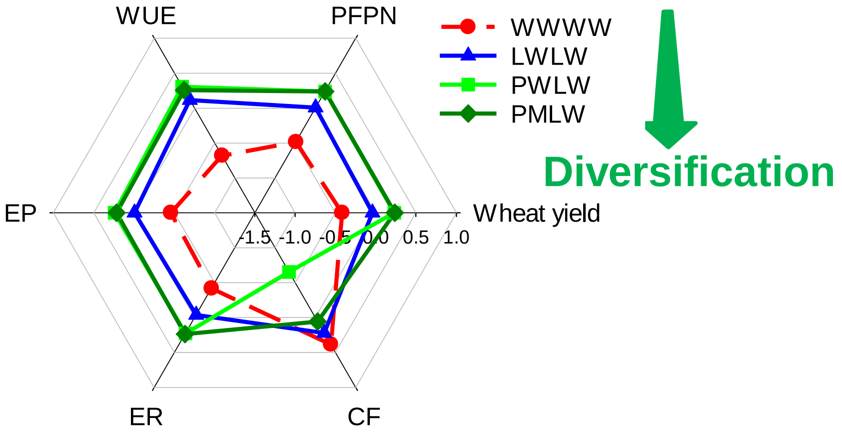
Mapfumo et al. 2023. Historic climate change trends and impacts on crop yields in key agricultural areas of the prairie provinces in Canada: a literature review. Can. J. Plant Sci.

Pathways towards resilient cropping systems

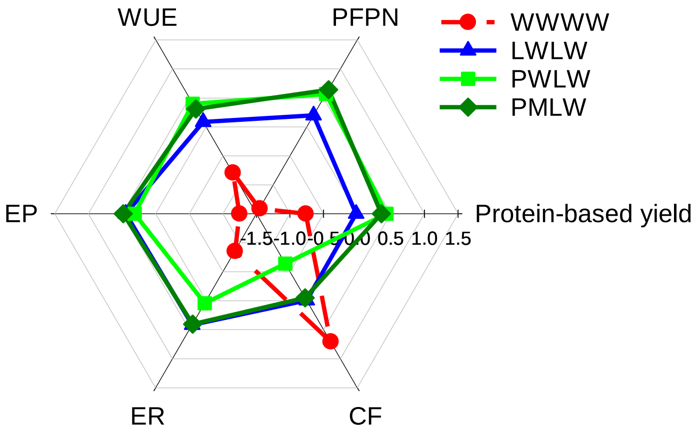


Multiple indicator assessment of crop diversification with pulse crops

at wheat phase



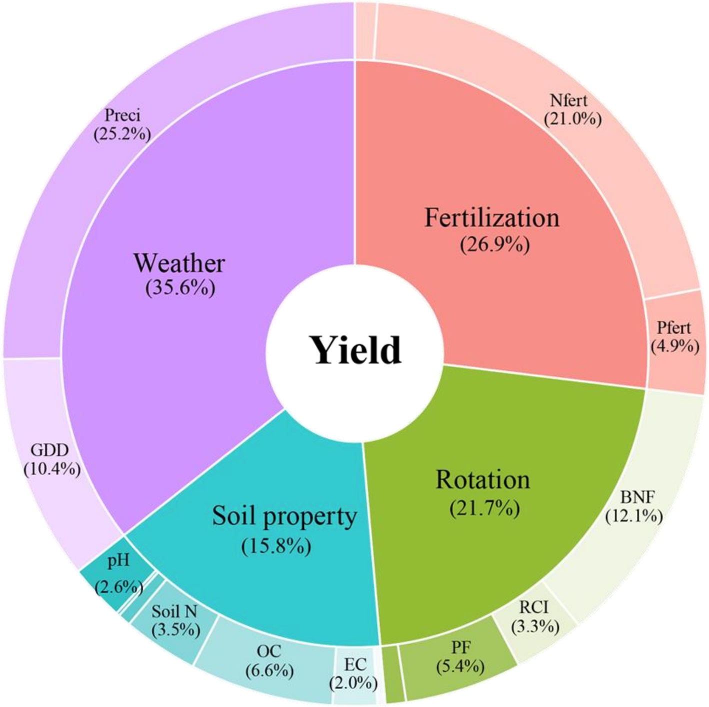
at 4-yr crop rotation level



- In general, crop diversification produces benefits.
- Over-diversifying cropping systems may not be necessary to achieve the maximal benefits

Liu, et al. 2025. Diversifying wheat-based cropping systems with pulse crops enhances ecosystem services. Agronomy for Sustainable Development. doi.org/10.1007/s13593-025-01009-2

Key factors affecting yield in the Canadian Prairies



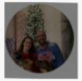
- Top two factors affecting yield: **precipitation** and N management
- The development of site-specific cropping systems is necessary to mitigate drought effects and optimize overall performance

Wen, G., Liu, K., Kubota, H., Peng, G., Semach, G., Lokuruge, P., Chau, H. W. and Khakbazan, M. 2025. Precipitation and nitrogen management are key drivers of cropping system productivity in the Canadian prairies. Can. J. Plant Sci.

Background: early seeding

- What is the optimum soil temperature?
  - Alberta Agriculture and Forestry indicates 20º C (http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex1203)
  - Most studies and crop insurance refer to dates over soil temperature ie. By May 10th for cereals in s. Alberta
  - In recent years, there is opportunity to get on land earlier, a trend we expect to continue.
  - Growing degree day requirements are increasing for wheat ie. Longer days to maturity for new higher yielding varieties

Conventional thinking…from Twitter



Chris Blenkin @crblenkin · 1h

With warmer temperatures this week some people may start to think about early seeding. Here's some info on ideal soil temp for germ. But just remember if your getting that itch to early seed come on in to @NutrienAg_SAB Coaldale, have a coffee and distract yourself for a bit.

	CROP	MIN. TEMP. (°C)	PREFERRED TEMP. (°C)
CEREALS AND OILSEEDS	Wheat	4	20
	Barley	3-5	20
	Oats	5	20-24
	Argentine canola	5	15-20
	Polish canola	7-10	15-20
	Flax	7-10	15-20
PULSES	Peas	4	4-24
	Kabuli chickpeas	12	12-29
	Desi chickpeas	5	7-29
	Dry beans	12	15-24
	Lentils	5	7-24
	Soybeans	8-10	16-30
FORAGES	Alfalfa	1	25
	Birdsfoot trefoil	1	26
	Red clover	3	25
	Sweet clover	1	18-25
	White clover	5	18-20
	Fescues	3	13-18
	Orchardgrass	4	18-20
	Timothy	4	18-22

Chris Blenkin and 6 others

1 2

Ultra-early durum wheat seeding, 2022-2024

Experiment 318
To determine if crop phenology and yield component responses differ between CWAD and CWRS wheat cultivars when planted into a range of soil temperatures.

Treatments:

Factor 1: Cultivars (3)

1. CT-CWAD1 (CDC Defy)
2. CT-CWAD2 (Stronghold)
3. CT-CWAD3 (AAC Donlow)
4. Transcend
5. CDC Desire

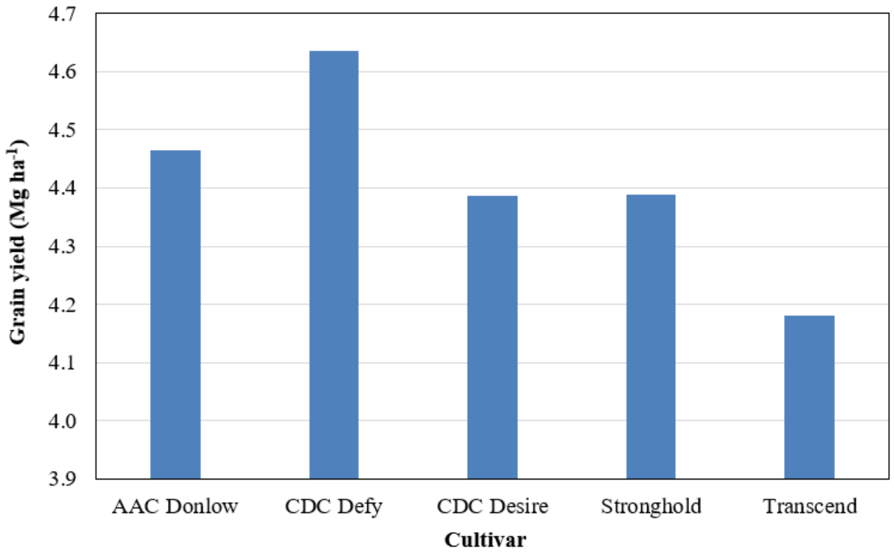
Factor 2: Planting Date (6):

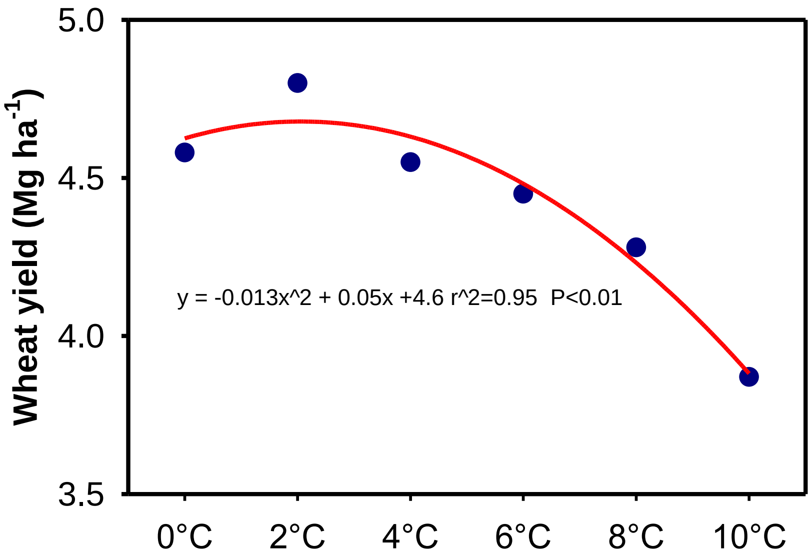
1. Soil temp in top 5 cm = 0° C
2. Soil temp in top 5 cm = 2° C
3. Soil temp in top 5 cm = 4° C
4. Soil temp in top 5 cm = 6° C
5. Soil temp in top 5 cm = 8° C
6. Soil temp in top 5 cm = 10°C

Total factorial combination treatments = 30 treatments x 4 replicates = 120 plots

Locations: Lethbridge, AB (2 locations - irrigated and dryland); Indian Head, Saskatoon, Swift Current, SK

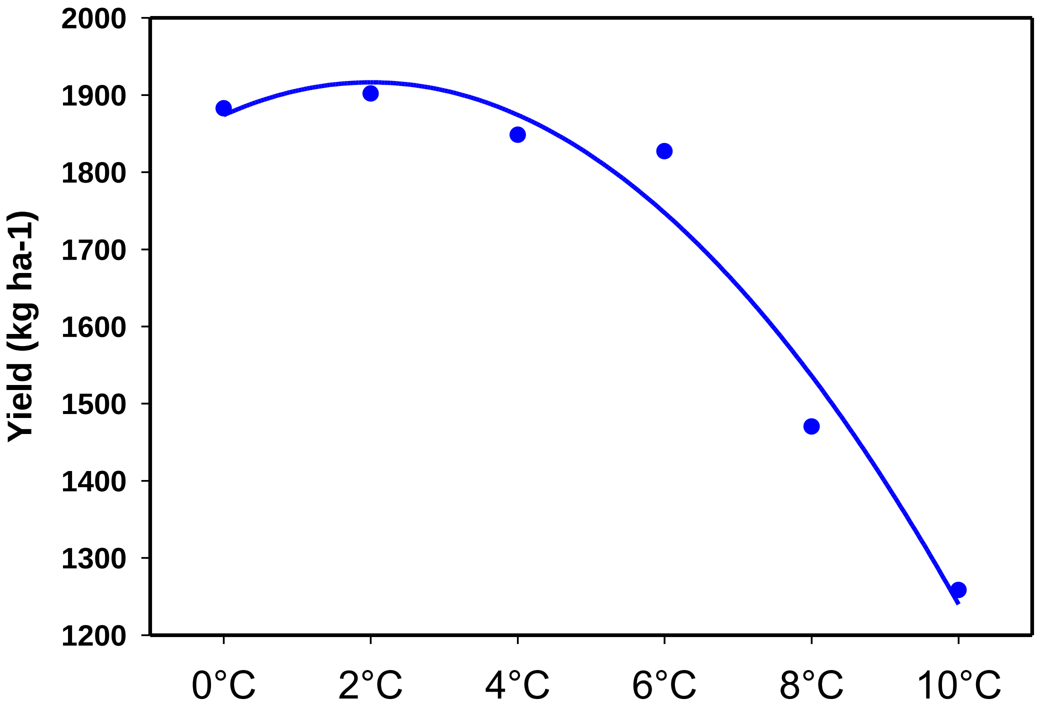
Ultra-early durum wheat seeding



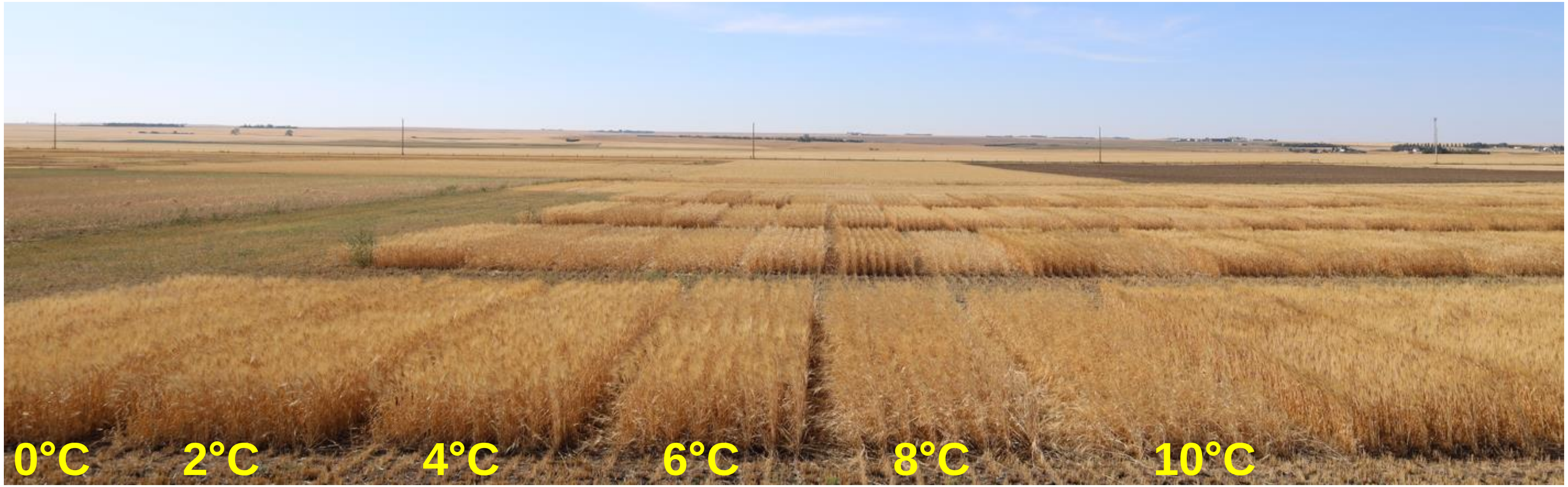


Averaged over 5 Locations: Lethbridge (Dry & Irr.), Indian Head, Saskatoon, & Swift Current.

Ultra-early durum wheat seeding, Swift Current, 2024



Stem sawfly damage increased with later seeding dates, Swift Current, 2024



0.6% **0.5%** **5%** **8%** **26%** **27%** (sawfly cut rate)

Dormant-seeding

Experiment 319

This experiment will determine conventional CWAD and cold tolerant durum wheat responses to manipulations made to the agronomic system in which they are grown.

Treatments:

Factor 1: Cultivar (3)

1. CT-CWAD1 (CDC Defy)
2. CT-CWAD2 (Stronghold)
3. Transcend

Factor 2: Seed Depth (2):

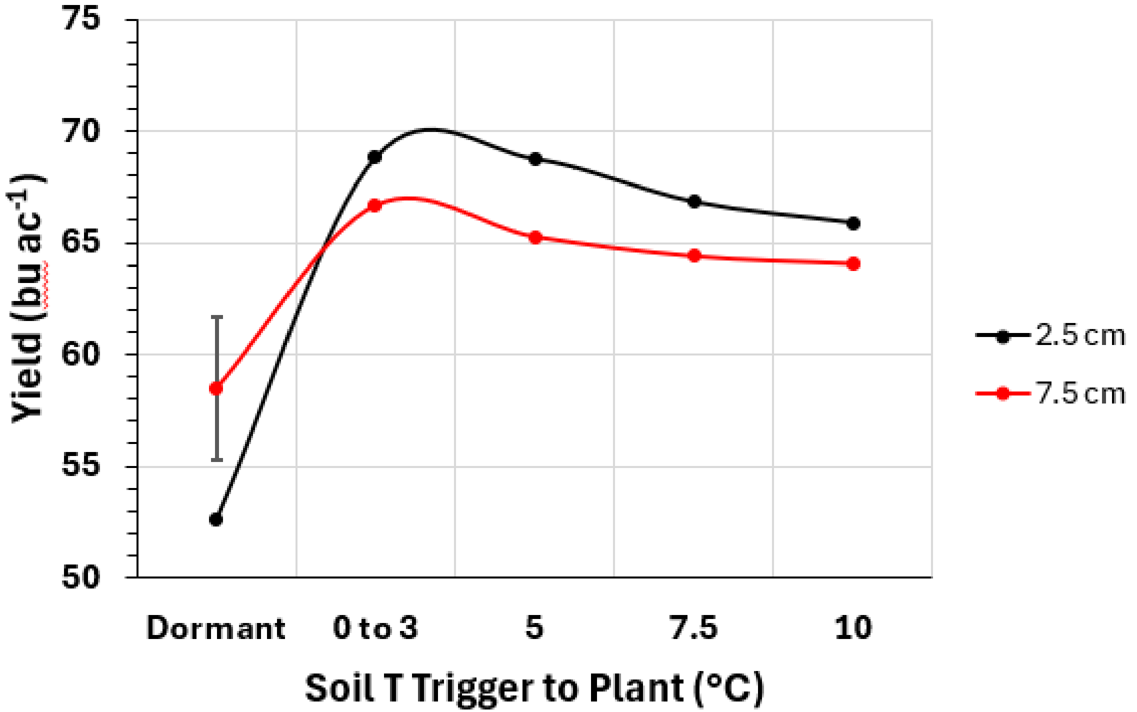
1. 2.5cm depth
2. 7.5cm depth

Factor 3: Planting Date/Trigger (5)

1. When soil temp in top 5 cm = 0 – 3° C
2. When soil temp in top 5 cm = 5° C
3. When soil temp in top 5 cm = 7.5° C
4. When soil temp in top 5 cm = 10° C
5. Dormant-seeded (November-January soil temps at 2” should be ≤ 0-2° C)

Total factorial combination treatments = 30 treatments x 4 replicates = 120 plots.

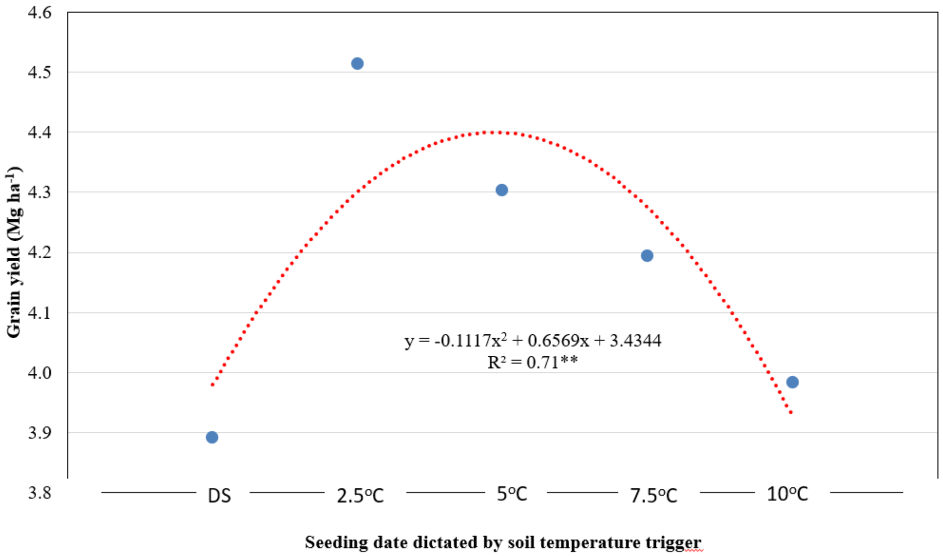
Yield responses to seeding depth of ultra-early durum seeding



- Dormant seeding occurs in fall when temperatures in top 5cm (2”) fall below 2° C.
- Ultra-Early seeding occurs in winter/spring when soil T starts to warm to specified ‘trigger temps’ in winter/spring ie. 0 to 3°C

5 sites: Lethbridge (Dry & Irr.), Indian Head, Saskatoon, & Swift Current

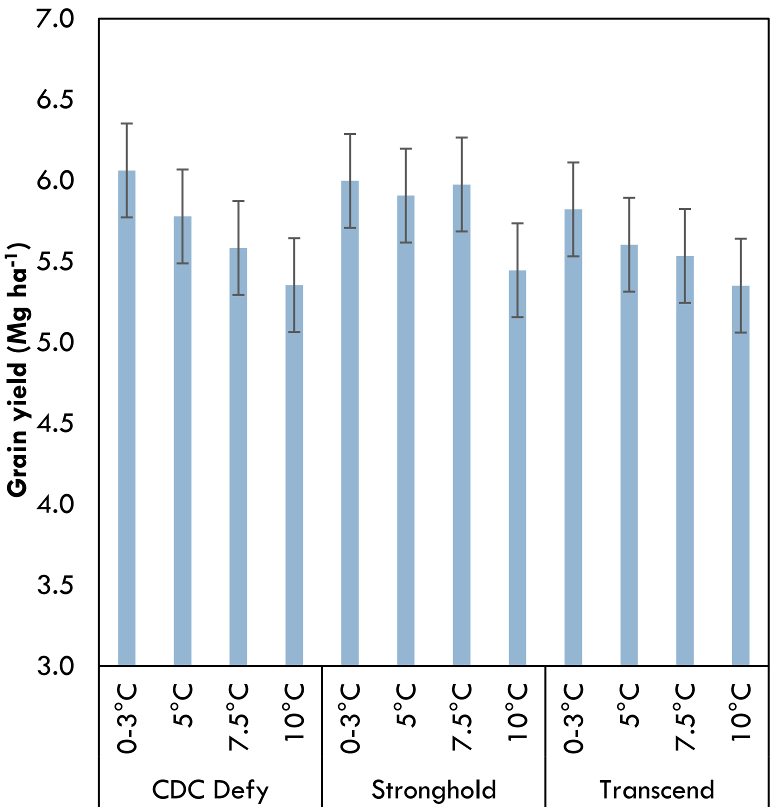
Dormant-seeding in November



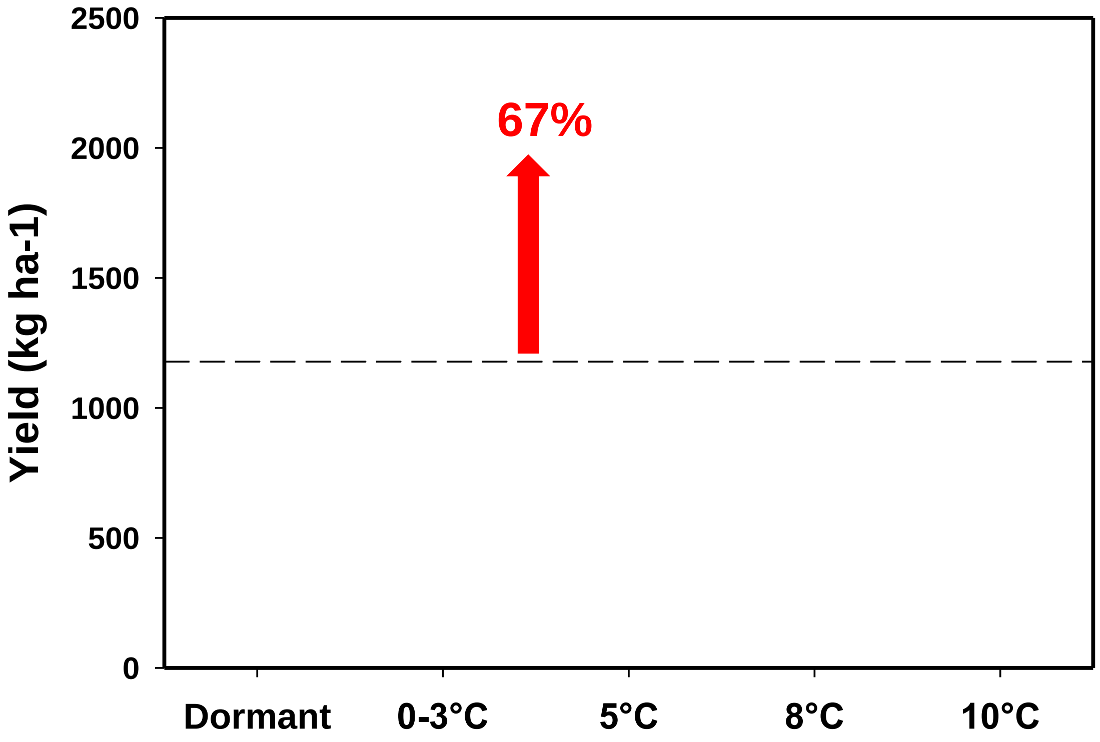
DS: dormant seeding in fall (Nov/Dec) of previous year when soil temp ≤ 2º C .

5 Locations: Lethbridge (Dry & Irr.), Indian Head, Saskatoon, & Swift Current.

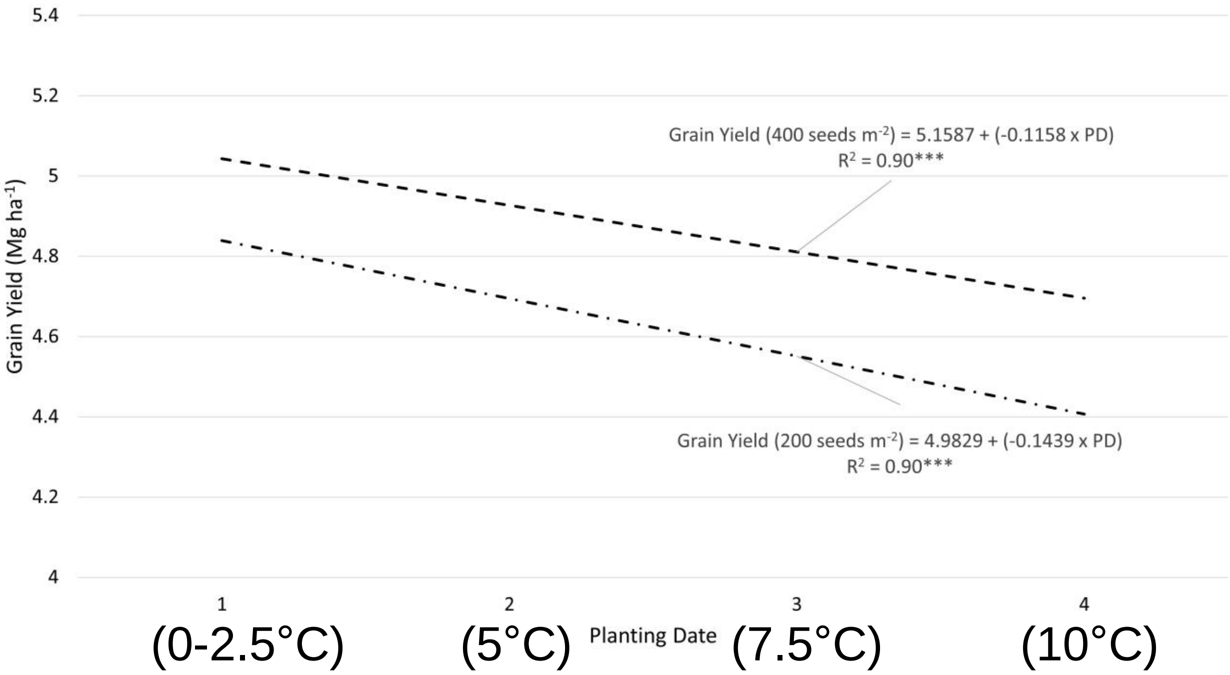
Dryland durum planted at select soil temp triggers, Lethbridge, 2024



Durum planted at select soil temp triggers, Swift Current, 2024



Yield responses to ultra-early sowing and seeding rates



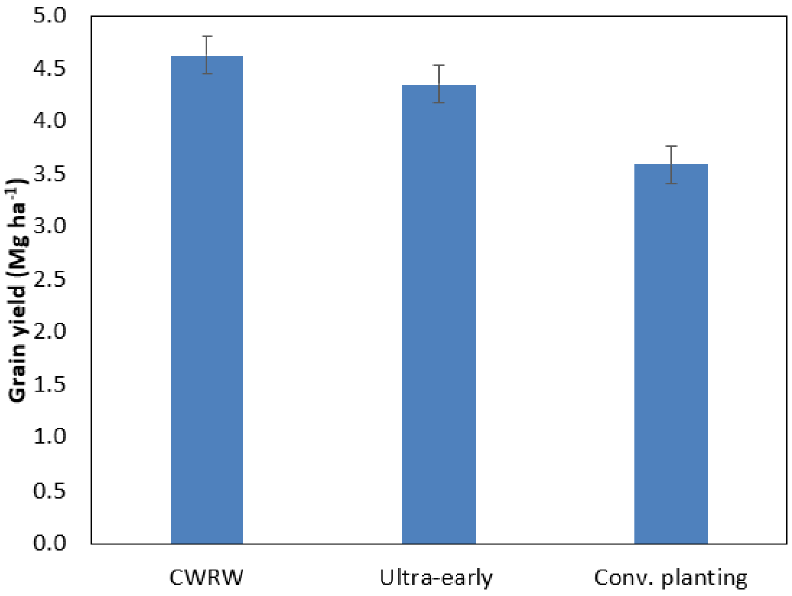
Wheat grain yield as a function of planting date at **13** environments on the northern Great Plains. (Collier et al. 2021. Agronomy)

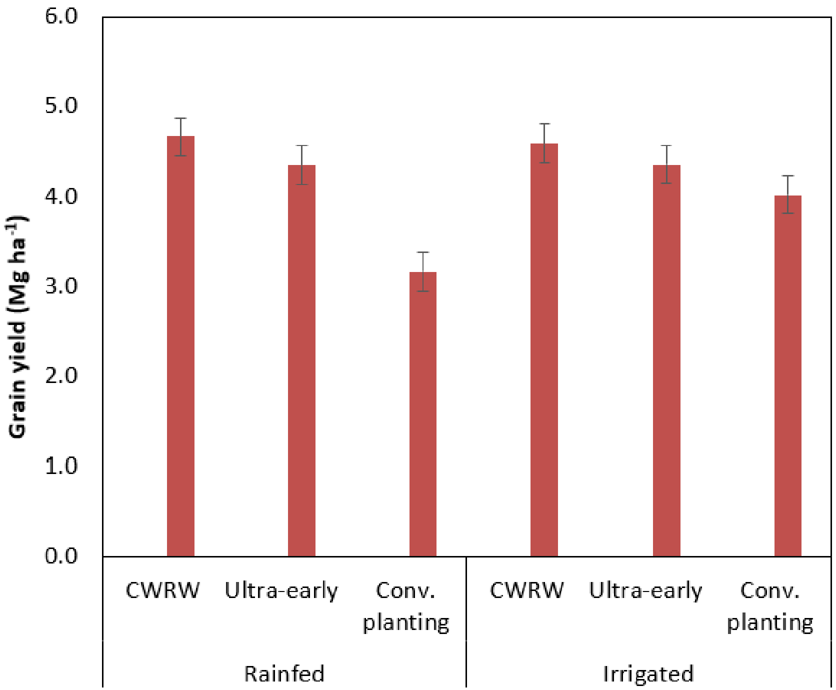
Early adaptor's feedback

n	Earliest seeding date (based on soil temperature of 0°C)	Number of individual days temperatures were below 0°C after first seeding	Lowest temperatures experienced
2015	March 6	37	-6.7 °C (10 nights below -3)
2015	April 9	12	-4.2 °C (1 night below -3)
k 2015	April 16	12	-5.0 °C (3 nights Below -3)
Swift Current 2015	April 10	23	-6.4 °C (6 nights below -3)
Lethbridge 2016	February 16	36	-10.2 °C (21 nights below -3)
Edmonton 2016	March 29	11	-3.6 °C (2 nights below -3)
Dawson Creek 2016	April 21	11	-6.1 °C (4 nights below -3)
Scott SK. 2016	April 2	21	-9.8 °C (12 nights below -3)

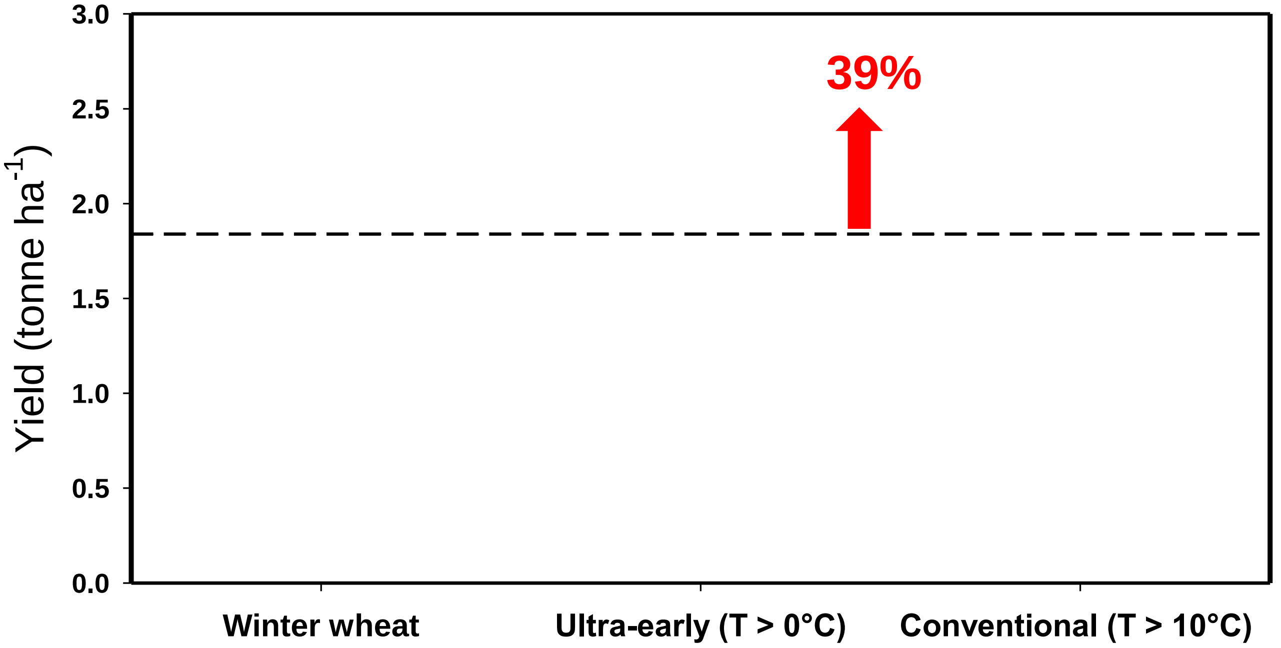
Collier, et al. 2020. Front. Plant Sci. 11:89 doi: 10.3389/fpls.2020.00089

Winter wheat vs ultra-early wheat vs. conv. wheat, Lethbridge, 2024

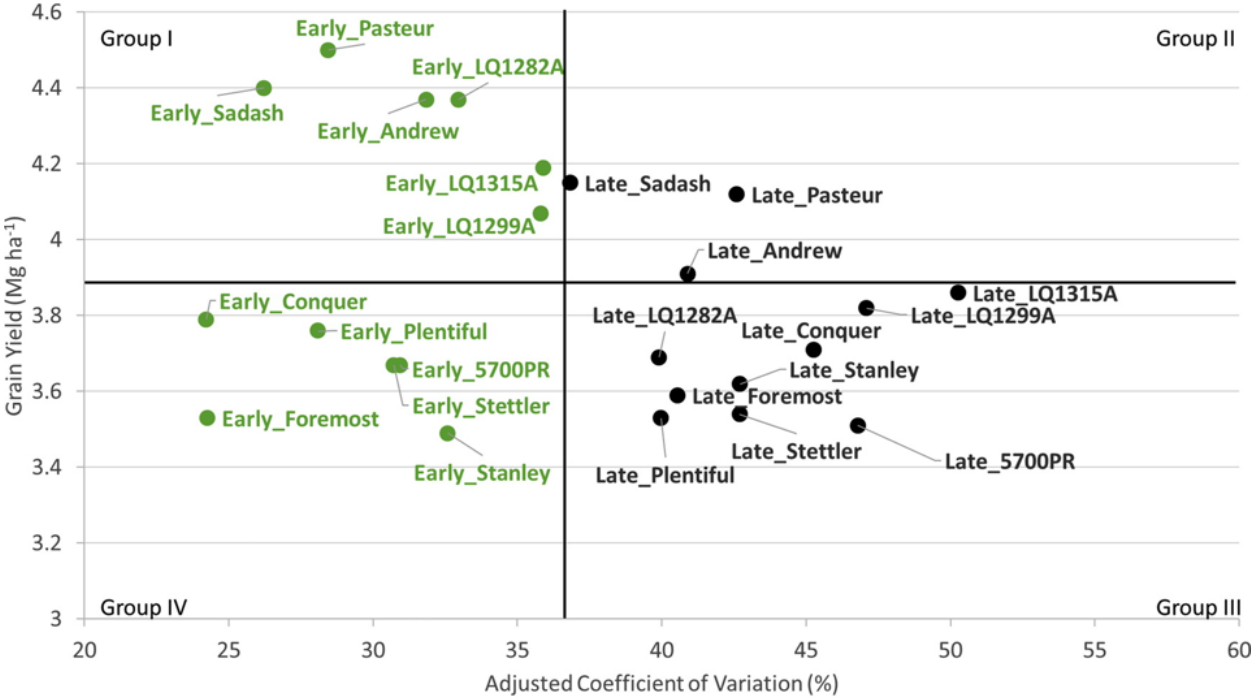




Winter wheat vs ultra-early wheat vs. conv. wheat, Swift Current, 2024



Early-seeding improves yield stability for different wheat market class varieties



- 3 sites: Edmonton, Lethbridge, and Scott
- Duration: 2017-19
- Early = 2°C; late = 8°C

Collier et al. 2021. Canadian Journal of Plant Science

Weed control in ultra-early seeding

Fall-applied soil residual herbicides in ultra-early wheat growing systems

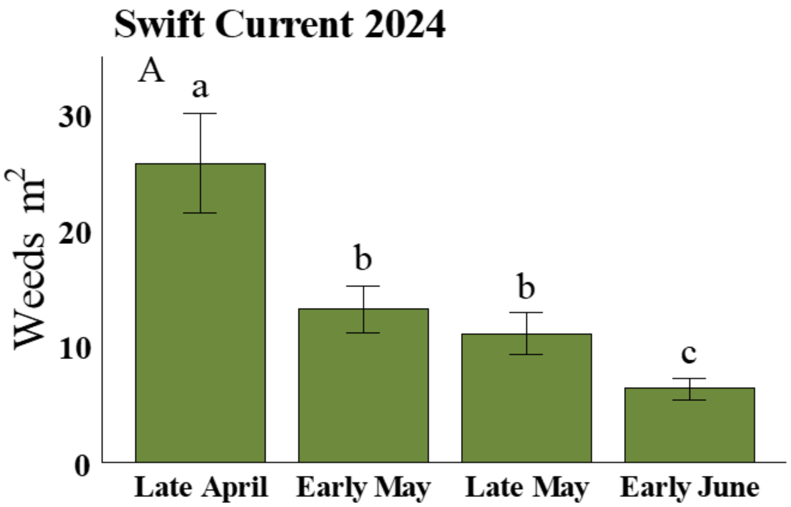
- Soil applied residual chemistries are commonly used in pulse crop production in western Canada where in-crop herbicide options are limited.
  - Newer chemistries including flumioxazin (Group 14) and Pyroxasulfone (Group 15) can be applied in the fall, planted into the following spring and provide residual weed control into the growing season.
- Wheat planted ultra-early after fall applications of Flumioxazin (Valtera), Pyroxasulfone (Pyroxasulfone 85wdg) and Flumioxazin + Pyroxasulfone (Fierce) did not exhibit crop injury
- Weed control extended well into the growing season
  - Fewer, smaller weeds present at in-crop herbicide application times
- Fall-applied residual herbicides successfully replaced spring burndown herbicide applications as weed management tools in ultra-early wheat growing systems.

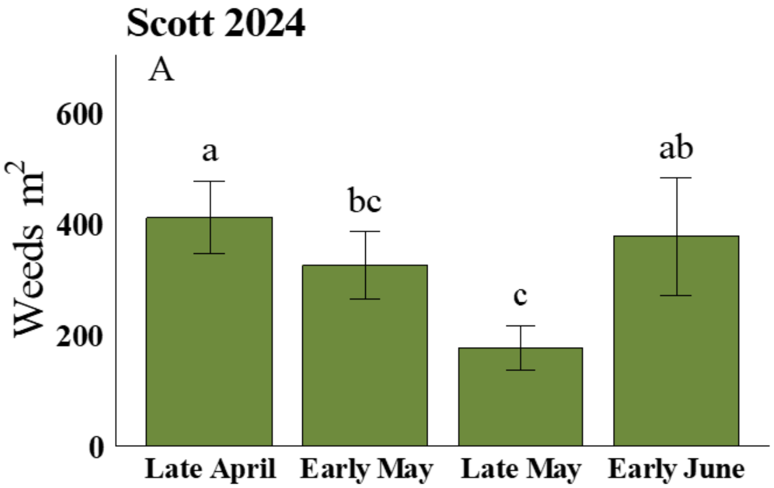
(Collier et al. 2022)

Early seeding of organic wheat, 2024

- 2 sites: Swift Current and Scott, SK
- Treatments
  - Factor 1: seeding date
    - Late April, early May, late May, early June
  - Factor 2: weed management
    - Control, living clover mixture mulch, interrow tillage, living clover mixture mulch + interrow tillage
- AAC Brandon (400 seeds m^{-2})

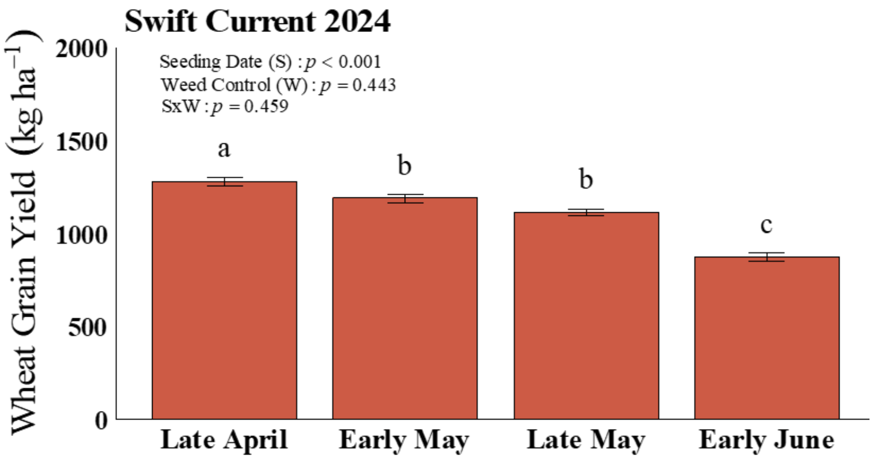
Early seeded organic wheat - weeds

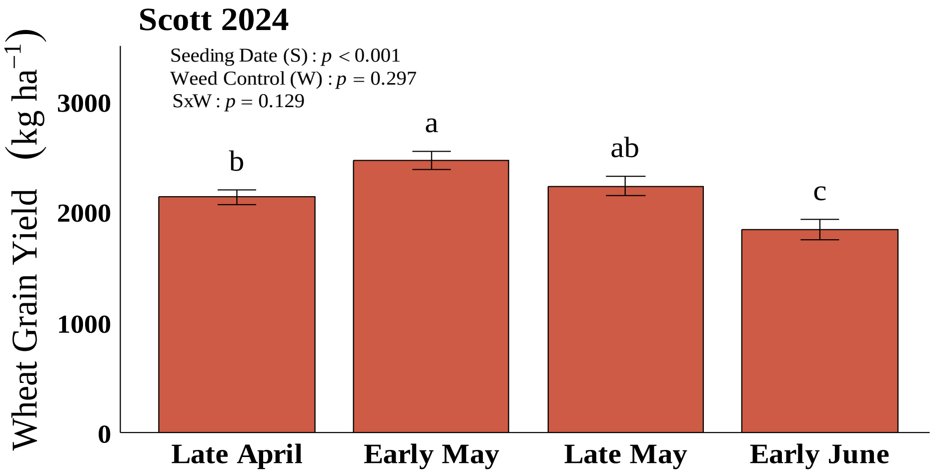




Weed pressure is about 20 times higher in Scott than in Swift Current, significantly affecting yield performance.

Early seeded organic wheat - yield





The relatively lower yield in early seeding in Scott is due mainly to excessive weed pressure

Theories behind yield improvement in ultra-early seeded wheat

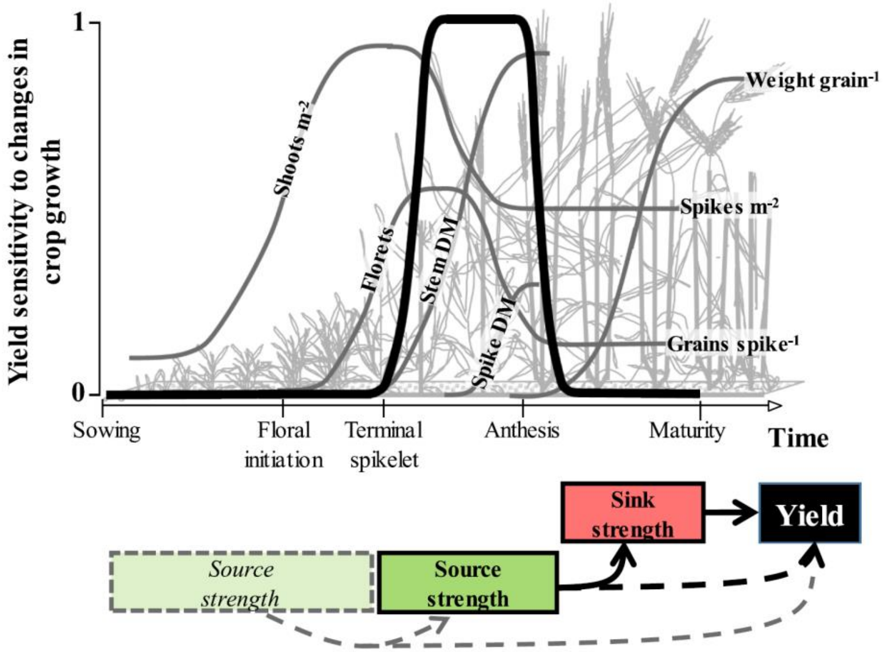
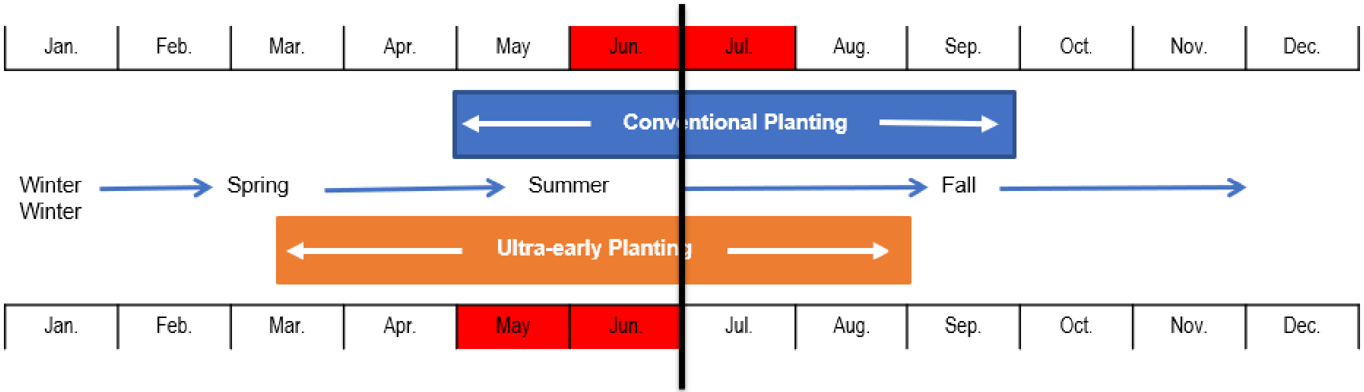


Fig. 2. Changes in the sensitivity of yield to crop growth from sowing to maturity (thick black line). The thinner grey lines show (not to scale) the dynamics of (i) tillering and tiller survival (Shoots m^{-2}) resulting in the final number of spikes m^{-2}; (ii) floret initiation and mortality (Florets) determining firstly the number of fertile florets and later the number of grains per spike; (iii) growth of stems (Stem DM) and spikes (Spike DM) before anthesis; and (iv) grain growth (weight $grain^{-1}$). Crop growth before the critical period (light green box) would affect yield only to the extent that it affects growth during the critical period (dashed grey arrow). (a) Coloured boxes highlight the minor role of source-strength before the critical period (light green), the major role of source strength in the critical period driving grain number (dark green), and the sink-limitation during grain fill (red box). (b) Plain arrows refer to the fact that yield is mostly sink-limited by the number of grains set (and their potential weight; Slafer et al., 2023) during the effective period of grain filling, and that the level of sink-strength at that stage is determined by the source-strength (linearly related to crop growth) during the critical period (when source-strength does determine yield; black dashed line).
(c) Adapted from Slafer and Savin (2006); Slafer et al. (2021); and Reynolds et al. (2022).

Slafer et al. 2023. Wheat yield is not causally related to the duration of the growing season. Euro. J. of Agron.

Agronomic basis for yield improvement in ultra-early seeded wheat



Typical onset of ≥30°C temps ↓ floret dev & can shorten critical growth period

Crop phenological cycles - planting (Left side of rectangle) to harvest (right side of rectangle) for spring wheat planted on the northern Great Plains. Critical growth period is denoted by the red highlighted months.

Graham R. S. Collier, Dean M. Spaner, and **Brian L. Beres***. 2024. Learning to balance wheat G × E × M interactions in response to a changing climate – the case for ultra-early planting systems. *Agronomy Journal*, 116, 395–414.

Benefits and risks of ultra-early seeding wheat systems

- Capture of early season moisture, snow melt and early rainfall.
- Accumulation of early season growing degree days.
- Early canopy closure – improved radiation use and weed competitive ability.
- Longer vegetative growth periods, more leaf area.
- Earlier, potentially longer grain filling.
- Avoidance of temporally dependent pests ie. Orange Blossom Wheat Midge, Wheat Stem Sawfly, FHB.
- Distribution of farm labour and capital costs.
- In other words: ≥yield, >yield stability, >$$$. Can parallel the benefits captured from a winter wheat system
- Risk – Field conditions not always amenable to planting at soil temp trigger

What have we learned?

- No yield penalty for seeding at 2°C, and in some environments, yield drag observed when soil temp > 6°C.
- Higher seeding rates have increased yield potential and stability.
- Delayed planting + lower seeding rates ie. May 1st in Lethbridge, AB when soil temp = 13.6 degrees C vs. using a soil temp trigger of 0-2.5 degrees = a loss of $206/ha


Sustainable crop production for resilient Canadian agriculture
June 23-26, 2025, Kelowna, BC

Thank you!

For more information, please contact:

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