Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Wheat Drought and Heat Stress Research and Breeding within AAFC

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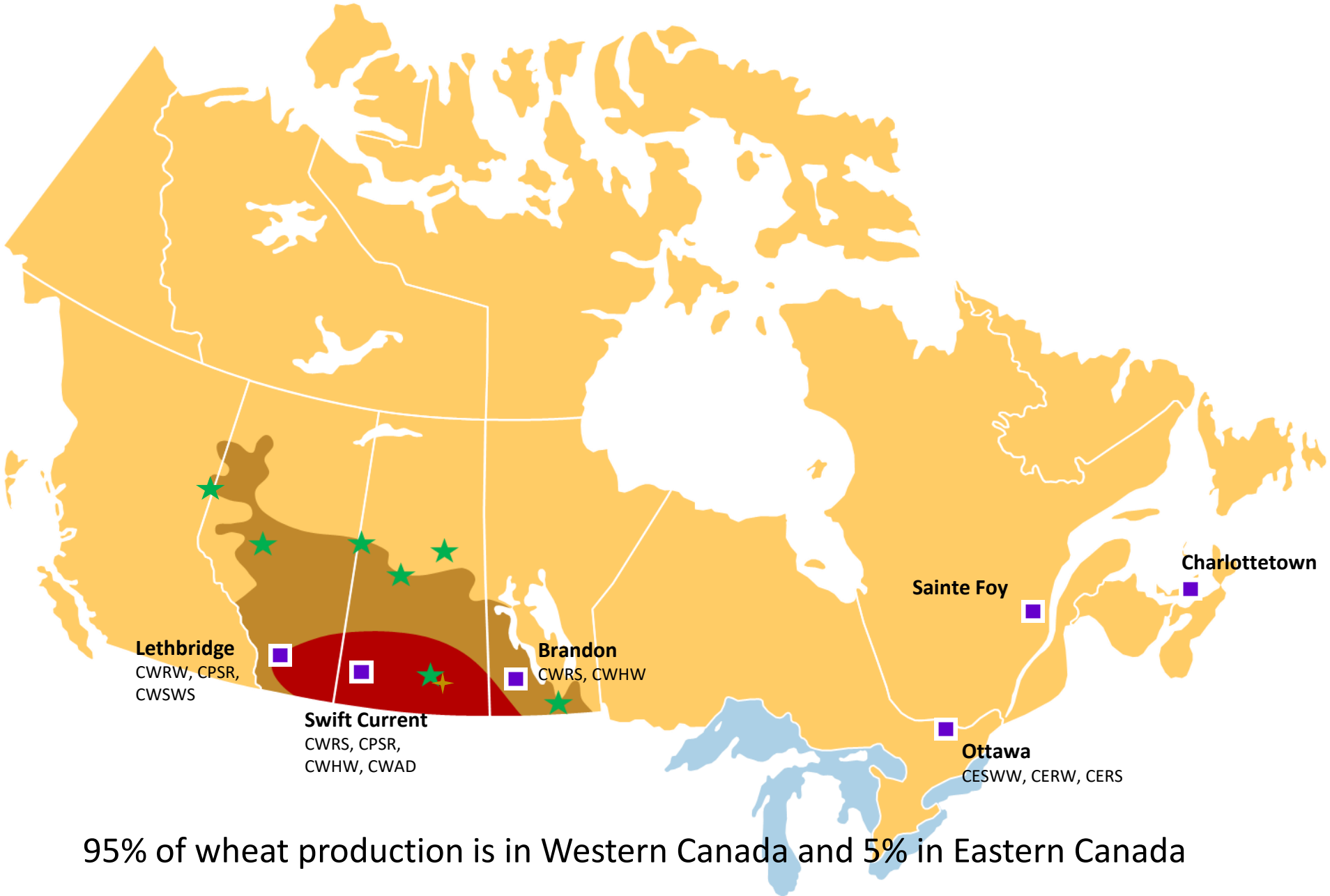
Alliance for Wheat Adaptation to Heat and Drought
24th February, 2021

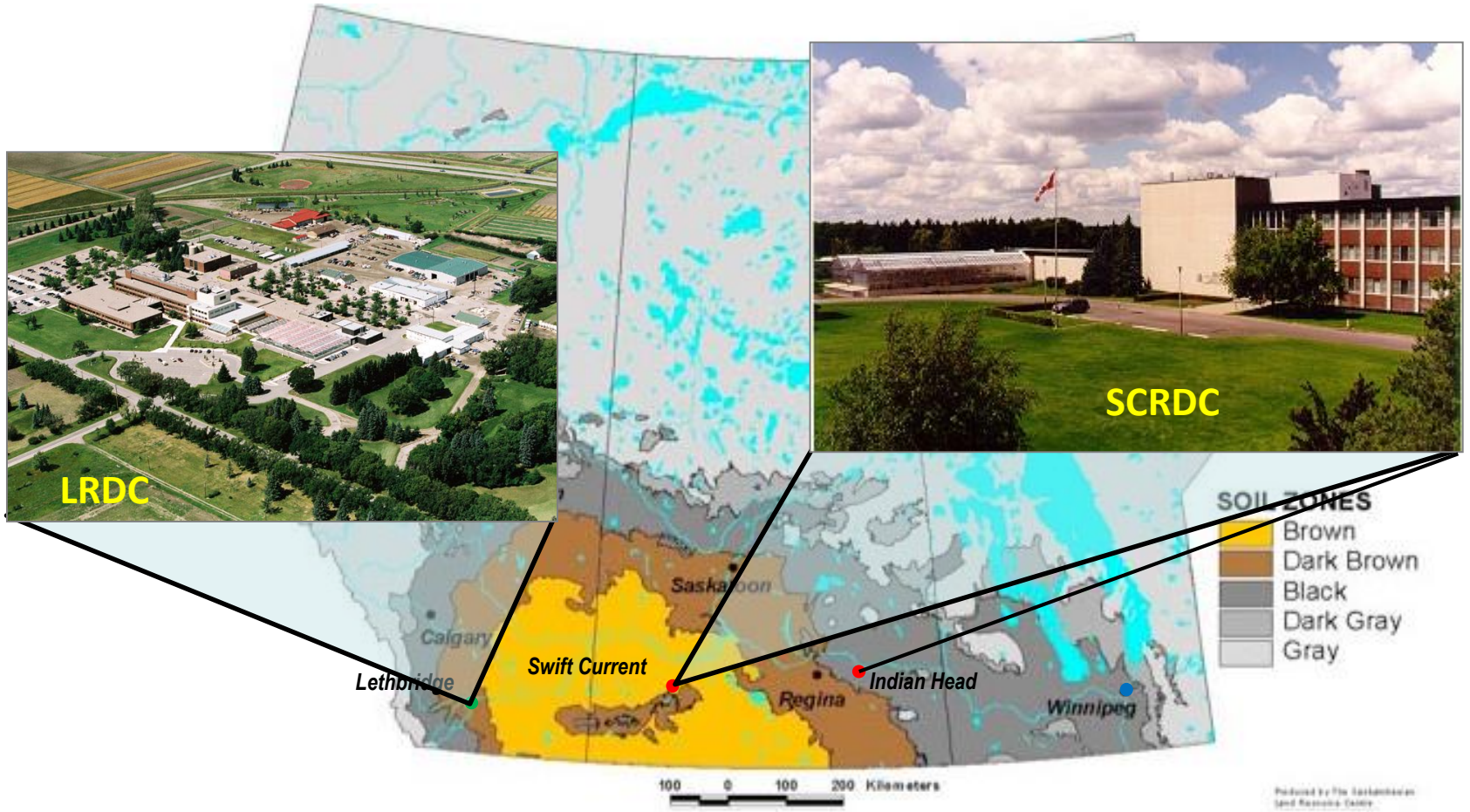
Canada

AAFCs Wheat Breeding Sites and Satellites



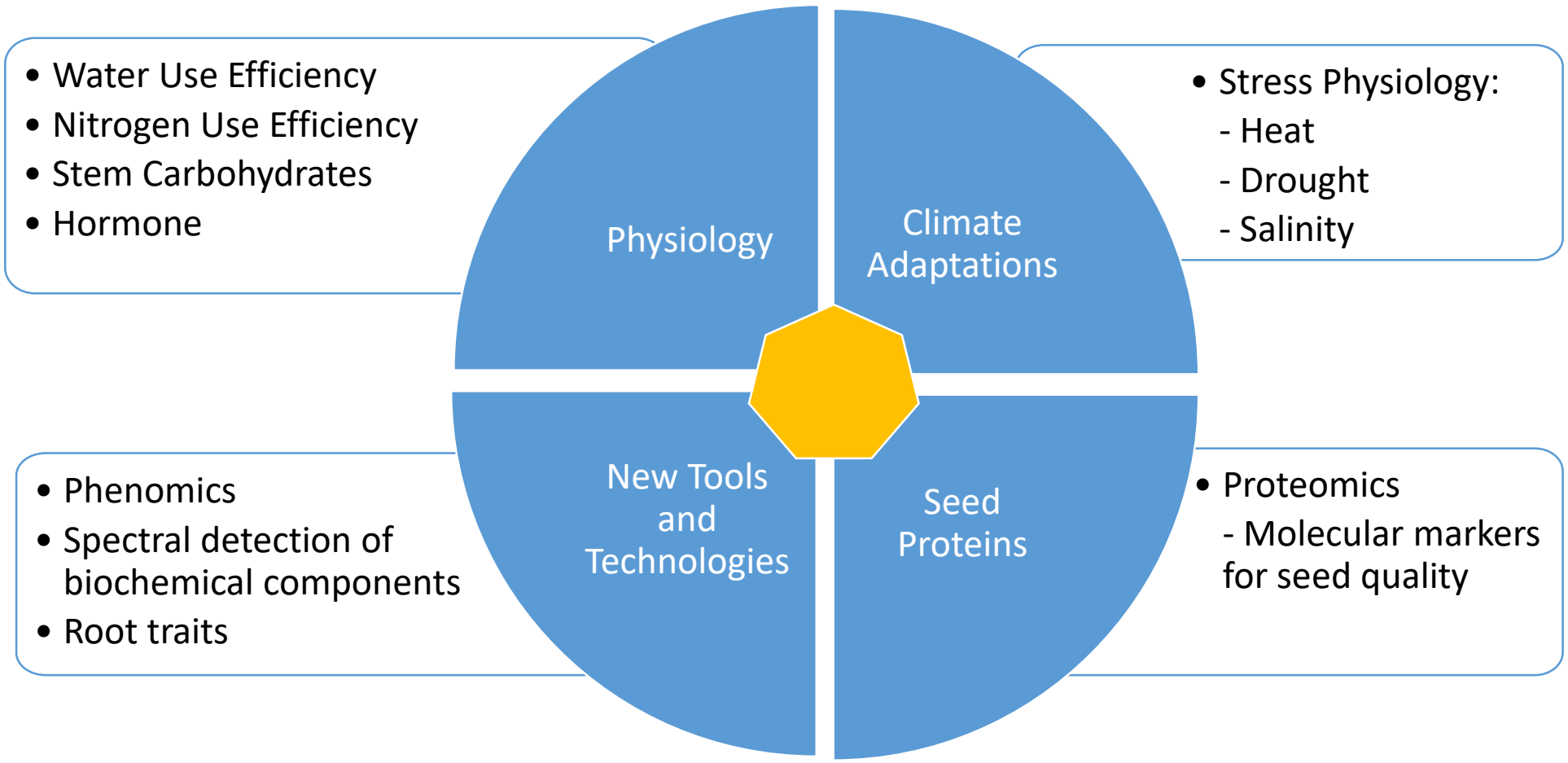
95% of wheat production is in Western Canada and 5% in Eastern Canada

AAFC Research Centers in Abiotic Stress Environments



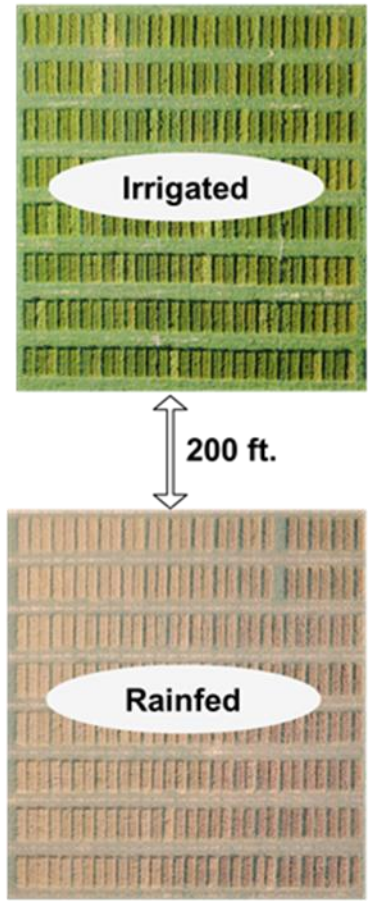
Lethbridge and **Swift Current** centers are actively engaged in breeding and selecting for stress environments (particularly, drought, heat, salinity) in the brown, dark brown, black and dark gray soil zones.

Research Interests: Understanding of Physiological Traits Imparting Stress Resilience and Improving Seed Quality in Wheat



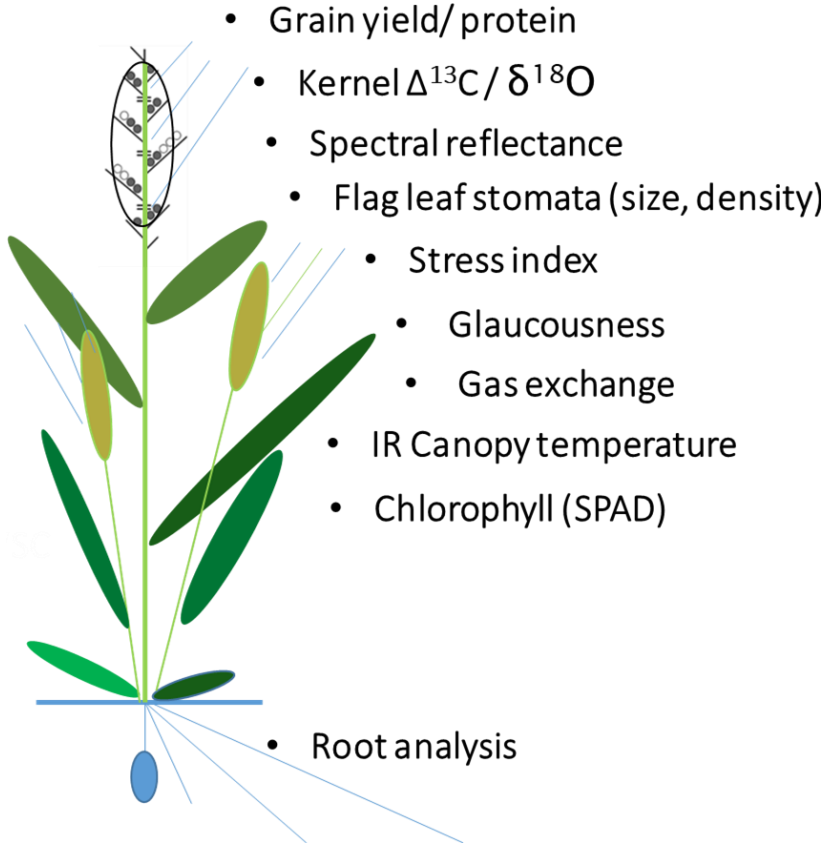
Drought Response in a Bread Wheat Population

Carberry/AC Cadillac derived doubled haploid (DH) bread wheat population



Field evaluation in two environments over 6 years

Data collection

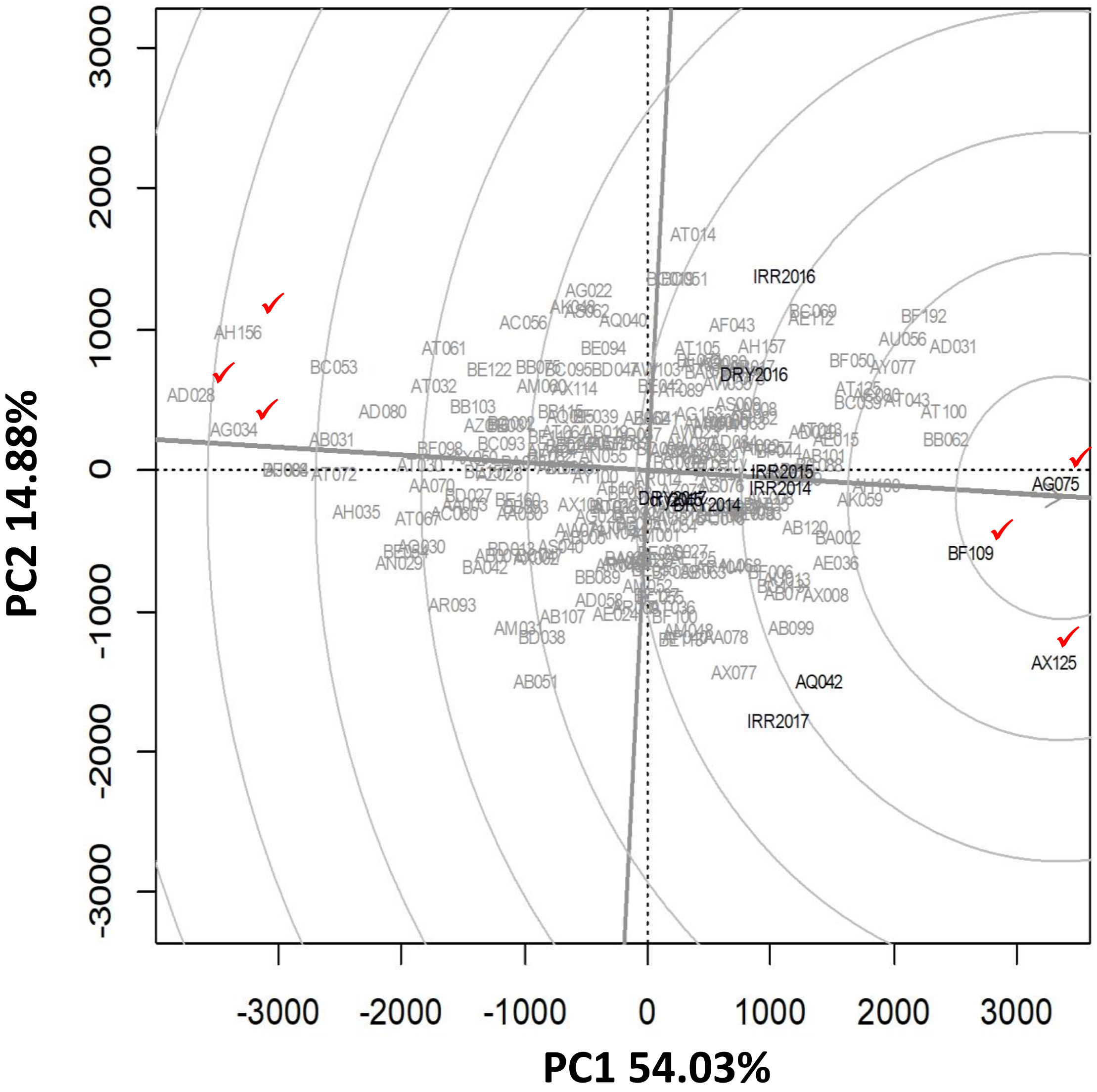


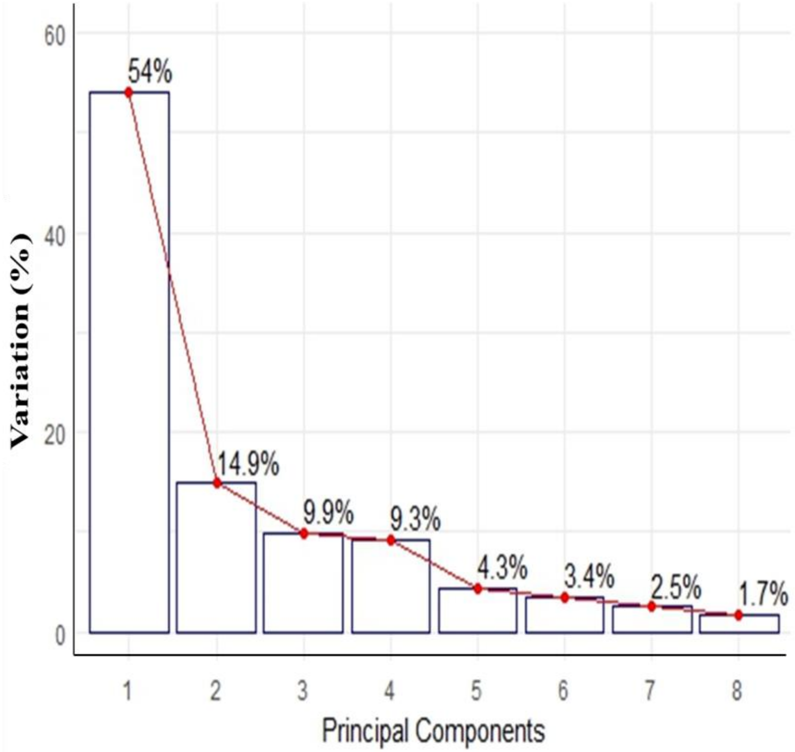
- Grain yield/ protein
- Kernel $\Delta^{13}C$ / $\delta^{18}O$
- Spectral reflectance
- Flag leaf stomata (size, density)
- Stress index
- Glaucousness
- Gas exchange
- IR Canopy temperature
- Chlorophyll (SPAD)
- Root analysis

Morpho-physiological traits observed to understand drought stress response

Sangha *et al.*, (under preparation)

GGE Biplot Ranking of Genotypes for Grain Yield





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Grain Yield, Quality Traits and Stress Tolerance index (STI) of Selected DH Lines Under Irrigated and Rainfed Environments

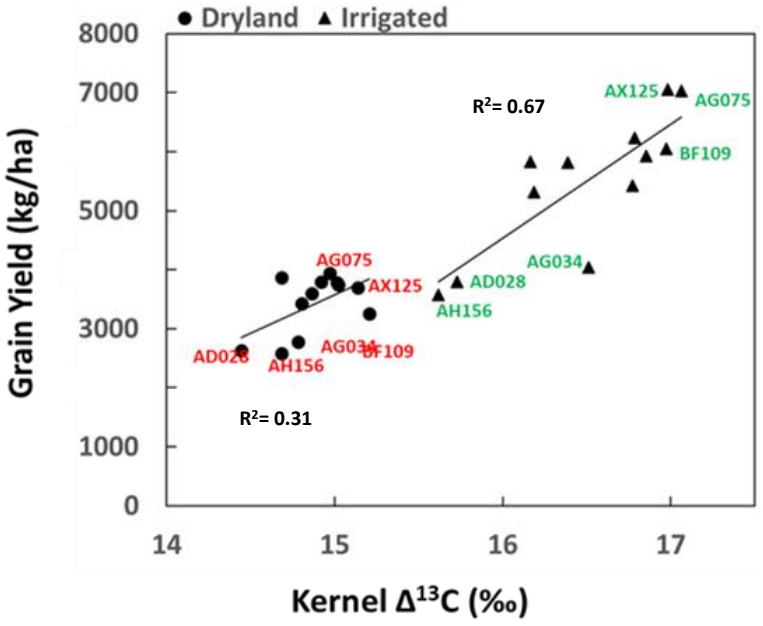
Line	Grain yield (kg/ha)		Protein (%)		TKW (g)		STI
	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	
AC Cadillac	5142.1	3343.4	14.8	14.1	37.2	31.1	0.64
Carberry	5092.1	3422.2	14.9	14.4	35.1	30.6	0.64
B0767&AD028	3618.9	2521.6	15.8	15.7	35.0	30.8	0.32
B0767&AG034	3700.4	2627.9	15.4	14.9	35.7	32.8	0.34
B0767&AH156	3499.2	2477.2	16.1	15.1	36.5	30.2	0.31
B0767&AG075	6654.2	3659.9	14.2	13.6	38.1	31.2	0.87
B0767&AX125	6713.0	3732.7	13.5	12.7	34.2	28.2	0.89
B0767&BF109	6130.7	3412.3	14.2	14.2	39.5	33.7	0.77
Prob > F	<.0001	0.1033	<.0001	0.03	<.0001	0.04	0.00
F Ratio	12.29	1.56	4.45	1.93	3.73	1.89	2.80

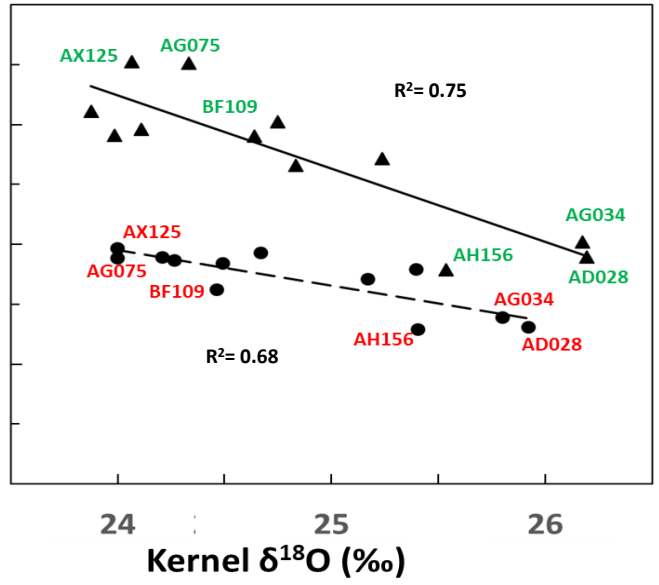
Low STI

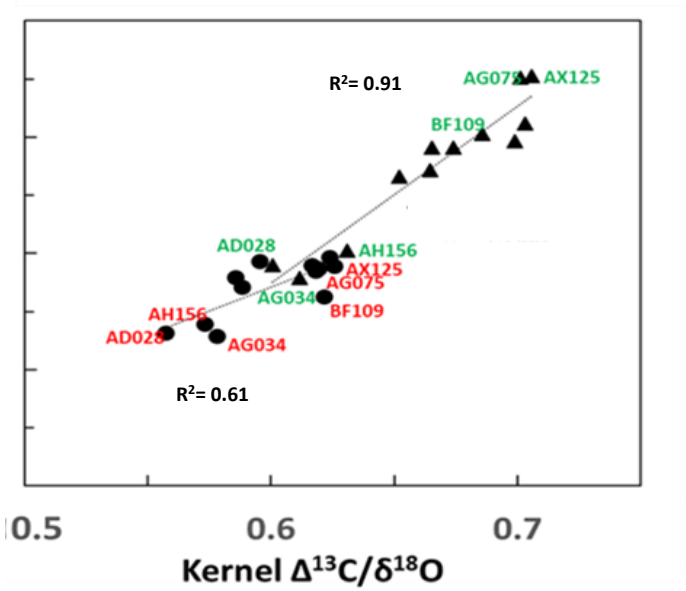
High STI

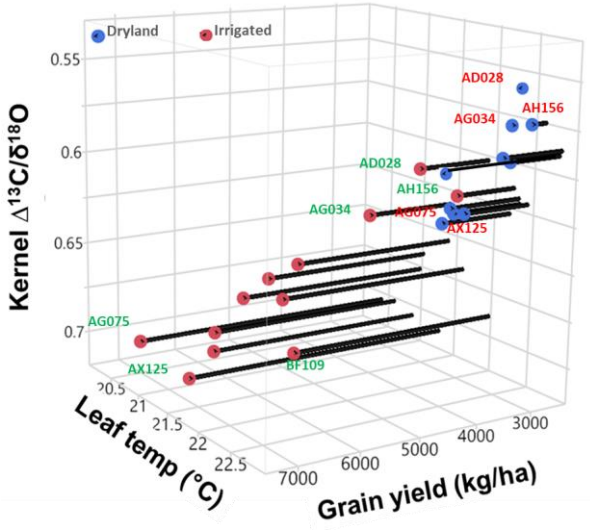
Sangha *et al.*, (under preparation)

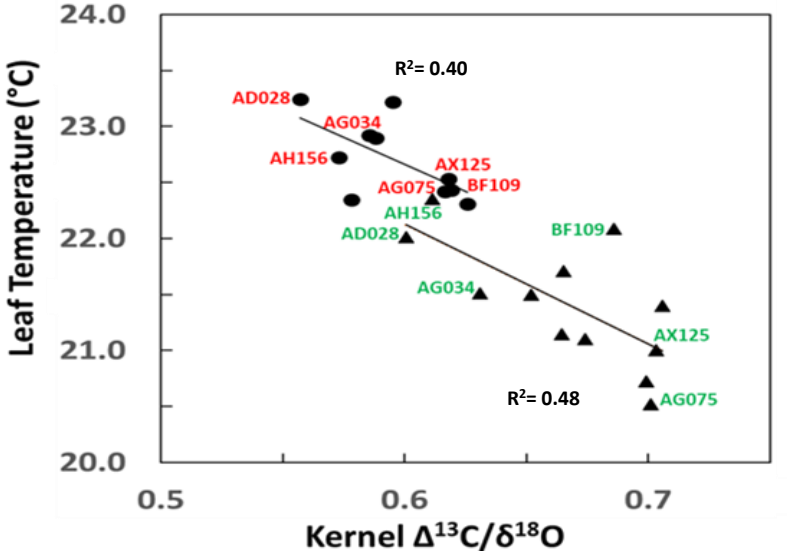
Relationship Between Grain Yield with Kernel $\Delta^{13}C$ and $\delta^{18}O$ Under Irrigated and Rainfed Environments





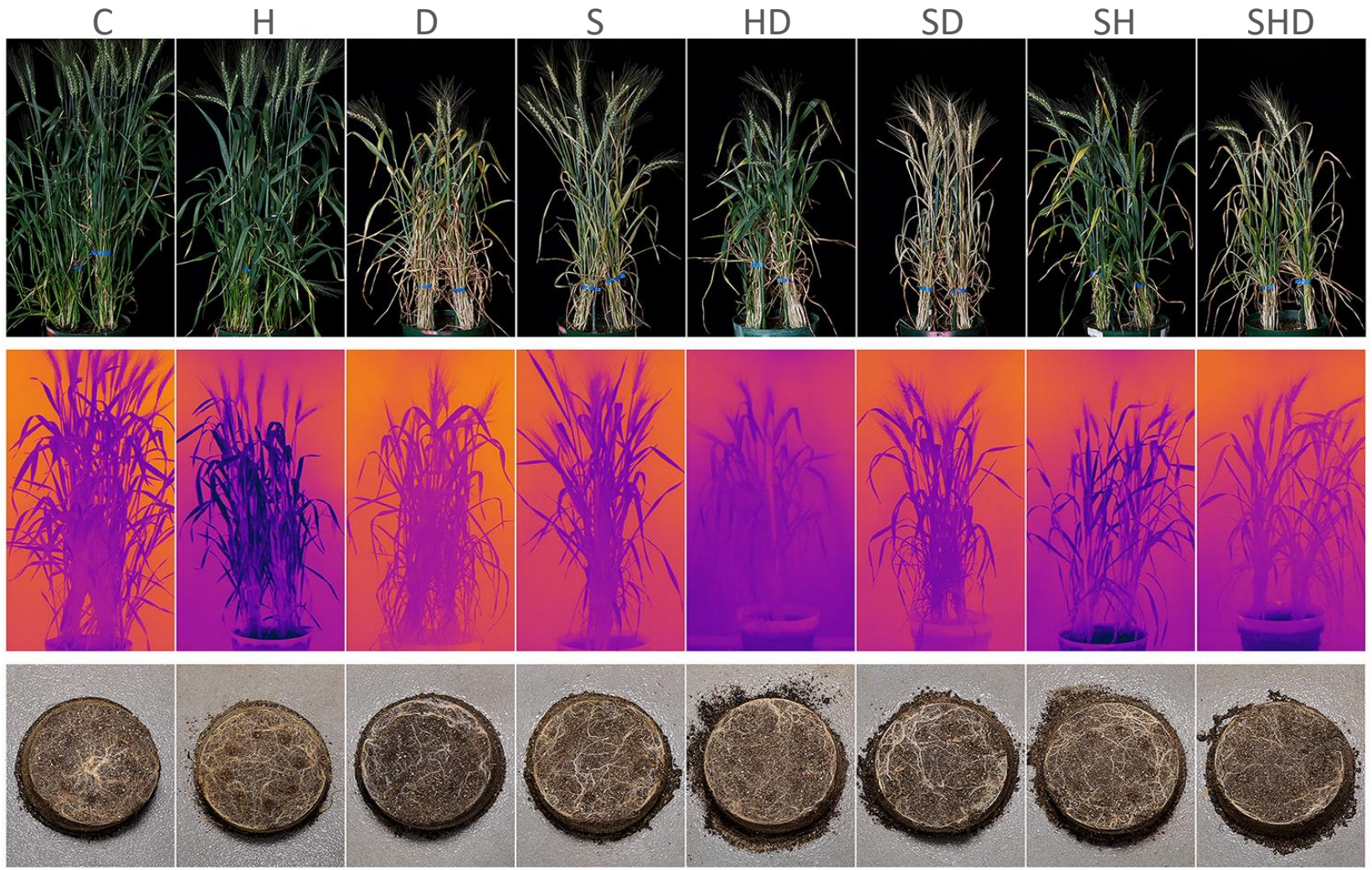






Sangha *et al.*, (under preparation)

Multi-omics Network-based Analyses Support Adaptive Gene Stacking for Combinatorial Abiotic Stress Tolerance in Wheat

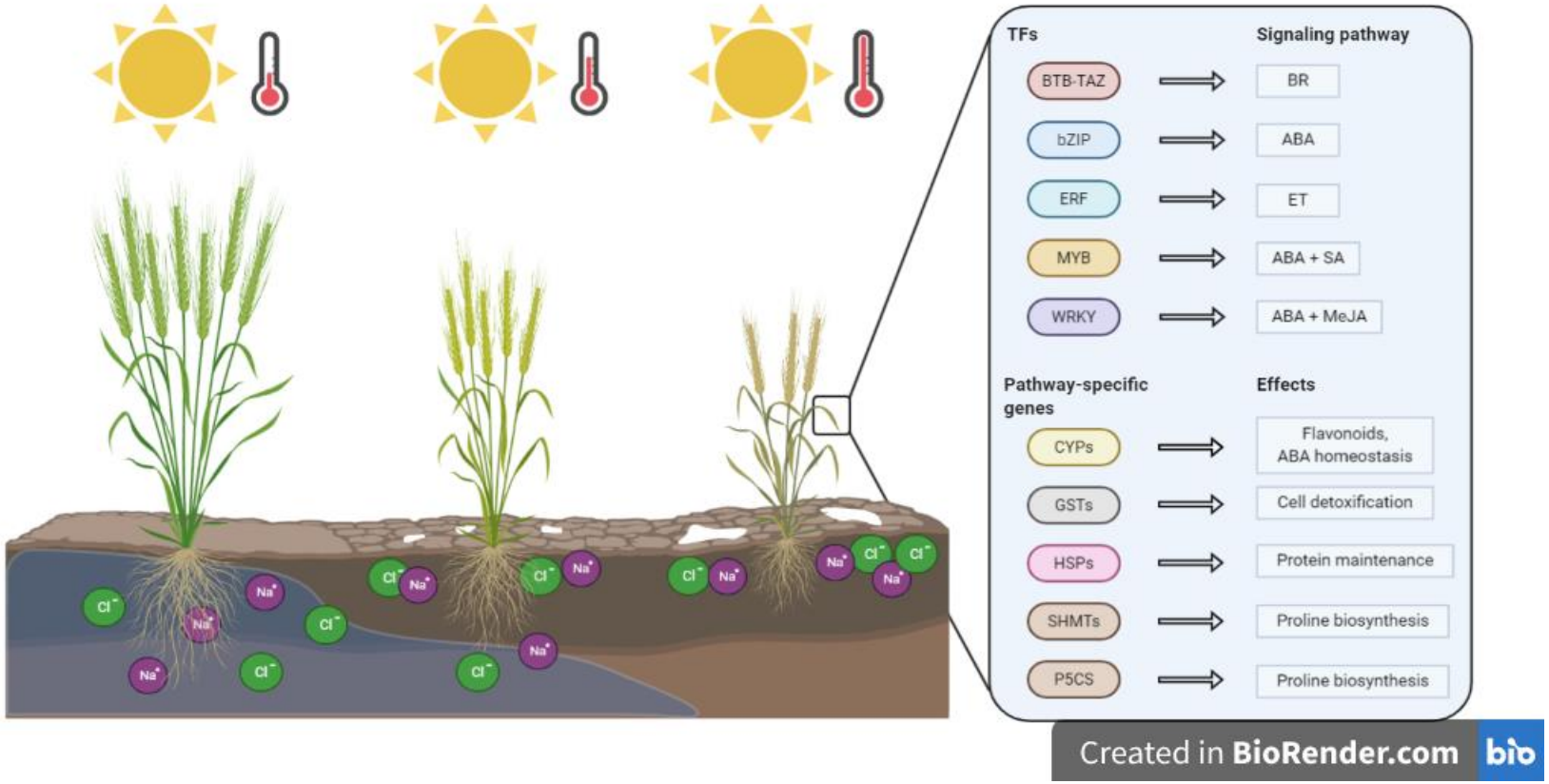


C = control
H = heat
D = drought
S = salinity
HD = heat & drought
SD = salinity & drought
SH = salinity & heat
SHD = salinity, heat & drought

Images of wheat plants grown under various stress treatments and their combinations

Letitia *et al.*, (under preparation)

Adaptive Gene Stacking in Wheat



Cultivar development through the comprehensive use of multi-omics knowledge bases in conjunction with characterization studies has the potential to meet future demand for wheat under a changing climate.

Letitia *et al.*, (under preparation)

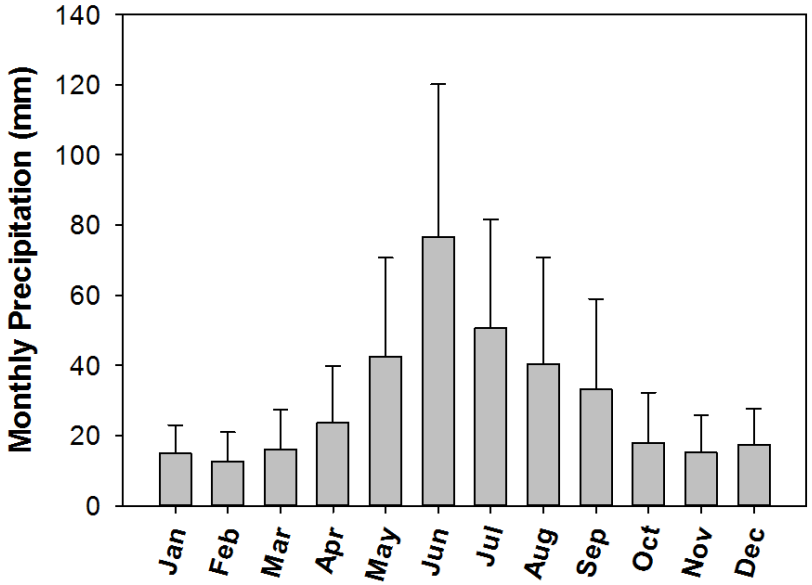
Impact of Drought Stress on Production in Canada

- 2001 and 2002 drought years
- Canadian Gross Domestic Product lost ~$5.8 billion
- Over 41,000 jobs were lost
- Contributed to provincial negative or zero net farm income for the first time in 25 years

Top soil erosion leading to negative environmental footprint

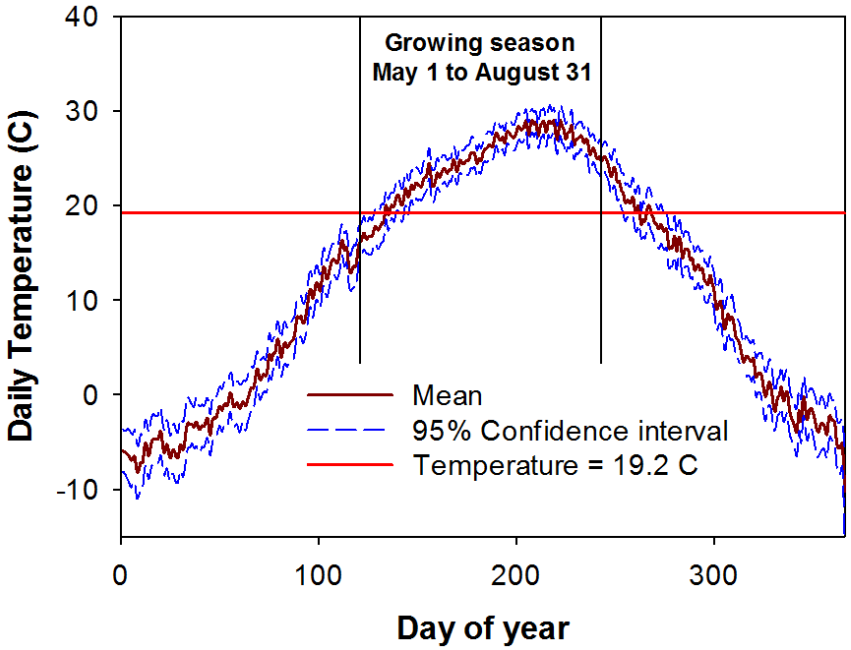
Nature of Drought and Heat Stress on Wheat Production at Swift Current

Long-term means (1954-2010)



- **Drought**
  - Early season
  - Late season

- **Heat**
  - Heat shock at flowering
  - Drought intensity



Canada's Climate Change Report

https://changingclimate.ca/CCCR2019/

- The effects of widespread warming is evident in many parts of Canada and are projected to intensify in the future.
  - More extreme heat, less extreme cold, longer growing seasons, shorter snow cover seasons

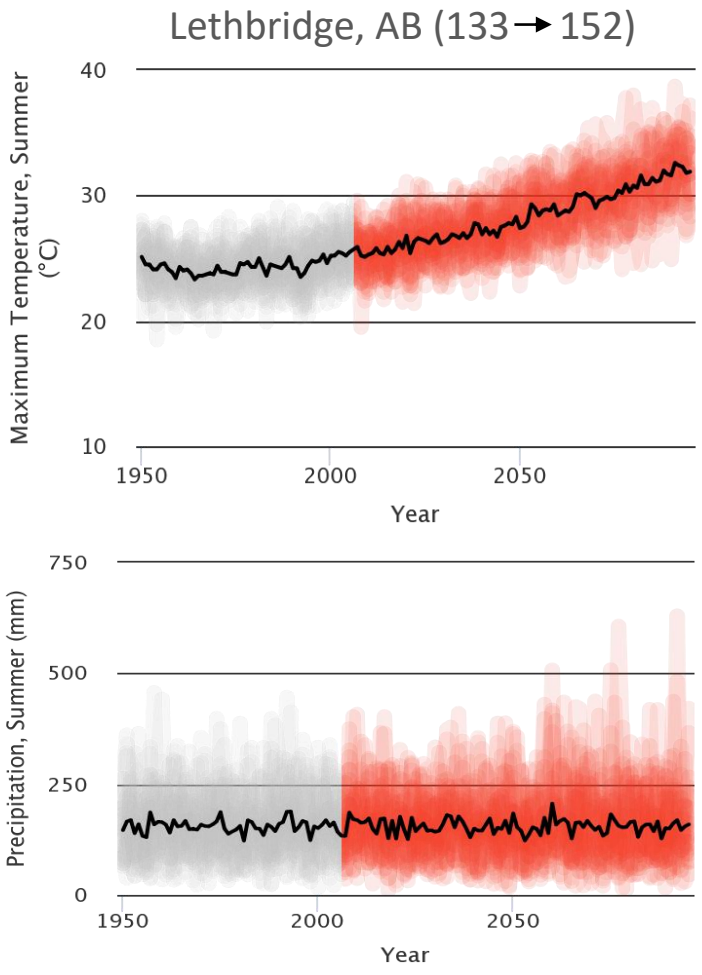
- Precipitation is projected to increase for most of Canada, on average, although summer rainfall may decrease in some areas (southern Canada).

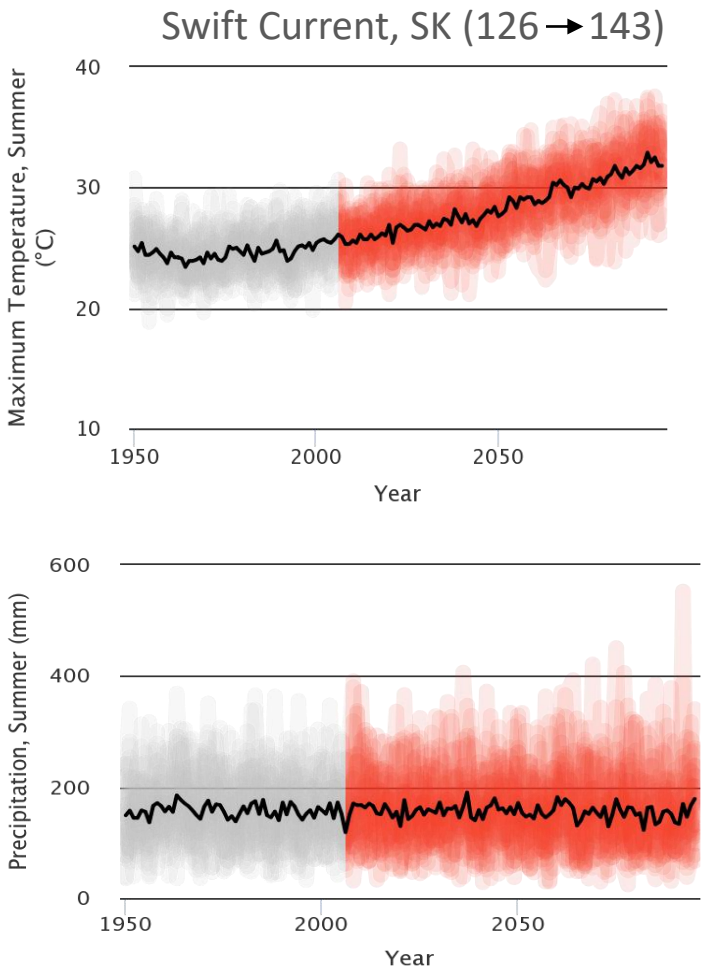
- Warmer summers will increase evaporation of surface water and contribute to reduced summer water availability in the future despite more precipitation in some places.

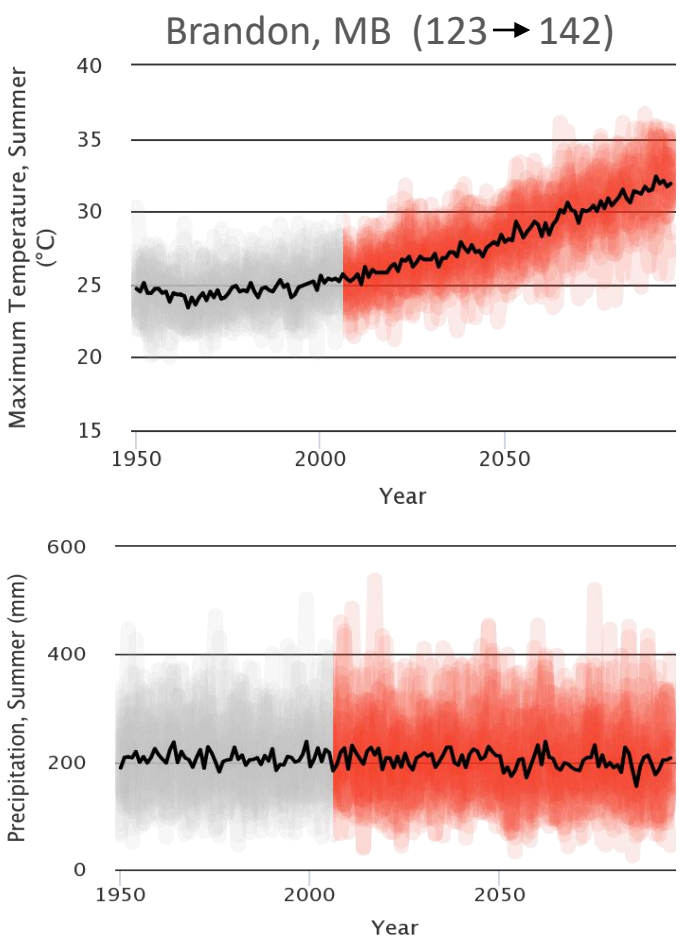
The Climate Atlas of Canada

RCP 8.5: High Carbon climate future

https://climateatlas.ca/







Ensemble mean Historical Values

Research Aims: Improving Drought & Heat Tolerance in Wheat

- **Improving breeding efficiency**
  - Need yield predictors that can be implemented earlier in the breeding cycle (i.e., use of stable isotopes)
  - Rapid physiology traits measurements (i.e., non-destructive phenotyping)
  - Selection for stress tolerance traits in favorable environments
  - Environmental factors affecting wheat seed quality
- **Understanding the role of microorganisms in stress tolerance**
- **Refined agronomic practices**

Current Limitations to Deliver Drought and Heat Tolerant Cultivars

- **Physiology infrastructure**
  - Rainout shelters and heat tents for outdoor screening and selection
  - Non-destructive technologies and computational capacity
  - Technical staff capacity

Rainout shelters

Heat tents

Leveraging from AHEAD partnership

- **Collaboration with international communities**
  - Protocol sharing
  - Exchange of students and visiting scientists among AHEAD member states
  - Germplasm exchange and data mining from various wheat trials
  - Co-op trials among member states
  - Leverage IWYP and NAWA connections

Thank you all……

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