Probabilistic patterns of drought, heat and frost stress for canola in Australia

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26 September 2023

GRDC
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Probabilistic stress patterns for canola

- Drought (water stress), heat & frost stress limit canola production.
- The effect of stress on crop yield depends on the timing & intensity in relation to critical stages for grain set and filling.
- Hence, agronomic practices & breeding targets need to be tailored to the prevalent stress patterns.
- Probabilistic stress patterns in Australia have been reported previously for crops such as wheat and pulses, but not for canola.

Objective of this work:

- To quantify the patterns of drought, heat and frost stress for canola across Australia, accounting for:

  - climate & soil

  - for agronomic drivers influencing the timing & intensity of these stresses (sowing date, cultivar phenology & nitrogen rate)

Methods:

- Using a modelling approach (APSIM-Canola Next Generation) to quantify:

  - daily drought (water supply/demand ratio)

  - heat (Tmax > 30 ^{o}C)

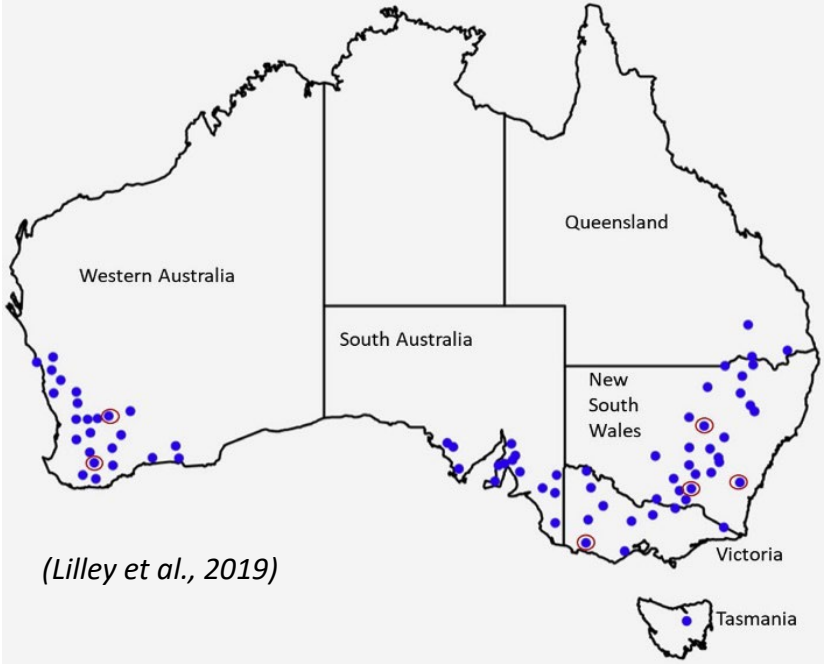
  - frost (Tmin < 0 ^{o}C)

  - on a phenological scale from sowing to maturity

APSIM factorial analysis of stress patterns

Simulate stress in contrasting:

- Locations (77 sites)
  - with representative soil types across the cropping regions of Australia
- Sowing date (4 TOS):
  - 10/3, 10/4, 10/5, 10/6
- Cultivar phenology (3 cultivars of contrasting maturity)
  - Fast developing ('GenericEarly')
  - Mid developing ('GenericLate')
  - Slow developing ('GenericWinter')
- Nitrogen rate (7 N rates):
  - 0, 50, 100, 150, 200, 250, 300 kg N/ha
- Year: 1961-2020



In total, 388,080 simulations were generated:

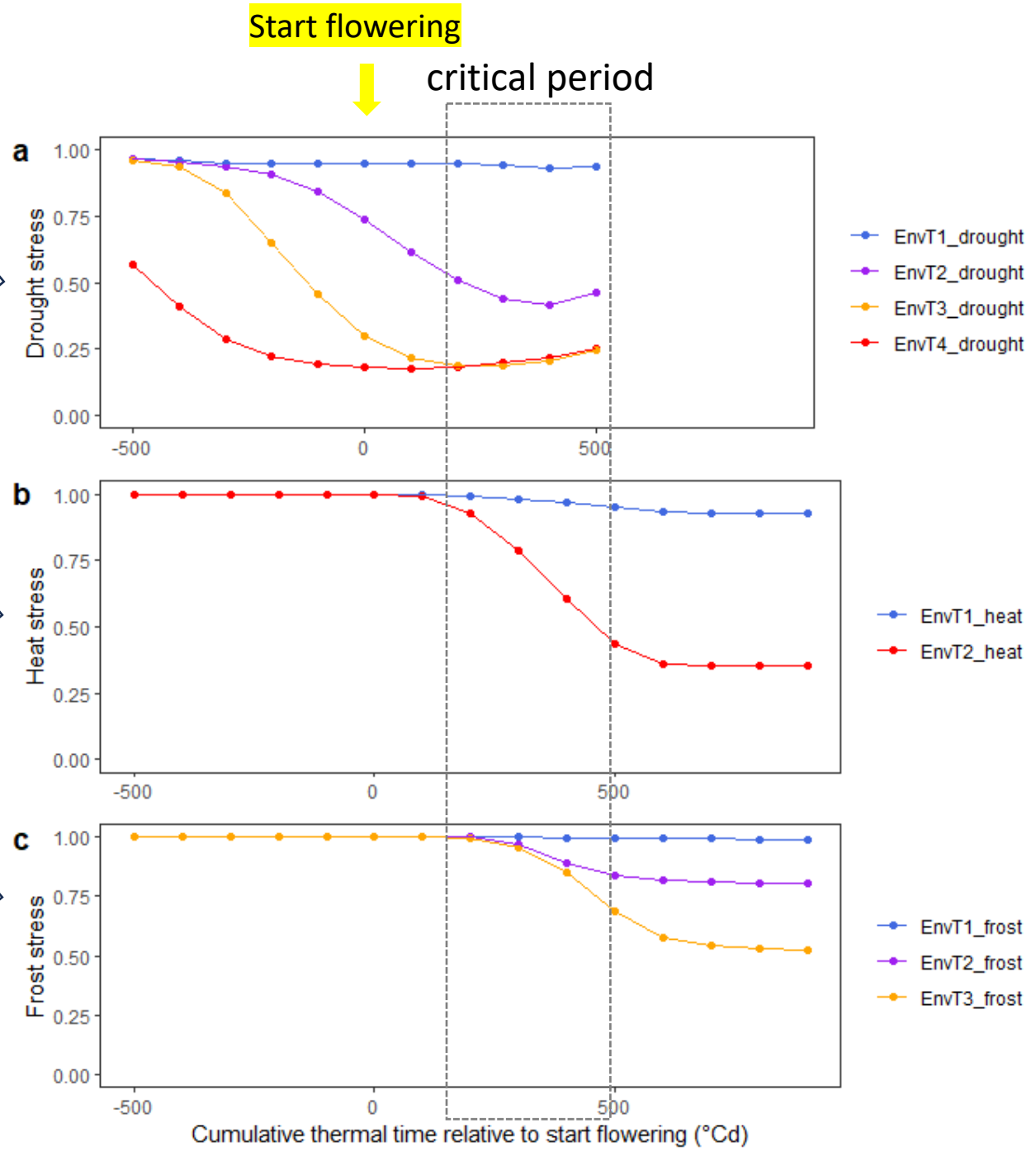
(77 locations × 4 sowing dates × 3 cultivars × 7 N rates × 60 year).

Drought, heat & frost patterns

- Drought (4 patterns):
  - **EnvT1:** mild/no stress in critical period
  - **EnvT2:** moderate stress in critical period
  - **EnvT3:** severe stress onset before the critical period
  - **EnvT4:** severe stress onset before start of flowering

- Heat (2 patterns):
  - **EnvT1:** mild/no stress in critical period
  - **EnvT2:** severe stress in critical period

- Frost (3 patterns):
  - **EnvT1:** mild/no stress in critical period
  - **EnvT2:** moderate stress in critical period
  - **EnvT3:** severe stress in critical period

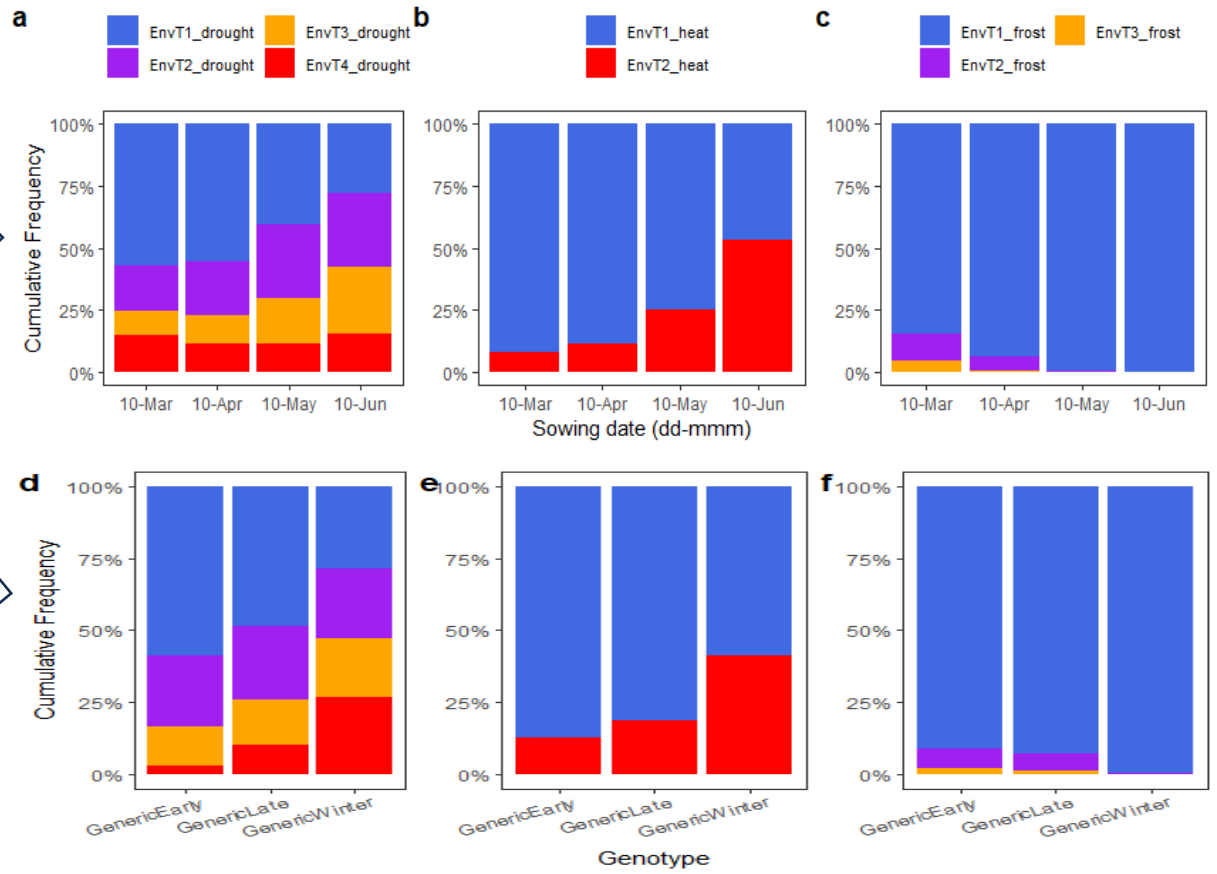


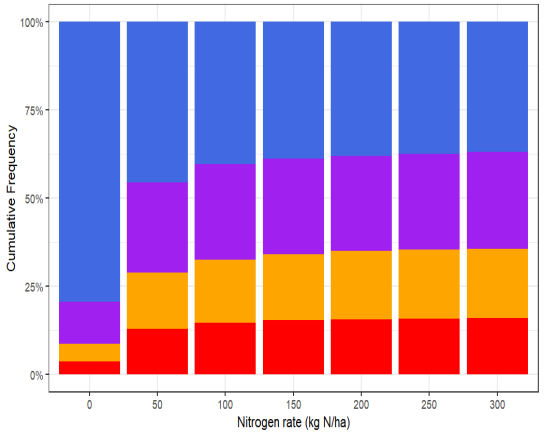
Agronomic management on frequency

- **Early sowing:**
  - reduced frequency of severe drought & heat
  - but increased frequency of severe frost

- **Fast maturing cultivars:**
  - reduced frequency of severe drought & heat
  - but increased frequency of severe frost

- **High nitrogen rates:**
  - increased frequency of severe drought stress





Complex interactions among sowing date, cultivar & N rates.

Alignment with grain yield

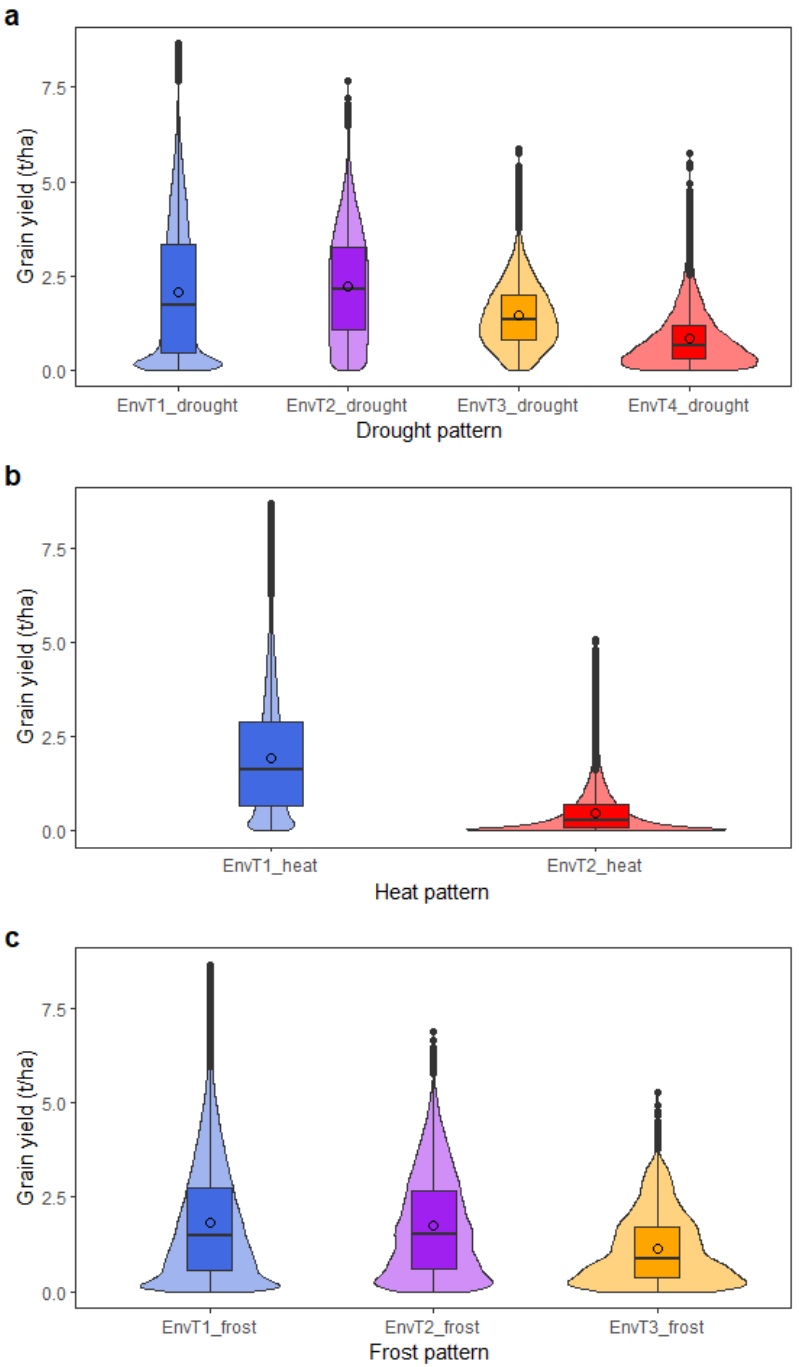
- **Yield reduction:**

  - Severe heat: 74% (EnvT2)
  - Severe drought: 23% (EnvT3) & 50%(EnvT4)
  - Severe frost: 37% (EnvT3)

- **Frequency:**

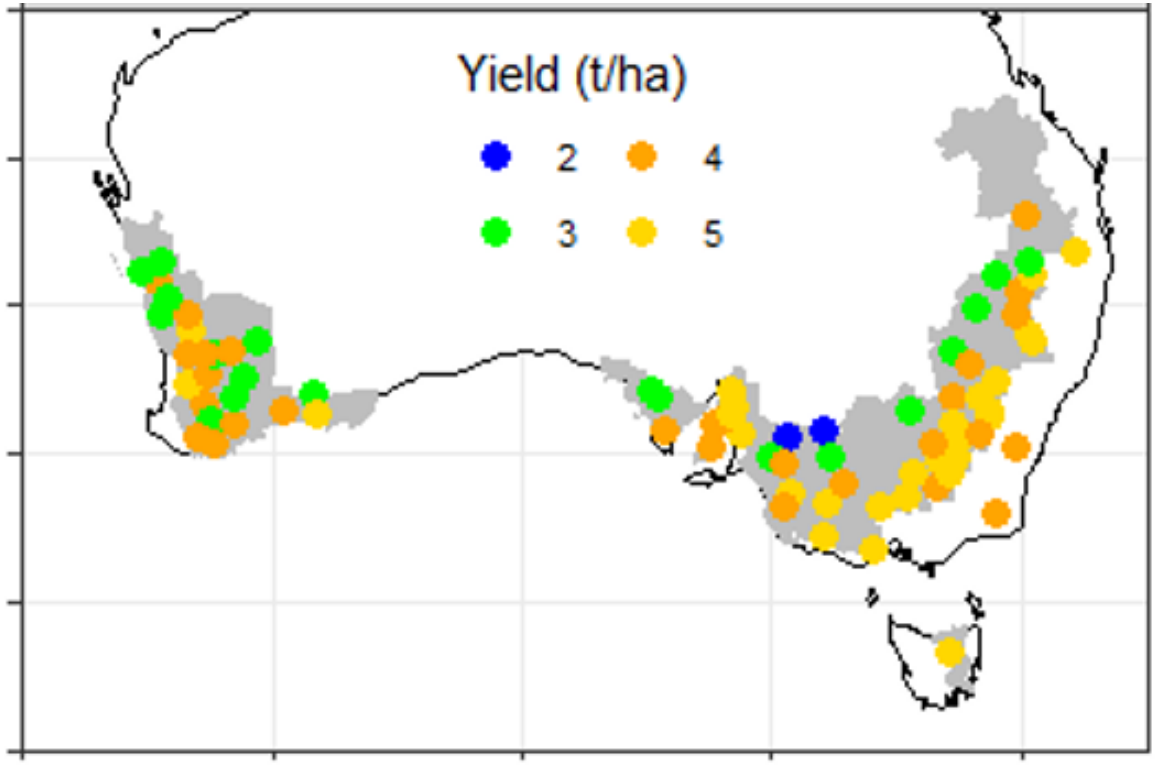
  - Severe heat: 24% (EnvT2)
  - Severe drought: 19% (EnvT3) & 15%(EnvT4)
  - Severe frost: 2% (EnvT3)

Severe heat was a more frequent and yield-limiting than drought or frost, but this varied with site.



Grain yield (simulated)

The best site-specific combinations of sowing time, cultivar phenology and N rate across sites increased modelled yield by >50% (>1.3 t/ha) compared to alternative combinations.



Take home message

- Cluster analysis identified 4 patterns for drought stress, 2 patterns for heat stress & 3 patterns for frost stress.

- Severe heat was a more frequent (24%) & yield-limiting (74%) stress than severe drought or severe frost.

- The best site-specific combinations of sowing time, cultivar and nitrogen rate across sites increased predicted yield by >50%.

Thank you

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