Physiological Impact of Combined Heat Stress and Elevated Carbon Dioxide (CO_2) on Wheat (*Triticum aestivum*) During Grain Filling Stages

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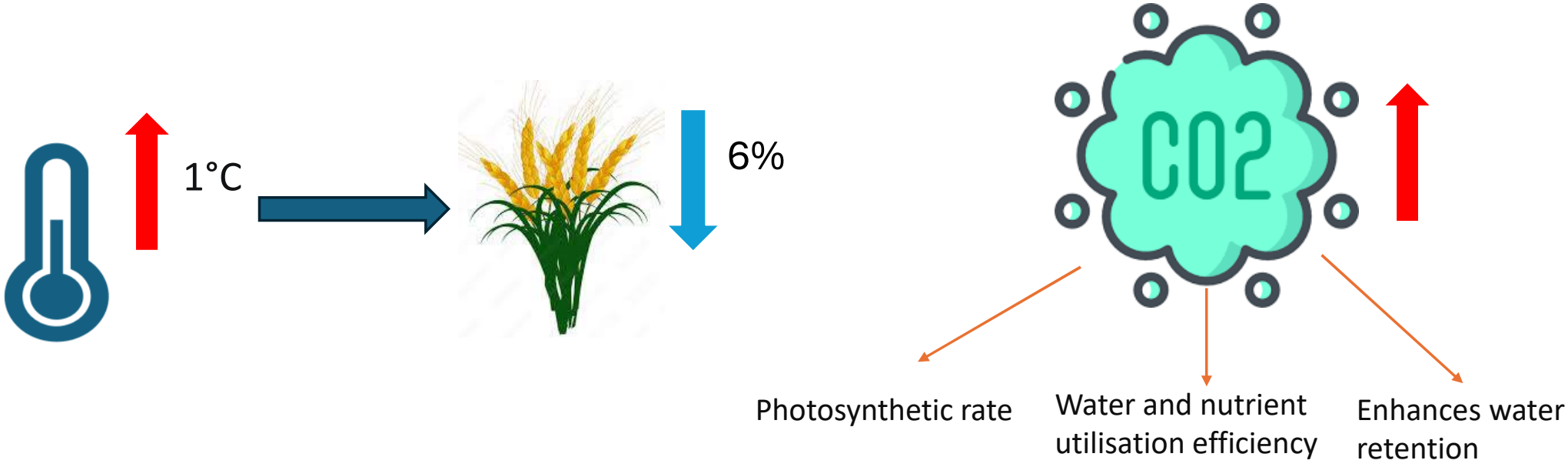
Background – Wheat Response to Heat Stress and Elevated CO_2



Research Question:

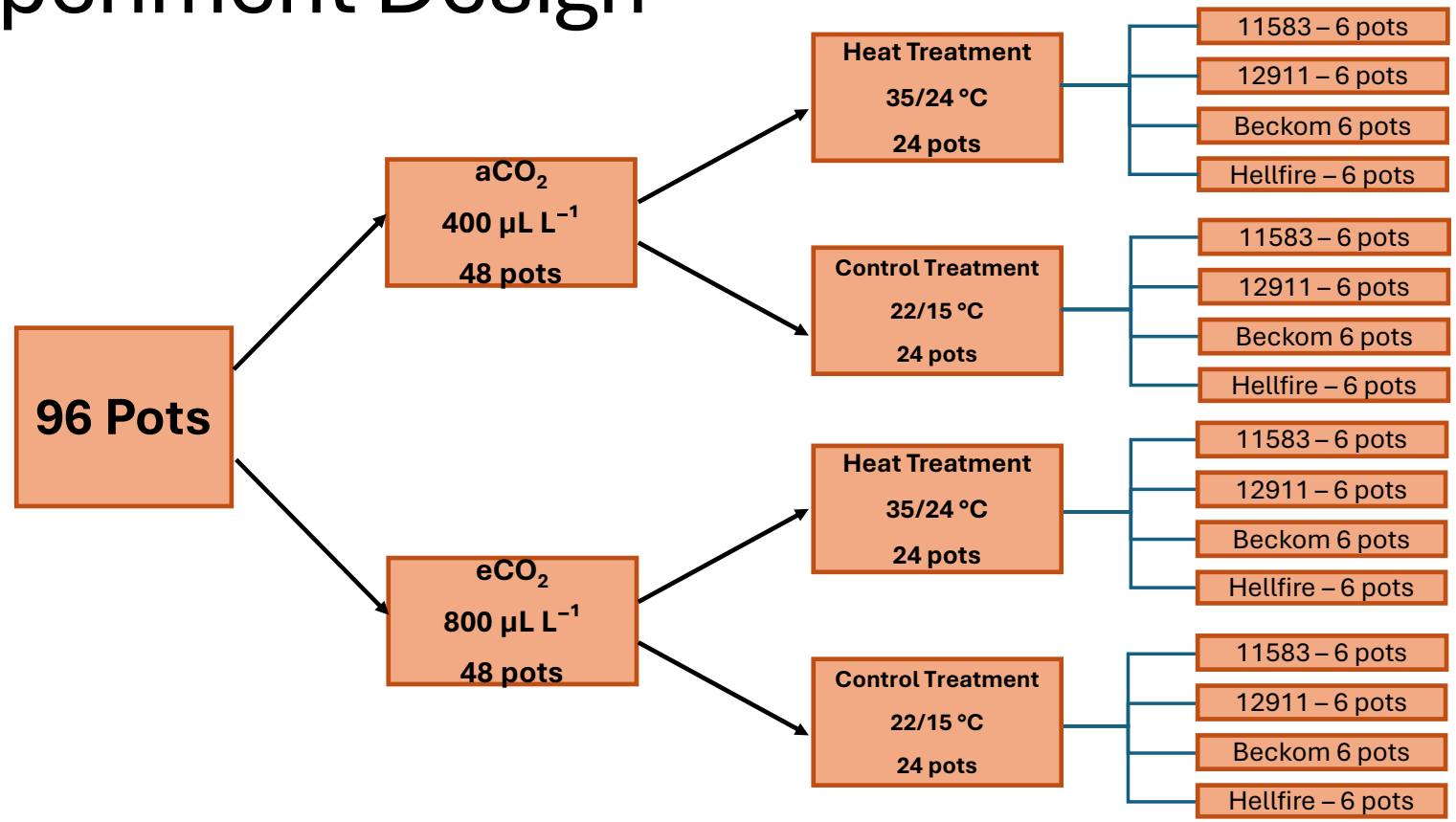
How do increasing temperature and CO_2 concentrations affect wheat yield and development?

Aims and Hypothesis

- **Aim:** Examine genetic diversity in wheat in response to high-temperature stress under ambient CO_2 (400 µL L^{-1}) vs. elevated CO_2 (800 µL L^{-1}).

- **Hypotheses**:
  1. Under ambient temperature, wheat yields will increase at elevated CO_2 (800 µL L^{-1}) compared to ambient CO_2 (400 µL L^{-1}) conditions.
  2. Elevated CO_2 will mitigate the effects of heat stress during grain filling and sustain yield better than heat stress under ambient CO_2 conditions.

Experiment Design



11583 – PBI –Heat susceptible

12911 – PBI –Heat tolerant

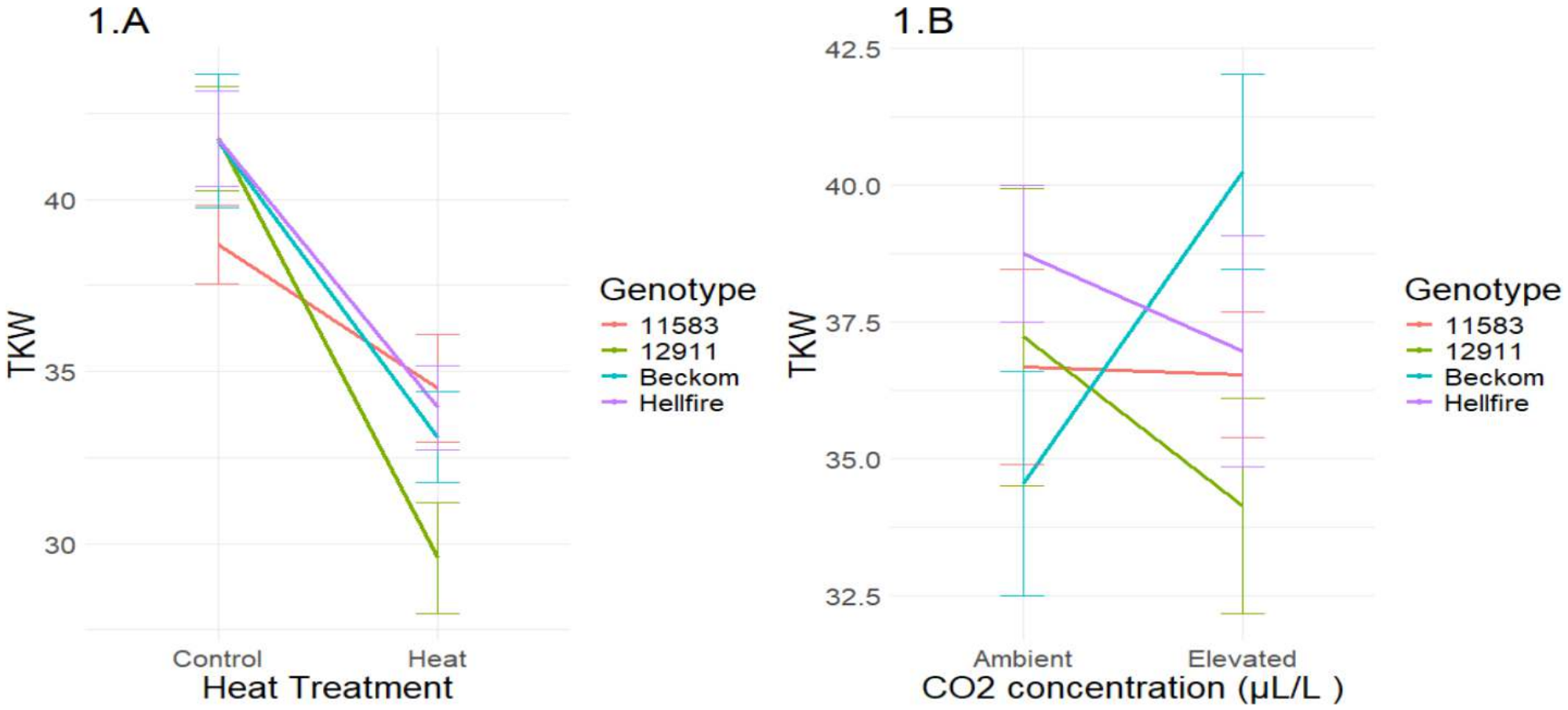
Beckom – AGT – Heat susceptible

Hellfire – LRPB – Heat tolerant

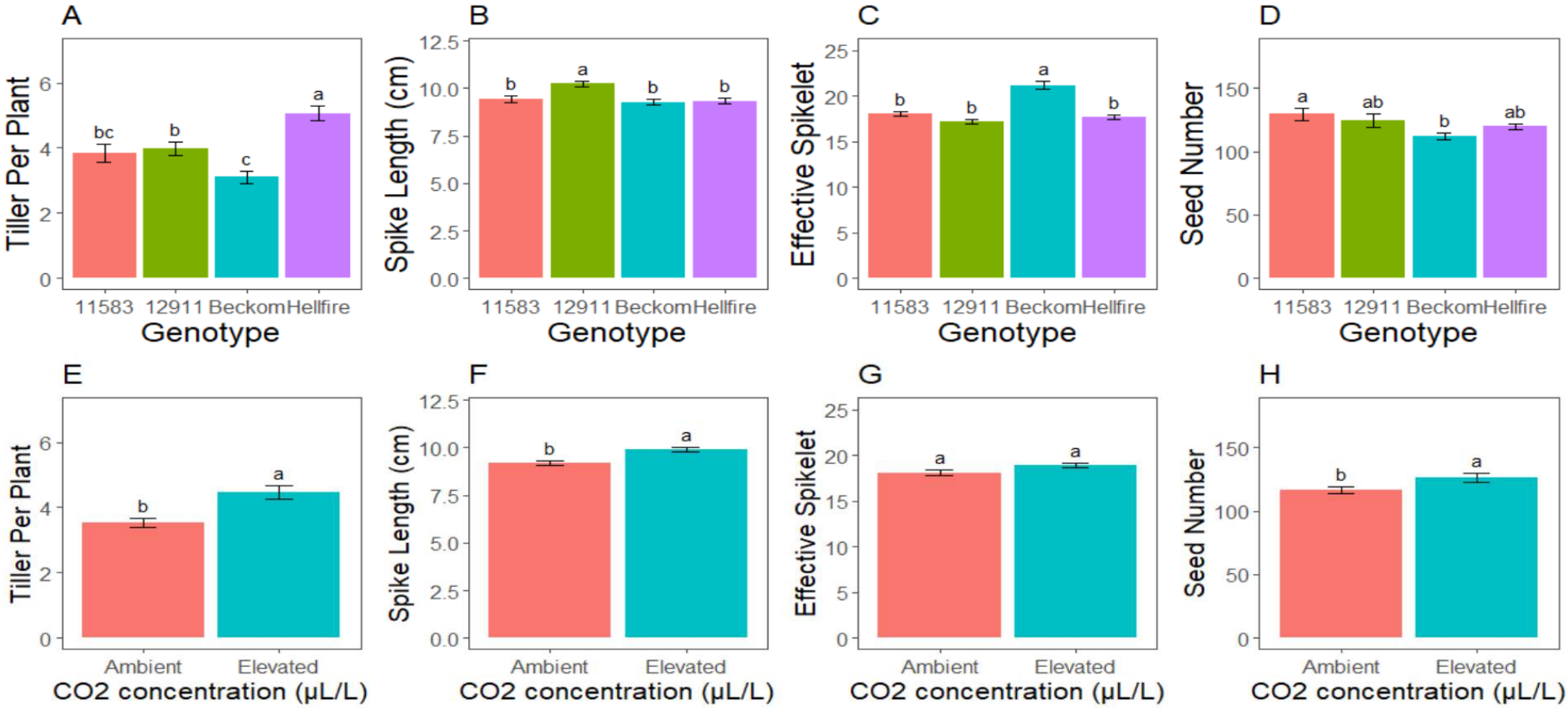
Material and Methods

- Data collected at maturity from tagged stems included:
  - Plant height
  - Spike length
  - Number of effective and non-effective spikelets
  - Grain number and weight per spike
  - Thousand kernel weight (TKW)
  - Number of tillers per plant
  - Total biomass
- Data analysis was performed using R Studio with a three-way ANOVA to assess the effects of:
  - Temperature
  - CO_2 levels
  - Genotype yield potential

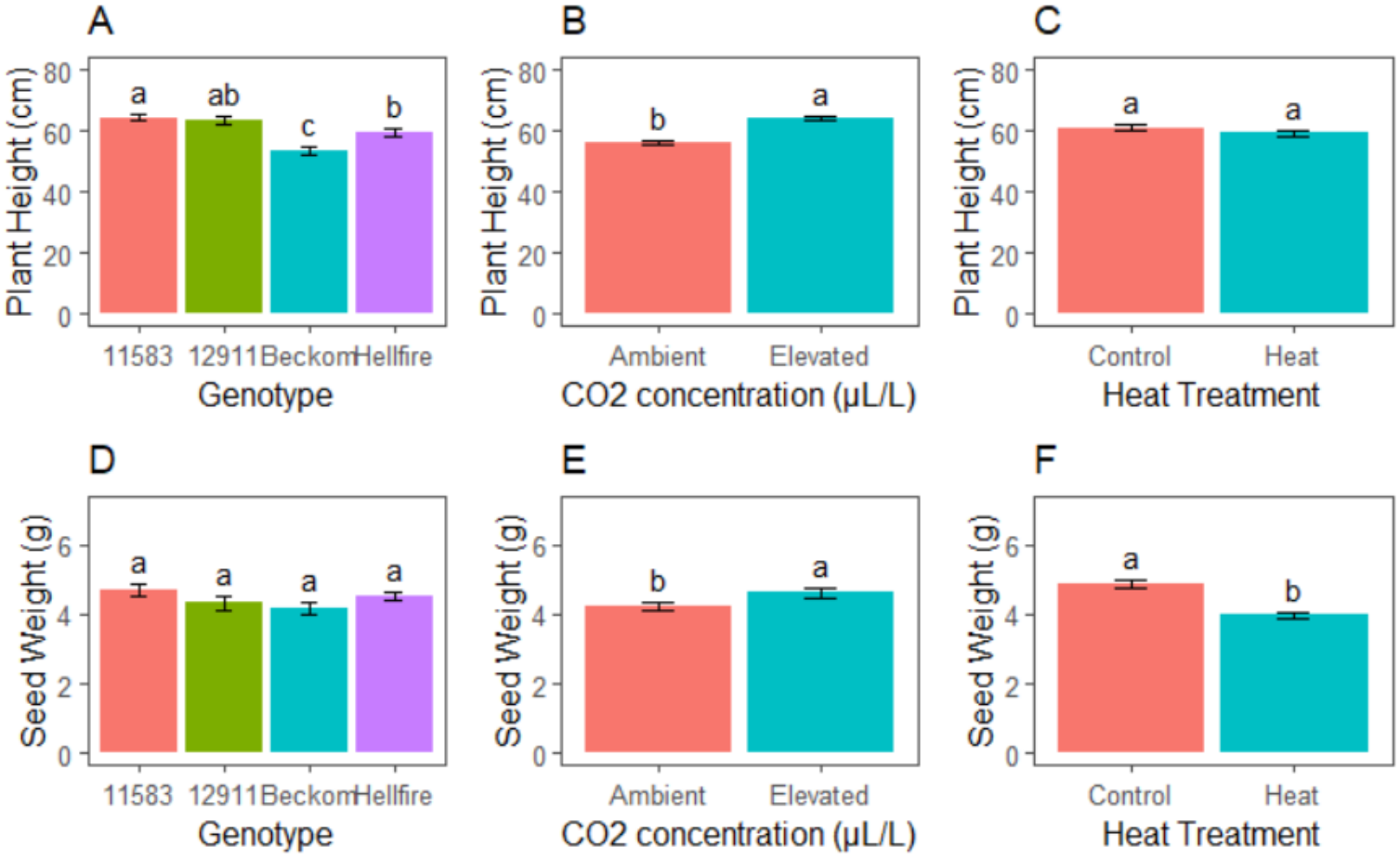
Thousand Kernel Weight (TKW)



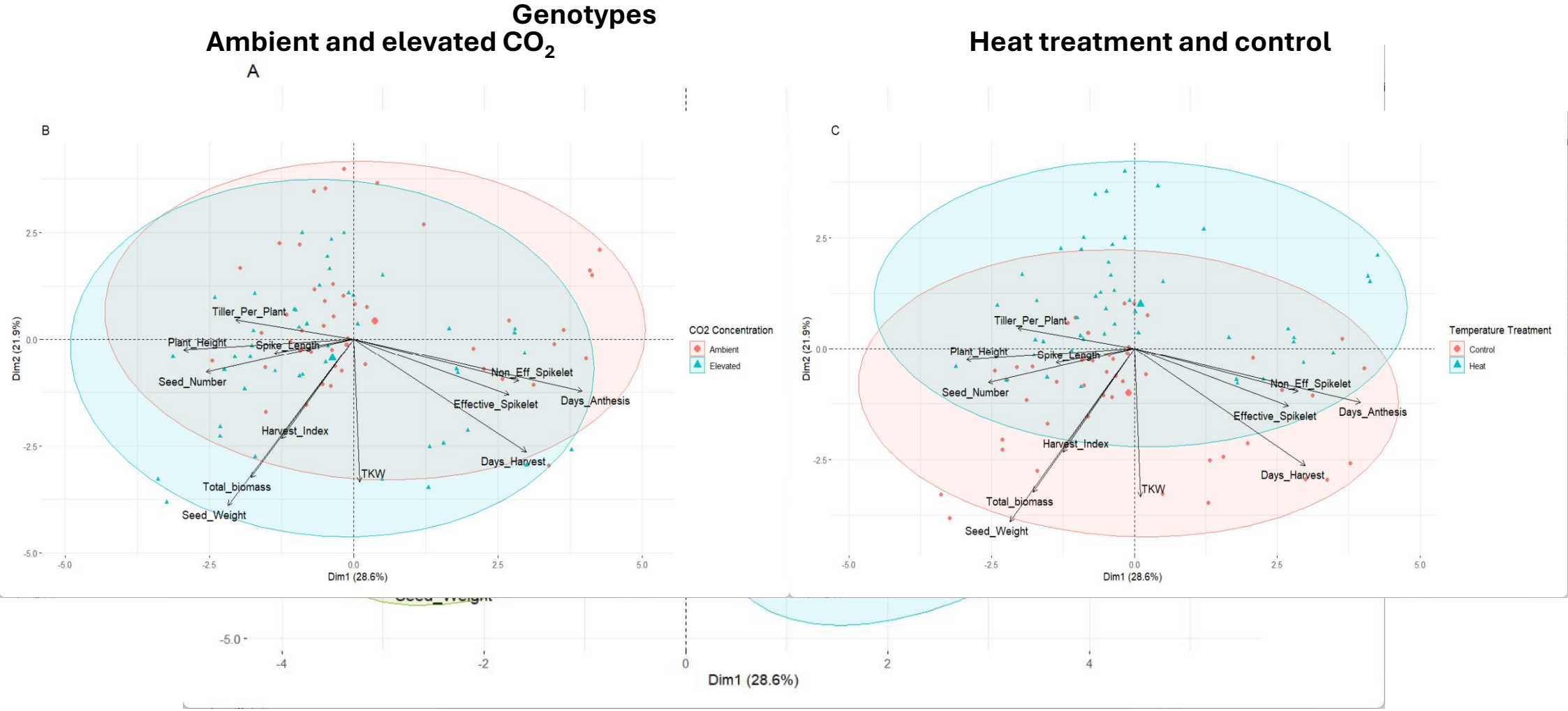
Plant Morphology and Yield Components



Effect of genotype, CO_2 concentration and temperature on plant height and seed weight



Principal Component Analysis (PCA)



Why These Phenomena Happen – Heat Stress

- Speeds up growth and development Shorter days to harvest
- Changes in flowering genes (FT1, FT2, SOC1)
- Alters phytohormone balance like gibberellins(GA), abscisic acid (ABA), ethylene, auxin, cytokinin
- Boosts photosynthesis and ATP synthesis
- Promotes early maturity (ABA and other hormones pathways)
- Water stress-related responses
- Decreases TKW, grain weight, seed number due to incomplete seed development

Why These Phenomena Happen – Elevated CO_2

- Extends sowing to harvest time
- Increases carbohydrate production and biomass
- Alters hormone balance (vegetative over reproductive growth)
- Delays harvest (carbon-nitrogen balance hypothesis)
- TKW increases in Beckom and decreases in 12911, Hellfire
- Increases days to harvest and seed number

Discussion of Implications of Results

Implication of Result	Accelerated phenological development under heat stress
	Yield reduction from heat stress
	Enhanced growth under elevated CO_2
	Genotype-Specific responses

Conclusions and Future Research Directions

Elevated CO_2 produces higher seed number (yield) and plant growth

Each genotype of wheat has unique responses to elevated CO_2 and heat stress, and elevated CO_2 can only mitigate some damages from heat stress

- **Future research directions:**
  - Understand the physiological responses and identify genotypic traits related to heat tolerance and CO_2 responsiveness in wheat.
  - Integration of genomic techniques, like genome-wide association studies (GWAS) in the field and PCR analysis
  - Long-term field trials are needed